Expanding the Frontiers of Design: A Blessing or a Curse?

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Remembering Ömer Akin
Foreword

The Design Thinking Research Symposia (DTRS) series of meetings was launched at TUDelft in 1992. It aims to research design thinking on the base of real-world evidence. Each of the past 12 meetings has dealt with a specific topic and in the 13th symposium we look at the expansion of what is understood as design (and design thinking), whereby many activities by professionals from different disciplines are seen as included in the term ‘design’. This is largely a result of the development of Design Thinking as a methodology, shortly after the DTRS series was initiated. The move from design thinking as the way in which designers think to Design Thinking as a method embraced by the business world has brought many new actors to the table, and it is no longer clear what exactly design means and how well it is served by the expansion of its boundaries. In DTRS13 we investigate precisely these questions. What are the new frontiers design is demarcating? Do they have the capacity to sustain the missions of design? What do we gain from this expansion of frontiers? What do we lose, if something is lost? Can we find a new signification for the designer, which will be wider than the traditional one but narrower than “everybody is a designer”? What are the implications for design education? For teamwork wherein team members have varied professional backgrounds? For sustainability, and for design for underserved human groups, and animals? There are also implications for design methods and the technologies involved, all of which are changing rapidly. These are some of the issues that come up in this compilation of papers, which were accepted, and for the most part presented, at DTRS13. Some of the papers in this volume are by authors whose papers were accepted and they registered to the conference but could not travel to it for various reasons. This conference was long in the making: it was initially planned for April 2021 but had to be postponed owing to the global Covid pandemic. It is finally taking place in March 2022, and we are so glad that it is really happening!

We would like to thank the Technion for supporting this conference, DesignTech for sponsoring it, the Azrieli Foundation for the rich aid they provided, and we especially thank Stratasys for their interest and generous support of the conference. Finally, many thanks to Sheila Osmanov, whose assistance in organizing the conference was indispensable.

Gabriela Goldschmidt and Ezri Tarazi
Haifa, March 2022
1 What is design?
Designed to write

Christine Toh\textsuperscript{a}, Andy Dong\textsuperscript{b} and Mike Sharples\textsuperscript{c}
\textsuperscript{a} University of Nebraska at Omaha, ctoh@unomaha.edu
\textsuperscript{b} Oregon State University, andy.dong@oregonstate.edu
\textsuperscript{c} The Open University, mike.sharples@open.ac.uk

Abstract. This article describes the cognitive and processual similarities between creative writing and designing. We have chosen to investigate this intersection as one way to address the expansion in the boundaries of design thinking. Evidence of this intersection is drawn from a book on the cognitive aspects of creative writing and an interview with the author. The article identifies four sets of similarities between creative writing and design: processes; cognitive structures and processes; methods; and social processes. Based upon our analysis, we find reason to conclude that writing is a form of design and that writers are \textit{ipso facto} designers.

Since the human faculty of language is the foundation for creative writing, and language is thus far considered the paragon of cognitive skills, we conclude that the proliferation of design thinking across disciplines should be expected. If writing is designing, then all forms of communication modes (mathematics, language, symbology) are all forms of design itself.

Keywords: creative writing, design cognition, mental models

1 Introduction

Stories, in the form of news, articles, books, and even tweets, and designs, in the form of objects, environments, and services, are all around us. Together, they represent the bulk of our material culture. Writings and designs share structural similarities. Designs have a function, structure, and behavior (Gero, 1990). Similarly, writings have a function (construe an experience, create a community), structure (genre, grammar, style), and behavior (narrate, report). This leads us to raise the question of whether the act of writing and designing share other similarities. Taking a more provocative stance, this article raises the possibility that writing is itself a form of designing. Indeed, in writing about writing, Mike Sharples claims that writing is akin to designing: “A writer is not only a creative thinker and problem solver, but also a \textit{designer}.” (Sharples, 1999, p. 10) We believe that discovering the extent to which writing is (or can be) a design process can drive a search for cognitive processes, tools, and mediations that underpin both practices. If central concepts such as ‘design thinking’ and ‘primary generator’ can be applied in creative writing, then the boundaries of these concepts expand.

If the claim that writing is a form of designing is true, this leads to a broader implication that would explain the expansion of the boundaries of designing, or more popularly ‘design thinking’ (Brown, 2008). This implication is that writing is an adaptation of the cognitive skills evolved for designing. Perhaps the evolution of cognitive skills for designing (Dong, Collier-Baker, & Suddendorf, 2017) provided the building blocks for language (Bickerton, 1981; Davidson, Noble, Lieberman, Ragir, & Burling, 1993; Deacon, 1997). As early as 1.75 million years ago, long before humans communicated through language, they were engaged in the top-down design of artifacts (Moore, 2020). They were designing hafted (having a handle) tools and symbolic, decorative items (Henshilwood, D’Errico, Marean, Milo, & Yates, 2001; Henshilwood et al., 2002). Moore (2011) suggests that the physical constraints of materials enforced boundaries on design spaces and influenced the emergence of design cognition and practice. A set of cognitive skills have evolved to enable humans to design. To engage in these sorts of activities requires deliberation and planning, both of which are enabled by the
cognitive skill of recursion (Hoffecker, 2007). Recursion is considered a building block for language and the creative ability to produce a seemingly infinite variety of combinations from discrete components. It is possible that some cognitive skills involved in design cognition such as imagination and causal reasoning are examples of convergent evolution. Both great apes and crows (corvids) have been found to possess these cognitive skills (Emery & Clayton, 2004), which enables them to perform acts such as crafting simple tools. Yet, to our knowledge, neither apes nor crows have shown any capability to write – which may simply be the case because there is no need, no natural response necessary, for them to do so even if they could. The capability to design gave humans an inherited difference that we leveraged to improve our species’ ability to survive and reproduce. Since humans developed an ability to design before writing, perhaps humans designed language itself. The evolutionary origins of capabilities to envision and reify that world such that it can be shared and communicated to others are more likely than not to be shared between writing and designing.

In short, if there are commonalities in terms of mental structures, processes, and methods between writing and designing, then there are far-reaching implications because the cognitive skills for design predate skills for language.

The central claim of this paper is that writing is a process of design and therefore writers are ipso facto designers. We have chosen an exploration of what writing and visual design have in common, through a search for cognitive processes, tools, and mediations that underpin both practices, to explore the boundaries of designing. We have chosen to investigate creative writing to address the expansion in the boundaries of design thinking because both writing and design result in the intentional planning and creation of cultural artifacts, one immaterial (writing), one material (design), to express and shape values and beliefs. Both deliver on the goal of communication (Forlizzi & Lebbon, 2002). As stated by Krippendorff (1989, p. 9), designing can be “regarded as meaning that “the products of design are to be understandable or meaningful to someone”. Similarly, creative writing can be viewed as the process and act of individual expression to share an experience to a specific group (Marksberry, 1963).

The evidence for our claim is a book about the process of writing, How we write: writing as creative design (Sharples, 1999) by Mike Sharples, and an interview with the author, provided in the Appendix. Sharples was provided an early draft of this paper and invited to respond to a set of interview questions. The responses to the interview questions have been integrated with the paper. We chose this book as data for our research because it is the only book we have been able to find that treats the process of writing as both a process and as a cognitive act, mirroring the way that designing has been researched as a process (Braha & Reich, 2003; Jones & Thornley, 1963) and as a cognitive act (Visser, 2004). Design as a process and a cognitive act are the two dominant themes of design research (Chai & Xiao, 2012). In addition, while a broader base of literature exists that compares writing with designing, the focus of this paper is not a comprehensive review of the existing research, but rather a critical analysis of Sharples’ claims using recent citations from the design domain to contextualize the authors’ claims for our research community. Scholars associated with the research group with whom the author collaborated to produce the research informing this book came from disciplines including psychology, ethnography, computer science, and journalism – which again mirrors the disciplines contributing to design research if we replace journalism with any of the disciplines associated with the practice of design such as architecture, industrial design, or engineering.

We will review the two most intriguing claims made in Sharples’ book to test the assertion of the commonalities between writing and designing:

1. The cognition of writing recruits the same cognitive processes used in design.
2. Both writing and design use congruent methods and approaches to structure the process.
2 Overview of How we write: Writing as creative design

Written as a book that explains writing from three perspectives – cognitive psychology, media theory, and social constructionism – *How we write: writing as creative design* by Mike Sharples is more an exposé about writing than it is an instruction manual on creative writing. The book is based upon research by the Collaborative Writing Research Group at the University of Sussex, UK. Separated into three parts, each analyzes writing from the following perspectives: i) cognitive psychology; ii) media theory; and, iii) social constructionism. Part One deals with creative writing as a mental activity. This part begins with an account of the cognitive development of writing in children and builds toward a general claim of writing as creative thinking guided by internal (i.e., self-imposed) constraints such as topic and style and external constraints such as grammar. Part Two presents a description of writing as supported by a set of methods and makes the strongest set of claims on the intersection between writing and designing. As Sharples makes clear in the Preface, “My own view is that writing is a process of design, a skill that is grounded in the way we use our intelligence to create and share things of meaning in the world.” (Sharples, 1999, p. xii) Finally, Part Three describes the ways in which an author’s social and cultural settings influences their writing. Across the three parts, Sharples makes four general claims about the intersection of writing and designing:

1. The process of writing is akin if not nearly identical to the process of designing except that writing produces a text and designing can produce everything that is not a text. For example, Sharples states that writing entails activities such synthesis and analysis and stages such as ideation, analysis, evaluation, and selection, activities and stages encountered in the process of design.

2. The mental processes of writing are similar to the mental processes in designing because both are mental activities that leverage the mind’s capacity for creativity to produce artifacts that are meaningful to others. While it is more likely the case that cognitive processes in designing (if designing is thought of as form-giving) emphasize mental representations that are spatial rather than linguistic (Finke, 1990), designing and writing may recruit similar cognitive skills and processes.

3. Both writing and designing use methods and approaches to structure inherently open-ended and ill-structured processes. Even though writing and designing happen in the mind, they rely on methods and external tools to increase productivity and serve as cognitive scaffolds throughout the process.

4. Both writing and designing are mediated by social processes that draw upon resources produced by others. Paraphrasing a statement on the formation of personal identity (Appiah, 2005), while authors and designers produce their own artifacts, it is other authors and designers who produce the artifacts that authors and designers will use to produce their artifacts. Designing involves stakeholders, technical conversations, and sometimes a client and a brief. Writing involves stakeholders (editors, agents, readers) and sometimes a client (publisher) and a brief (prospectus).

While all four claims outlined above illustrate many similarities that run through the core of both writing and designing, in this paper, we will focus on claims 2 and 3 for the sake of brevity and since they are both non-obvious assertions that deserve greater explication. The following sections review claims 2 and 3 respectively, discussing the links between writing and designing as both a cognitive process and a set of methods used in practice.

3 Cognitive aspects of writing and designing

Interest in understanding the mental processes and structures associated with the process of design started from a broader program to develop intelligent software programs to automate the design of specific artifacts, if not entire classes of artifacts (Coyne, Rosenman, Radford, Balachandran, & Gero, 1990). Inspired by foundational concepts from the field of artificial intelligence, research in the
mental processes and structures associated with designing came about primarily through an objective to develop computable models of a design and of designing (Gero, 1990). This area of research has come to be known as design cognition (Visser, 2004). The design cognition research paradigm views designing as essentially a cognitive activity, which entails the description of design practice through descriptions of cognitive processes rather than through descriptions of tools, methods, or processes. The fundamental theory espoused by the design cognition paradigm is that the structures and processes of cognition have causal importance in explaining designers’ behaviors and outcomes. Design cognition researchers do not neglect the role of tools, processes, and social context; rather, the interest lies in understanding how cognitive processes intersect with the technical methods of design, such as the intersection between mental imagery and short-term memory while sketching (Bilda & Gero, 2007). Design cognition researchers theorize a set of cognitive processes salient to designing (Farrell & Hooker, 2013) such as abductive reasoning (Dorst, 2011) and evolutionary building blocks such as representation, recursion, and curiosity (Dong et al., 2017).

Sharples (1999) expresses a similar interest in the mental aspect of writing. Based upon ‘think-aloud’ research about writing (Hayes & Flower, 1980), a research method widely used in the design cognition community (Ericsson & Simon, 1993; Lloyd, Lawson, & Scott, 1995), Sharples focuses on the mental processes associated with creativity in writing. His definition of creativity in writing exactly mirrors the definition of creativity used in design theory. According to Sharples, creativity in writing entails both originality and appropriateness. Appropriateness means that the content and style of the writing suit the author’s audience and the purpose of the text. These are the same criteria applied to creative designs – novelty and utility. Novelty in design is usually conceptualized as how unusual or unexpected a design is relative to others within its category. Utility is conceptualized as quality, the extent to which a design objectively meets its intended purpose according to some measures of goodness. Originality in writing is achieved by following the rules of grammar, or sometimes flexing and extending the expected conventions of style. Originality in design can be achieved by following the rules of a shape grammar (Stiny & Gips, 1972) or algorithms that transform and combine simple representations into original designs (Emdanat, Stiny, & Vakaló, 1999). However, the novelty of certain designs can also come from the deliberate bending of existing paradigms and questioning of established design guidelines, as seen in well-known examples in industrial design, typography, architecture, and the design of musical instruments (Lawson, 2006).

The cognitive pathway to creativity in writing connects with the model of creativity as a psychological phenomenon as explained by C-K theory (Hatchuel & Weil, 2009). C-K theory proposes the existence of two spaces (mathematical sets): the concept space $C$ and the knowledge space $K$. The knowledge space contains all true propositions and available knowledge. The concept space contains designs that may be true because it is not yet possible to prove that a particular design is true given the current knowledge space. As such, each design is a proposition. The process of designing transforms undecidable propositions (concepts) into true propositions (designs) in the knowledge space. In other words, the process of designing creates knowledge that makes the undecidable propositions in the concept space true. C-K theory proposes four operators that expand the $C$ and $K$ spaces until a true proposition (design) can be logically proven.

These C-K spaces appear in Sharples’ explanation of a writer satisfying constraints in order to generate an appropriate text. (It should be noted that Sharples was unaware of C-K theory when writing his book.) Sharples identifies two types of constraints: internal constraints such as the author’s self-imposed topic, and external constraints such as the style and structure of writing that would be meaningful to the audience. For example, an author can self-impose an interest in writing a news article on a specific topic, but, in writing for The New York Times, the author will adhere to the style stipulated in The New York Times Manual of Style and Usage. Sharples claims that writers start with a set of ideas represented in “a tangled web of associated concepts as an organised conceptual
space...that can be systematically explored and transformed. (Sharples, 1999, p. 45). The “organised conceptual space” that Sharples cites are named the same as concept spaces in C-K theory. Ideas in the writer’s conceptual space have the same properties as propositions in C-space because ideas have attributes (words) – they originate from a “search through long-term memory for appropriate ideas and appropriate language to express each idea”. Similarly, propositions in C-space have attributes that are the properties of a design such as its geometry or material. The K-space is what Sharples describes as internal and external constraints. The constraints, like the K-space, are what are known to be true or false about language, grammar, style, etc.; they guide (constrain) the writer in formulating a meaningful chain of ideas rather than a series of random, disconnected words. Designers retrieve ideas from long-term memory (Bilda & Gero, 2007; Del Missier, Visentini, & Mäntylä, 2015) and connect these ideas “to define, constrain and clarify the problem space of the design task.” (Goldschmidt, 1995, p. 208) Likewise, writers “invoke conceptual spaces [emphasis added] relevant to the task and then exploring and transforming them to create products that the writer could not have imagined previously” (Sharples, 1999, p. 47) – a transformation that is reminiscent of the C-K operators and their transformation of propositions in the C-space and knowledge in the K-space. Admittedly, C-K theory applies better to the writers’ external constraints (as opposed to internal constraints) since much of the work that goes into the process of writing is concerned with satisficing internal constraints. Nevertheless, both writing and designing involve an exploration of these conceptual spaces to meet internal and external constraints. In sum, the model of thought theorized by C-K theory finds empirical support in Sharples’s description of creative thought in writing, most likely since they are both underpinned by Herbert Simon’s notions of human problem solving and creativity as explorations within conceptual spaces (Newell & Simon, 1972).

Sharples further elaborates on the fundamental processes of idea generation for writing in hypothesizing ‘states of mind’ associated with knowledge telling and knowledge transforming. Borrowing a taxonomy proposed by Gelernter (1994), Sharples hypothesizes that knowledge telling and knowledge transforming can either be low-focus or high-focus. High-focus thinking is associated with solving a particular problem whereas low-focus thinking is associated with inconsequential thinking associated with emotion. Given these dimensions, Sharples hypothesizes four ‘states of mind’ for idea generation in writing as shown in Table 1 (Sharples, 1999, p. 48).

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<td>Knowledge telling</td>
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<td>High focus</td>
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<td>Low focus</td>
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While there is no equivalent concept of ‘state of mind’ in design cognition, these four states could be mapped to the following concepts in design cognition:

1. Associational thinking – concept formation as the construction of ideas at increasing levels of complexity (e.g., Dong, 2006; Galle, 1996; Gero, 1998)
2. Idea flowing – a significant body of design cognition research addresses the effects of exposure to far-field, less-common examples during ideation (e.g., Chan et al., 2011; Fu et al., 2013; Tseng, Moss, Cagan, & Kotovsky, 2008)
3. Problem solving – the problem-solving paradigm in design (e.g., Goel & Pirolli, 1992; Simon, 1995) describes the mental processes associated with problem-solving in detail
4. Daydreaming – other than brainstorming (Osborn, 2001), in which it is shown that brainstorming is most effective when individuals work alone first and then share ideas in a group (Girotra, Terwiesch, & Ulrich, 2010), the most similar research would be avoiding design fixation
through incubation and forgetting (Smith & Linsey, 2011) though techniques for de-fixing fixation that involve re-representation and abstraction (Zahner, Nickerson, Tversky, Corter, & Ma, 2010) could be considered low-focus if these activities are undirected externally.

It seems fair to say that categorizing states of mind as a way to distinguish cognitive pathways to creativity in idea generation would not neatly organize research on ideation in design given the very diverse perspectives on the cognitive psychology of creativity (Runco & Chand, 1995). Although Sharples does not review the cognitive psychology behind idea generation in writing, the reasonable overlap between his dimensions of creative thinking in writing and empirical research on idea generation in design allows us to conclude that empirical findings in the design cognition research will likely hold if the research were about writing instead of designing. One important difference stands out, though. The main difference in Gelernter’s high-/low- focus taxonomy and convergent/divergent thinking is the hypothesis that low-focus thinking is driven by emotion. Divergent thinking in design, and creativity, more generally, can be driven by many cognitive processes (Hernandez, Shah, & Smith, 2010) such as incubation, frame of reference shifting, and exposure to novel examples. The effect of emotion on a designer’s creativity has received very little attention other than the effect of emotions about past experiences as a trigger for novel ideas (Solovyova, 2003) and curiosity (Saunders, 2007). However, Sharples (1996) himself has critiqued the notion that emotion is the sole driver of creative imagination, and that other forces may shape creative thought in writing, much like in design.

One topic on the mental processes associated with writing addresses that Sharples explores in depth but has received little attention in the design cognition community is the development of cognitive abilities for writing (or designing) in (neurotypical) children (cf., Dong & Heylighen, 2018). Sharples describes the progressive development of cognitive skills for writing in children. As children acquire the ability to speak, they also learn to develop imaginary worlds. Learning indirectly through communication with parents, teachers, and older peers, they begin to learn simple genres such as a book story or a recounted event. For example, a child might be asked to relay a story about their recent birthday party. The most significant advances in cognitive skills occur when children learn to form ‘what next’ scenarios and to stop and reflect on their mental processes. Children between 10 to 14 develop the ability to talk about their writing, which suggests that they are thinking about their thinking through “a mixture of engagement and reflection” (Sharples, 1999, p. 24). Sharples calls this cognitive skills knowledge telling, the formation and pursuit of chains of mental associations, and knowledge transforming, the construction of mental spaces to be explored and transformed (Bereiter, 1987). The closest analogous cognitive skills that have been studied in adult designers are mental simulation (Christensen & Schunn, 2009) and reflection-in-action (Schön, 1983; Valkenburg & Dorst, 1998), respectively. In a review of the developmental psychology literature, Suddendorf and Dong (2013) conclude that the development of secondary representation and meta-representation skills (Perner, 1991) give us the ability to imagine an object that is not present and to see versions of the object in different contexts to imagine how they would perform. At about two years of age, children develop the secondary representation skill to represent the world independent from perception (pretend play). At about four years of age, children develop the skill to represent an object or situation simultaneously in different ways. They may find a TikTok video of a cat swatting away ornaments the cat’s guardian recently put away amusing because they can represent the situation as a conflict between the cat’s representation of the situation as a game and the guardian’s representation of the situation as a chore. The development of these representational skills allows us to imagine objects that are not bound by pre-specified characteristics and should be salient in the ability for writers to imagine the structure of texts in ways that defy conventional understandings.
4 Methods of writing and designing

One of the most striking similarities between writing and designing lies in the reliance of tools and methods to help navigate an inherently ill-structured and open-ended process (Buchanan, 1992; Rittel & Webber, 1973). In fact, Sharples compares writing by dictation, a method of freeform writing, to be akin to walking in the dark. Similarly, design is often described as involving unclear goals and incomplete information (Voss & Post, 1988) and designers have to resolve conflicting requirements from stakeholders with competing priorities (Agouridas, McKay, & de Pennington, 2004). The uncertainty inherent in the design process shares many properties of walking in the dark, and decades of research and experimentation has led to the use of tools and methods to help designers grapple with this uncertainty. The use of tools to structure the highly unstructured process of both writing and designing can be attributed to the many shared properties between the two (written by Bryan Lawson in How Designers Think and cited by Sharples): they are both open-ended and cannot be fully specified; the process is endless; there is not an infallibly correct process to follow; the process involves finding and solving problems; it involves subjective judgment; it is a prescriptive activity; and, both designers and writers work in the context of a need for an action (they create change).

For writers, these tools take the form of books, files, notes, word processors, notecards, and many other mediums—all for the purpose of being signifiers of the writers’ ideas—external representations that convey meaning to the reader. Ideas live in the head until they can be expressed in the form of these external representations, and their expression is as varied as the type of medium used by each writer. While writers’ media of choice are typically constrained by the need to adequately express the written word, designers have a much wider range of external representations and tools at their disposal. Design journals, drafting paper, whiteboards, sticky notes, and even computer aided design (CAD) software are all used to make external “marks” on the world during the design process. The act of creating external representations of ideas is so central to design that a wealth of research has explored the relationship between one of the most common methods of expression, sketching, on the design process. Some have even characterized sketching as the “language” of design itself, a process by which the designer dialogues between internal ideas and external representations of those ideas (Cross, 1999; Goldschmidt, 1991; Shah, Vargas-Hernandez, Summers, & Kulkarni, 2001; Tovey, Porter, & Newman, 2003). Beyond the use of tools for writers to express themselves, Sharples also briefly discusses the use of external resources such as reference books or colleagues to guide the writer in their efforts to effectively express their ideas effectively. One of the most ubiquitous reference books for writing is Strunk’s Elements of Style (2007), which has shaped generations of writers and readers, highlighting the power of these external resources during the process of writing. In design, the use of these external resources has received significant attention in the form of guidelines, heuristics, and principles, which seek to help the designer draw from a rich library of design knowledge. Well known examples of these external resources include Schneiderman and Plaisant’s 8 Golden Rules of Interface Design (2010), Norman’s 7 Principles (2013), and Nielsen’s 10 Usability Heuristics (1994). So ubiquitous are these external resources that undergraduate design programs often include them as standard training materials for novice designers.

In considering the tools that both designers and writers use to externally represent their ideas, it becomes clear that much of the decision about which tool to use greatly depends on the context and need of the writer or designer. Sharples describes how writers have highly personal preferences for the tools used to capture their ideas, from the saturation of the ink used to write on paper, to the type of word processor used to compose text. So too do designers have highly personal preferences for design tools, albeit with more constraints in place by resources and established platforms used by organizations designers are in. Ferguson (1993) even discusses the different types of sketching used by designers: the thinking sketch, the prescriptive sketch, the talking sketch—all of which serve different purposes during the design process. However, the variety and quantity of tools that exist to
help support writers and designers do not fully resolve the central dilemma that Sharples brings into focus in this book: that writing (and designing) are both subject to the tension between the ephemeral nature of ideas as they are formed in the mind and the inflexible nature of the written word (or sketch) once they are put down on paper. In this way, writers and designers both have to struggle to update ideas once they are externally represented since the very act of writing (or sketching) causes the designer to reflect on their idea, interpret it, and modify it. However, not all mediums are created equal in the ability to easily update and modify ideas once they are expressed. Sharples uses the example of a typewriter: it allows a writer to record the flow of words rapidly and easily in a conversational manner. However, revising the text once it is typed on the page is much harder. Similarly, designers sketching rough ideas on the back of a napkin will find that refinements and modifications to the sketches are prohibitively cumbersome. The advent of digital sketching tools, such as Autodesk’s Sketchbook, now allow designers to make use of visual layers to make stepwise modifications, and advanced editing tools allow the designer to make substantial changes, such as line color or texture, rapidly and with minimal effort. Despite this, the use of these digital tools is not without constraints, and designers must work within the bounds of feasible editing actions available within these platforms.

While many frameworks for characterizing the process of both writing and designing exist in the literature, Sharples broadly classifies the activities involved into three main categories: planning, composing, and revising. In planning, the writer is focused on creating an outline and intention for content to be written. Unlike the romantic vision of a lone writer sitting down to compose a novel in a single sitting, Sharples provides compelling evidence that successful planning activities are key to intentional writing and significantly impact the quality of the final outcome. Similarly, designers or teams of designers who proactively perform background research into their users, competitors, and project constraints can plan their design activities more strategically, utilizing the resources available to them to make the best decision in their given design context. In the literature, this planning stage occurs during the conceptual design stage, and is of immense importance to the success of design activities, so much so that it is said that 60-80% of design costs are typically committed to this process (King & Sivaloganathan, 1999). Two types of planning methods are discussed by Sharples as being used by writers. The first is mind-mapping, a process of linking associated concepts together in a visual layout to help organize networks of thoughts and keep writers organized during this stage. While mind-mapping is not a formal tool used in design, the use of associational thinking bears a striking resemblance to the use of computational tools for encouraging idea generation (Hu, Ma, Feng, & Peng, 2017; Siddharth & Chakrabarti, 2018). Another well-established method of planning used in writing is developing outlines, typically in the form of bullet points describing the content to be covered in the writing. While the structure of such outlines is clearly specified for producing written text, designers have their own methods of “outlining” the design process, or the intended design activities to be engaged with, such as developing a Project Requirements Document (PRD), MoSCoW Prioritization Plans (Waters, 2009), and product specifications (Ulrich & Eppinger, 2016), to name a few. Regardless of the design framework or planning method used, the core purpose of these planning methods is to enable the designer to strategically allocate resources to different stages of the design process to maximize their chances of producing successful design outcomes.

Figure 1. Process of reflection (Sharples, 1999, p. 91)
The next main stage of writing described by Sharples is composing, whereby writers generate ideas and transfer them to written language using a medium of their choice. However, this process of idea generation does not happen in a vacuum, as illustrated by the diagram shown in Figure 1 from Sharples’s book.

Writers must first translate their own experience that is organized by their own mental schemas (ways of understanding the world) into a written language, which is then interpreted by the readers’ own mental schemas, integrated into their own personal experience of being in the world and reading the written text. In this way, the written artifact is subject to both the experience of the writer and the reader and can never be experienced objectively in both directions. This is not dissimilar to theory of design posited by Norman (2013), which states that the designer’s mental model is manifest in the artifacts that they design, and how these artifacts in turn are interpreted by users is subject to their own mental models of how the world ought to work, as depicted in Figure 2.

![Figure 2. Mental models (Norman, 2013, p. 32)](image)

These two mental models (the designers’ and the users’) do not always align, and therein lies one of the central challenges of design: to design artifacts that can be interpreted accurately by users who themselves have their own narrative of how the world ought to work to create seamless and effective user experiences. This is an active process on the part of the designer and user, similar to how interpretation of a text sometimes requires mental effort by the reader to relate to the written meaning and the writers’ own experience.

Sharples takes this process of expression and interpretation one step further and asserts that writers themselves interpret their own written word once it is externally represented, and that writers’ own understanding of their ideas shift once they interpret it on the written page. In this way, the act of composing is essentially captured through cycles of writing, interpreting, and revising to approach a state in which the written word on the page more closely resembles the writers’ idea of what it ought to be. This cycle closely resembles the cycle of action and reflection (Schön, 1983; Valkenburg & Dorst, 1998), where designers use their metacognitive abilities to reflect on design activities while in action. This type of “knowing in practice” has been documented in Schön (1983) work on design as a reflective practice, where designers are especially sensitive to the effects of their actions amidst designing and use this awareness (often in a tacit way) to guide their actions in uncertain and ambiguous situations (as is common in design).

The last stage of writing that Sharples describes is revising, wherein the composed text is then analyzed and modified to fit the goal of the writing task itself. Like design, there is a psychological barrier inherent in revising text that has been painstakingly composed by the writer. This phenomenon has been studied in design and takes the form of the Sunk Cost Effect (Viswanathan & Linsey, 2013), where designers are reluctant to change their designs substantially, even in the face of evidence to the
contrary, because of the amount of resources (time, energy, emotion) sunk into the initial design. Even if certain designs bear smaller costs to change (software code), the emotional investment into the design itself poses significant barriers to changing directions or removing large portions of already developed concepts. This is a challenging phase of the writing process, and Sharples notes that experts are more competent at revising than novices: they revise more, and their revisions are better. Similarly, studies exploring expert designer behavior show that expert designers iterate more and reinterpret the problem and solution concurrently until a good “fit” is discovered (Dorst, 2019). Expert designers are also able to use more complex reasoning about design at higher levels of abstraction, which helps them transform declarative knowledge into procedural knowledge for recognizing solutions, resulting in better outcomes at the end of the process of iteration (Adelson & Soloway, 1985; Akin, 1990). The value of revising based on interpretation, called recursion by Sharples, is realized through the generation of new ideas that often are better aligned with the writer’s goals. Indeed, the value of critique in design has long been recognized (Costantino, 2015) for its ability to help guide design decisions while they are being made and can enhance design education.

All the steps in the writing process that Sharples described are framed as the foreground for the backdrop of the writer’s own personal attributes that can affect this process. Namely, writers’ behaviors and attitudes about writing can play a significant role in their process of writing. Factors such as personality traits can affect writers’ attitudes, and motivation and apprehension can interact to create problematic behavior in writers, such as procrastination and fear of failure. These behaviors are very familiar to designers who face a similar apprehension about rejection of ideas that they have invested time and effort in. The impact of biases such as Ownership Bias have been studied in design, and research has shown that (Cooper and Lucas, 2006) designers place more value on their ideas over the ideas of others, and this can have negative effects on objective decision-making in design (Toh, Strohmetz, & Miller, 2016). Other similar themes are found throughout the engineering design literature, with studies exploring the impacts of personal attributes such as personality traits (Toh & Miller, 2016), cognitive style (Buffinton, Jablokow, & Martin, 2002), and self-efficacy (Starkey, Hunter, & Miller, 2018) on designer behavior and outcomes. Both writing and designing share a core trait of requiring a designer to put substantial investments into endeavors that have inherently uncertain outcomes, risking rejection and failure. These are vulnerable acts of creation that call upon the writer or designer to trust in their ability to navigate the unstructured process with courage. As Sharples wrote, “Being a writer is, above all, having control over how you write and trust in your ability to make progress.” (Sharples, 1999, p. 128) So too must designers when faced with the ambiguity and uncertainty of the design process.

5 Conclusions

This article presented a review of a book to claim that writing is a process of design and therefore writers are *ipso facto* designers. The article reviewed the evidence behind this claim by presenting empirical research in the field of design theory. The act of designing, like the act of writing, envisions a future world that does not yet exist and reifies that world in semiotic form.

While this paper focused on the research on writing as designing from a single book and its author, new research has explored how a conceptualization of writing as design can be applied in areas as diverse as children’s collaborative writing (Vass, Littleton, Miell, & Jones, 2008) and computational creativity (Alvarado & Wiggins, 2018). An important and growing area of research is in multimodal writing – to understand how visual design and imaginative writing can be combined to communicate meaning and achieve effects. New tools and form factors, such as multimedia smartphones, have prompted research into visual and informational design of texts for multiple devices (Ling, Fortunati, Goggin, Lim, & Li, 2020). All these strengthen a central claim of the book that writing and designing
involve similar methods and cognitive skills. Also, regarding creative writing as a design activity can extend perspectives for both fields and inform new ways to write for multiple media. The paper’s main thesis that writing is a process of design and therefore writers are ipso facto designers leads to two implications. First, there is value in showing and teaching the commonalities of writing and design. Theories from writing, such as narrative cognition, high and low focus thinking, engagement and reflection, and the materiality of writing practices can inform design thinking, and theories from design such as primary generators, design spaces, visual balance, and design patterns can inform writing. Skills such as ideation, brainstorming, storytelling, iteration, prototyping, reflection and revising underpin both practices. The challenge in design education will be to show students how these theories and practices mesh together (or not) to support the differing fields of creative writing, engineering design, product design, and software design.

Second, current research in storytelling in creative writing offers new directions for research in the field of design. Design thinking already embraces storytelling to gain insight into users and to present a prototype artefact. Storytelling in design could be explored further to include shared stories about the design process, storytelling as design, and the rhetoric of storytelling in design (Stevenson, n.d.; Suleman, 2017). One contribution of such research would be to explore whether storytelling in design is a subtractive process (it gets to the essence of the design), an expansive process (it embellishes designs with stories of possible use) or a rhetorical process (it persuades people to ‘buy’ a design), or all three. Perhaps this heralds a new field of “narrative design” (already established in videogame design) where powerful emerging tools such as Wu Dao 2.0 (Romero, 2021) allow creative exploration of narrative and visual design.

Through our analysis, we made the case that designing (or design thinking) forms the building blocks of the intentional creation of cultural artifacts, and provide a foundation for understanding how, like mathematics, the design discipline can position itself as a central language for creative and generative disciplines. If all forms of communication modes such as language, mathematics, visual art, and, more broadly, semiotics, are all forms of design itself, it becomes possible to cast many disciplines as a form of design. Doing so does not make everything a practice of design. Rather, to view other practices as akin to the practice of design suggests that the thought processes and methods of design should, rightly, be construed as uniquely valuable. In other words, design thinking is as distinct and valuable as other established modes of thinking such as critical thinking, scientific thinking, and systems thinking, to name a few – and yes, writing. Rather than devaluing design thinking because of the ubiquity of its application, our position elevates design thinking as a unique and powerful mode of thinking that can be utilized by many disciplines (such as creative writing) in the same way that mathematics is regarded as a central language in science, engineering, economics, and many other disciplines and practices.

For centuries, the purpose of the academic essay has been to encourage ‘writing thinking’ – to enable students to expand a thesis, challenge assumptions, clarify arguments, exercise critical judgment, and examine multiple perspectives (see e.g., Fitzgerald (1994)). Writing thinking is at the core of intellectual life in some of the great traditional universities. Perhaps, as ‘writing thinking’ has become less fashionable, it has been replaced by applying ‘design thinking’ more widely. In short, design thinking has become core to intellectual life because the cognitive skills and processes associated with it are core to being human.

6 References


Appendix: Interview with Mike Sharples

We provided Mike Sharples with a draft of this paper in preparation for this interview. The following are questions posed to Sharples and his typewritten responses.

“Since the publication of your book How we write, what new research strengthens or weakens the claims you made about writing as creative design?”

Since publication of How We Write, new research has explored how a conceptualization of writing as design can be applied in areas as diverse as children’s collaborative writing (Vass et al., 2008) and computational creativity (Alvarado & Wiggins, 2018). An important and growing area of research is in multimodal writing – to understand how visual design and imaginative writing can be combined to communicate meaning and achieve effects. New tools and form factors, such as multimedia smartphones, have prompted research into visual and informational design of texts for multiple devices (Ling et al., 2020). All these strengthen a central claim of the book that writing and visual design involve similar cognitive processes. Also, regarding creative writing as a design activity can extend perspectives for both fields and inform new ways to write for multiple media.

“The key question raised by this Design Thinking Research Symposium is that ‘it is no longer clear what exactly design means and how well it is served by the expansion of its boundaries’. Do you think that making the claim that writing is (like) designing expands or sharpens the boundaries of what it means to be a designer or the practice of design?”

I think it illuminates design practice from a different angle, that of creative writing. It shows how some central concepts such as ‘design thinking’ and ‘primary generator’ can be applied in creative writing and so expands the boundaries of these concepts. The claim that writing is (or can be) a design process may help to clarify what writing and visual design have in common, and drive a search for cognitive processes, tools, and mediations that underpin both practices.
“The field of design has grown tremendously in popularity especially with the coining of the term ‘design thinking’ – which is stated in the name of the conference at which this paper will be presented. Why do you think it is that there is no equivalent concept of ‘writing thinking’?”

I suggest there is the construct of ‘writing thinking’, it’s just not described as such. For centuries, the purpose of the academic essay has been to encourage ‘writing thinking’ – to enable students to expand a thesis, challenge assumptions, clarify arguments, exercise critical judgment, and examine multiple perspectives (see e.g., Fitzgerald (1994)). Writing thinking is at the core of intellectual life in some of the great traditional universities. Perhaps, as ‘writing thinking’ has become less fashionable, it has been replaced by applying ‘design thinking’ more widely.

“Given that the core proposition of your book is that writing is like designing, what research would you like the design thinking community to perform that would explore this relationship deeper, and what would the contributions of such research be?”

I would love to see the design community explore storytelling in more depth. If I were authoring How We Write now, I would cover recent research into storytelling (e.g., Storr (2020)), including neuro-cognitive processes of storytelling, and the suggestion that language evolved from storytelling, not the reverse (Ferretti et al., 2017). If storytelling pre-dates language, then it can be seen as an early design practice (the first storytellers were mime artists and visual designers). Design thinking already embraces storytelling to gain insight into users and to present a prototype artefact. I suggest this could be explored further to include shared stories about the design process, storytelling as design, and the rhetoric of storytelling in design. Good starting points are Stevenson (n.d.) and Suleman (2017). One contribution of such research would be to explore whether storytelling in design is a subtractive process (it gets to the essence of the design), an expansive process (it embellishes designs with stories of possible use) or a rhetorical process (it persuades people to ‘buy’ a design), or all three. Perhaps this heralds a new field of “narrative design” (already established in videogame design) where powerful emerging tools such as Wu Dao 2.0 (Romero, 2021) allow creative exploration of narrative and visual design.

“There has been a tremendous amount of debate in evolutionary psychology on the origins of the human abilities for language, which, as you state in the book, precede writing. Why do you think that there has not been an equivalent debate about the origins of the cognitive skills needed to design?”

There is some research into the evolution of tool design in early societies, e.g., Moore (2011). One obvious issue is that we can only study the evolution of design through the surviving artefacts, such as arrow heads. I like the way that Moore has studied the experiences of modern experimental knappers to understand the design space and make assumptions about tool design by hominin stoneworkers. Moore suggests that the physical constraints of materials enforced boundaries on design spaces and influenced the emergence of design cognition and practice.

“Extrapolating from your central claim that a writer is a designer, do you think we could educate better writers by teaching design skills? And, conversely, do you think we could educate better designers by teaching writing skills?”

I think it is valuable to show and teach the commonalities of writing and design. Theories from writing, such as narrative cognition, high and low focus thinking, engagement and reflection,
and the materiality of writing practices can inform design thinking, and theories from design such as primary generators, design spaces, visual balance, and design patterns can inform writing. Skills such as ideation, brainstorming, storytelling, iteration, prototyping, reflection and revising underpin both practices. The challenge is to show how these theories and practices mesh together (or not) to support the differing fields of creative writing, engineering design, product design, and software design.
What is design? The semantic core and periphery of design definitions

Jan Auernhammer and Chris Ford
Center for Design Research, Stanford University, jan.auernhammer@stanford.edu, cford4@stanford.edu

Abstract. This paper examines the shared semantics among diverse Design definitions to identify its semantic core and discusses several dilemmas that make a clear boundary for defining Design difficult and multifaceted. The research provides evidence that there is a diverse understanding and usage of the term Design. However, shared word-groups inherent in the definitions provide a family resemblance or bundles of interpredictable attributes for a shared comprehension of Design. Furthermore, a thematic analysis revealed five dilemmas, including Complexity, Zeitgeist, Expertise, Identity, and Disciplinary Perspective, making defining Design multifaceted. While activities and practice differ in diverse disciplines, the fundamental human capacity of productive or design thinking of determining a purposeful and meaningful (end) design (means) is shared among diverse professional disciplinary practices.

Keywords: Definitions of Design, Design, Design Thinking, Semantic analysis

1 Introduction

In 1965, Tomas Maldonado (1965) expressed his concern about the meaning of the word “design” and that it “has been strangely corrupted by general usage.” Today, one explanation for recent conflation surrounding the definition of design thinking is proportional conflation within contemporary definitions of Design. A definitional consensus of the terms design thinking and Design loses fidelity through semantic creep hastened further with each invocation. The graphic designer questions when an engineer characterizes themselves as a designer. The design engineer then disputes when the organizational designers make similar claims. Tension ensues. Any meaningful expansion of the frontier of Design ought to first ascertain those forces causing expansions and contractions of its boundaries. A valuable first step is redirecting attention currently focused on the dynamism of Design’s definitional edge to instead refocus on its comparatively stable core. Shared characteristics or among different definitions from diverse disciplines may provide increased clarity into the universal characteristics of all forms of Design. However, the semantic categorization of the term Design may not have a common feature among different disciplinary definitions. They instead have a family resemblance as they are related to one another through overlapping several similarities and connected in different ways (Wittgenstein, 1953). The semantic categorization of a specific way of acting or thinking into “Design” is used in diverse disciplines as it corresponds to bundles of interpredictable attributes (Rosch & Mervis, 1975). Importantly, the consideration of what is design must also examine the fuzzy peripheral boundaries that make it difficult to have a shared definition. This research aims to spark a conversation about the meaning of Design and asks: What are the similarities and differences between diverse definitions of Design?

The primary data set for this investigation is compiled from individuals with diverse disciplinary backgrounds who have shared insights and perspectives on the parent domain of Design. These seventy-seven definitions are based on all four orders of design, including graphic design (first-order), architecture and engineering (second-order), interaction design (third-order), and organizational and
business design (fourth-order) (Buchanan, 1992). The statements canvassed by authors, who themselves may be practitioners, educators, historians, or scholars on Design, form the dataset to analyze the core and peripheral of what Design is. This paper discusses the (1) characteristics shared among diverse Design definitions and (2) the dilemmas preventing clear boundaries for defining Design. This research contributes by explicating shared concepts and terms among diverse Design definitions and discusses the various dilemmas of why establishing definitional boundaries for Design is difficult. This paper closes with insights and implications for design thinking, design research, and design practice, emphasizing the need for clarifying the studied construct beyond the use of the overarching term: Design.

2 Background

Since humans first fashioned stones into tools, Design has evolved in ways guaranteeing both the shaping of its body of knowledge and its practices remain in flux. In sociology, Thomas Kuhn (2012) examined how disciplines structure shared principles, norms, and understanding into a paradigm. However, Design evolves at a constant pre-paradigmatic phase resisting the fixing of definitional boundaries (Verganti, 2009). Design contains many connotations and has been corrupted by general usage (Maldonado, 1965; Moholy-Nagy, 1969). It describes the primary characteristics of humans, human attitudes, everyday activity, and professional practice (Lawson & Dorst, 2009; Moholy-Nagy, 1969; Protzen & Harris, 2010). Design practices are continuously evolving and expanding, and with them, the definition and understanding of design. Bruce Archer (1965) expressed, “[...] there has been a world-wide shift in emphasis from the sculptural to the technological. Ways have had to be found to incorporate knowledge of ergonomics, cybernetics, marketing, and management science into design thinking.” The design of human interactions with interactive systems emerged with personal computing and information and communication technologies (Card, Moran, & Newell, 1983; Moggridge, 2007; Norman & Draper, 1986). In business management, establishing organizations based on specific design qualities resulted in innovation management approaches (Auernhammer & Roth, 2021; Brown, 2009; Martin, 2009). However, each claim by a “non-traditional” discipline presents a new dilemma for “traditional” design disciplines, who collectively question this expansion of inclusionary understandings of Design when compared against disciplinary definitions. László Moholy-Nagy (1969) expressed that “the designer must see the periphery as well as the core, the immediate and the ultimate, at least in the biological sense. [Sh]e must anchor [her/his] special job in the complex whole.” The same applies to design research. Design researchers must see the core of Design and its fuzzy periphery to place their findings and insights within the complex whole. Therefore, the investigation presented in this paper examines diverse definitions of Design to identify valuable shared characteristics forming Design’s semantic core and its fuzzy periphery.

3 Methodology

The research is designed to identify shared characteristics among different definitions of Design from different designers, design scholars, researchers, and historians. We employed a systematic search to identify and capture diverse Design definitions.

3.1 Data collection

We searched for “design is” and “[FIRST NAME] [LAST NAME]” on search engines, including Google and Google Scholar, to capture general, practitioner, and academic perspectives on the definitions of Design. We furthermore examined several books by design authors to identify Design
definitions to collect diverse perspectives from different fields. We collected over two hundred thirty statements, examined each statement, and categorized them as either a definition or a description. While discerning the textual dataset, definitions were found to speak directly to requirements and attributes of Design operations, whereas descriptions instead spoke to only a particular attribute, property, effect, or result. Therefore, we included the definitions and excluded the more detailed descriptions. The resulting definition included seventy-seven statements from individuals with diverse disciplinary backgrounds, representing the four orders of design (Buchanan, 1992). The seventy-seven statements were included in this analysis.

3.1.1 Sample bias and limitation. A limitation of this research is the focus on definitions in the English language, excluding a large amount of diverse cultural perspectives and semantic meaning. Furthermore, the data sample incorporates selection bias as definitions were searched by the researchers selecting specific authors. The data sample also incorporates a gender, cultural, and ethnicity bias of which there is no self-identified data available.

3.1.2 Table 2 outlines the diverse disciplinary backgrounds of definition authors, including a categorization of the four orders of design as outlined by Buchanan (1992). The limitation of this paper is that it includes a limited number of definitions, which are not providing a complete picture of the semantic meanings of Design.

<table>
<thead>
<tr>
<th>Disciplinary Background</th>
<th>Count (person)</th>
<th>Order of Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Education, Methodology, Research</td>
<td>25</td>
<td>general</td>
</tr>
<tr>
<td>Engineering, Industrial, Product Design</td>
<td>18</td>
<td>second</td>
</tr>
<tr>
<td>Architecture, Interior, Urban Design</td>
<td>10</td>
<td>second</td>
</tr>
<tr>
<td>Business Design, Economics</td>
<td>8</td>
<td>fourth</td>
</tr>
<tr>
<td>Communication, Graphic Design</td>
<td>7</td>
<td>first</td>
</tr>
<tr>
<td>Electrical, Structural Engineering</td>
<td>3</td>
<td>second</td>
</tr>
<tr>
<td>Computer Science, Interaction Design</td>
<td>4</td>
<td>third</td>
</tr>
<tr>
<td>Textile, Fashion Design</td>
<td>1</td>
<td>second</td>
</tr>
<tr>
<td>Others (Journalism, Psychology)</td>
<td>3</td>
<td>n/a</td>
</tr>
</tbody>
</table>

3.2 Data analysis

The data was analyzed through three different analysis techniques. First, we employed the software Leximancer to identify inherent concepts in the definitions. Leximancer allowed investigating the qualitative data through unsupervised semantic mapping of natural language to map concepts inherent in the dataset (Smith & Humphreys, 2006). The visualization of the findings is presented in Figure 1, and the identified main concepts are listed in Table 3. Secondly, we analyzed the definitions through a word count analysis to reveal shared words among the different definitions. Table 4 shows the shared word groups with the highest frequency (word count of six and higher). Lastly, we analyzed the definitions and descriptions to identify emergent themes that make the boundaries of Design challenging to define. Table 5 outlines the five emergent themes that are discussed controversially in the various Design definitions.

4 Findings

The data analysis revealed several (1) concepts, (2) shared terms, and (3) themes of dilemmas inherent in the Design definitions. This section first discusses the revealed concepts identified through
unsupervised semantic mapping of natural language with Leximancer. Secondly, the top shared terms are outlined and discussed to provide a semantic core of the meaning of Design. Lastly, the identified themes of dilemmas are summarized, explaining why the definition of Design has various fuzzy boundaries.

4.1 Concepts inherent in the Design definitions

The semantic mapping of the natural language of the Design definitions revealed the inherent concepts. Figure 1 shows the interconnected concepts within the diverse Design definitions.

Figure 1. Visual representation of concepts inherent in the Design definitions. The figure shows a visual representation of the themes as a conceptual map from the Leximancer analysis of the design definitions. The map shows three distinct main patterns: (1) process, problem, goals, makes, and world; (2) things, means, distinct, class, and art; (3) activity and plan

A more detailed analysis revealed that design is conceptualized as outlined in Table 3. The inherent themes in the design definitions are “Changing World” and “Changing Situations.” Unsurprisingly, thirteen definitions conceptualize Design as changing situations and the world. Furthermore, Design is conceptualized as “Plan Function,” “Analysis Process,” and “Making Meaning.” Design is planning for a specific purpose, analysis process of a goal, problem, and solution, and making sense and giving meaning to things. The themes in the design definitions also include “Activity” of planning for bringing about a specific change, “Planning Making” of making meaning, and “Nature Design” and “Solution Used.”

The analysis revealed the different themes and main conceptions inherent in the Design definitions. Table 3 shows that only seven and below definitions share semantic meaning, revealing that there is
not a dominant conceptualization of Design inherent in the diverse definitions. We further employed a word group frequency analysis to reveal the most used words in the definitions of Design.

Table 3. Main concepts inherent in the definitions of Design (unsupervised semantic analysis - Leximancer)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Freq.</th>
<th>Concepts</th>
<th>Example Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing World</td>
<td>7</td>
<td>World: change, changing,</td>
<td>“Design is really a way of looking at the world with an eye toward changing it.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>materials, shape, thinking.</td>
<td></td>
</tr>
<tr>
<td>Plan Function</td>
<td>7</td>
<td>Function: plan, purpose,</td>
<td>“[… ] Design [i]s a plan for arranging elements to accomplish a particular purpose.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>specific</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plan: purpose, specific</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Purpose: specific</td>
<td></td>
</tr>
<tr>
<td>Changing Situations</td>
<td>5</td>
<td>Changing: class, situation,</td>
<td>“The whole class of situations means that the experienced environment is constantly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>situations, environment,</td>
<td>changing, but nevertheless the object must always be just as good a solution, or fit, to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>means</td>
<td>the situation.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class: situation, situations, environment, means</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Situation(s): situations, environment, means</td>
<td></td>
</tr>
<tr>
<td>Making Meaning</td>
<td>5</td>
<td>Meaning: making, sense,</td>
<td>“The etymology of design goes back to the Latin de + signare and means making</td>
</tr>
<tr>
<td></td>
<td></td>
<td>things, giving, means</td>
<td>something, distinguishing it by a sign, giving it significance, designating its relation to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Making: sense, things,</td>
<td>other things, owners, users, or gods. Based on this original meaning, one could say: design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>giving</td>
<td>is making sense [of things].”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sense: things, means</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Things: giving</td>
<td></td>
</tr>
<tr>
<td>Analysis Process</td>
<td>4</td>
<td>Process: analysis, goals,</td>
<td>“The premise is that designing is a combinatorial problem-solving process in which</td>
</tr>
<tr>
<td></td>
<td></td>
<td>problem, solutions</td>
<td>analysis of a body of available information (which must first be collected) is used to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>generate candidate solutions to the problem, or to subproblems. Candidate solutions are</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>compared and assessed, and the most appropriate solution is then selected.”</td>
</tr>
<tr>
<td>Activity</td>
<td>4</td>
<td>Activity: bring, plan,</td>
<td>“Design’ is a fundamental human activity, as well as the name of a number of quite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>specific, change</td>
<td>specific professions.”</td>
</tr>
<tr>
<td>Planning, Making</td>
<td>4</td>
<td>Planning: making, meaning,</td>
<td>“a particular purpose held in view by an individual or group; deliberate, purposive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>means</td>
<td>planning; a mental project or scheme in which means to an end are laid down.”</td>
</tr>
<tr>
<td>Nature Design</td>
<td>4</td>
<td></td>
<td>“Design is a circumstantial act. It is a battle with the nature of man, with the nature of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>nature, with the laws of nature, with the rules of [hu]man, and with principles.”</td>
</tr>
<tr>
<td>Solution used</td>
<td>4</td>
<td>Solutions: used, analysis,</td>
<td>“Design is a multi-answer situation, and analysis is used to reach an end, not for its</td>
</tr>
<tr>
<td></td>
<td></td>
<td>problem</td>
<td>own sake.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used: analysis, problem</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Shared words among the Design definitions
The word frequency analysis revealed shared terms (word groups) among the different definitions. Table 4 shows the word groups with a word count of six or higher.

Table 4. Word frequency analysis of the definitions of Design

<table>
<thead>
<tr>
<th>Word</th>
<th>Count</th>
<th>Similar Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>design</td>
<td>153</td>
<td>design, designating, designed, designer, designers, designing, designs</td>
</tr>
<tr>
<td>making</td>
<td>22</td>
<td>make, makes, making</td>
</tr>
<tr>
<td>plan</td>
<td>21</td>
<td>plan, planning, plans</td>
</tr>
<tr>
<td>process</td>
<td>19</td>
<td>process, processes</td>
</tr>
<tr>
<td>things</td>
<td>15</td>
<td>thing, things, things’</td>
</tr>
<tr>
<td>using</td>
<td>15</td>
<td>use, used, useful, usefulness, using</td>
</tr>
<tr>
<td>arts</td>
<td>15</td>
<td>art, arts</td>
</tr>
<tr>
<td>new</td>
<td>14</td>
<td>new</td>
</tr>
<tr>
<td>purpose</td>
<td>14</td>
<td>purpose, purposeful, purposes, purposive</td>
</tr>
<tr>
<td>human</td>
<td>14</td>
<td>human, humanities</td>
</tr>
<tr>
<td>problem</td>
<td>14</td>
<td>problem, problems</td>
</tr>
<tr>
<td>products</td>
<td>13</td>
<td>product, production, productive, products</td>
</tr>
<tr>
<td>action</td>
<td>12</td>
<td>action, actions, act, acts</td>
</tr>
<tr>
<td>industrial</td>
<td>11</td>
<td>industrial, industrially, industry</td>
</tr>
<tr>
<td>situations</td>
<td>11</td>
<td>situate, situation, situations</td>
</tr>
<tr>
<td>forms</td>
<td>11</td>
<td>form, forming, forms</td>
</tr>
<tr>
<td>activity</td>
<td>10</td>
<td>activities, activity</td>
</tr>
<tr>
<td>change</td>
<td>10</td>
<td>change, changed, changes, changing</td>
</tr>
<tr>
<td>function</td>
<td>10</td>
<td>function, functional, functionality, functions</td>
</tr>
<tr>
<td>way</td>
<td>10</td>
<td>way, ways</td>
</tr>
<tr>
<td>world</td>
<td>10</td>
<td>world</td>
</tr>
<tr>
<td>materials</td>
<td>9</td>
<td>material, materials</td>
</tr>
<tr>
<td>solutions</td>
<td>9</td>
<td>solution, solutions</td>
</tr>
<tr>
<td>means</td>
<td>9</td>
<td>meaning, means</td>
</tr>
<tr>
<td>objects</td>
<td>9</td>
<td>object, objects</td>
</tr>
<tr>
<td>nature</td>
<td>8</td>
<td>naturally, nature</td>
</tr>
<tr>
<td>specific</td>
<td>8</td>
<td>specific, specification</td>
</tr>
<tr>
<td>creating</td>
<td>7</td>
<td>create, creates, creating</td>
</tr>
<tr>
<td>needs</td>
<td>7</td>
<td>need, needs</td>
</tr>
<tr>
<td>technology</td>
<td>7</td>
<td>technological, technologies, technology</td>
</tr>
<tr>
<td>language</td>
<td>6</td>
<td>language</td>
</tr>
<tr>
<td>order</td>
<td>6</td>
<td>order, orderly</td>
</tr>
<tr>
<td>sense</td>
<td>6</td>
<td>sense, sense’</td>
</tr>
<tr>
<td>solving</td>
<td>6</td>
<td>solve, solving</td>
</tr>
<tr>
<td>towards</td>
<td>6</td>
<td>toward, towards</td>
</tr>
<tr>
<td>living</td>
<td>6</td>
<td>live, lives, living</td>
</tr>
<tr>
<td>creative</td>
<td>6</td>
<td>creative</td>
</tr>
<tr>
<td>people</td>
<td>6</td>
<td>people</td>
</tr>
<tr>
<td>something</td>
<td>6</td>
<td>something</td>
</tr>
</tbody>
</table>

The most shared terms are “making,” “plan,” and “process.” Making emphasizes that design incorporates the activity making sense and things. The plan stresses that designing is about the consideration of pre-action and making representations of the designed (situated) artifact, while the process highlights the semantic meaning that Design is a series of sequenced actions taken to achieve
a particular end. However, there is not a clear conceptualization and shared terms among the design definitions. For example, “making” is shared among eighteen definitions, representing around 23.38%. For this reason, establishing the definitional boundaries of defining Design remains difficult.

4.3 Themes of boundary dilemmas

The thematic analysis of the dilemmas inherent in the Design definitions and descriptions revealed five themes, as shown in Table 5. These dilemmas explain why Design has fuzzy boundaries, representing the peripheral of Design definitions.

Table 5. Identified main themes are preventing a clear definition of Design

<table>
<thead>
<tr>
<th>Theme</th>
<th>Codes</th>
<th>Example Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity</td>
<td>Mystification</td>
<td>[industrial design] is the only profession that became a myth before it reached maturity (Nelson, 1965).</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>Zeitgeist</td>
<td>Historical context</td>
<td>Design is reflective of its social, historical, and regional culture of production. This is manifest in specific cultural influences on the designer (Micklethwaite, 2002).</td>
</tr>
<tr>
<td></td>
<td>Cultural context</td>
<td></td>
</tr>
<tr>
<td>Expertise</td>
<td>Everyday design</td>
<td>‘Design’ is a fundamental human activity, as well as the name of a number of quite specific professions (Lawson &amp; Dorst, 2009).</td>
</tr>
<tr>
<td></td>
<td>Attitude</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profession</td>
<td></td>
</tr>
<tr>
<td>Identity</td>
<td>Not Art</td>
<td>Design is a new liberal art of technological culture that has the capacity “to connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problems and purposes of the present (Buchanan, 1992).</td>
</tr>
<tr>
<td></td>
<td>Not Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Combination of Art and Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distinct from Art and Science</td>
<td></td>
</tr>
<tr>
<td>Disciplinary Perspective</td>
<td>Focus on function / fit</td>
<td>Designing is not a search for the optimum solution to the given problem, but that it is an exploratory process. The creative designer interprets the design brief not as a specification for a solution, but as a starting point for a journey of exploration (Cross, 2011).</td>
</tr>
<tr>
<td></td>
<td>Focus on aesthetics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Focus on communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design as search</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design as exploration</td>
<td></td>
</tr>
</tbody>
</table>

The first identified dilemma is the Complexity dilemma. A clear conceptualization of design prevents the flexibility, adaptability, and evolution inherent in the creative practice of Design. Designers and design scholars avoid the ridged definition, which leads to the mythification of Design. Similarly, the Zeitgeist dilemma produces fuzzy boundaries as Design depends on historical and cultural context and is constantly evolving. Different technological possibilities and cultural values at specific points in time and place influence and determine the design practices. Further complexity is that Design is both an everyday activity and a professional practice, making the boundaries to define Design fuzzy. This complexity is the Expertise dilemma of who designs. Another theme is the Identity dilemma. Designers and design scholars debate that Design is neither Art nor Science or a combination of both. Related to this theme is the Disciplinary Perspective dilemma. The rational technical disciplines emphasize process, function, and goal orientation, while the humanistic artistic disciplines emphasize exploration, culture, aesthetics, and needs. These different dilemmas produce a fuzzy boundary for defining Design.

5 Discussion: What is Design?
The investigation of the semantic core and peripheral of diverse Design definitions revealed diverse conceptualizations within the definitions. Therefore, we are using a metaphor for visualizing the findings through a method used to measure peripheral vision to illustrate the semantic core and peripheral of Design definitions, as illustrated in Figure 2.

The semantic core incorporates the shared words, such as making, plan, and process, and the peripheral is represented by the dilemmas that make it challenging to define a clear boundary for defining Design.

![Figure 2](image)

**Figure 2.** A visual metaphor for the core and the peripheral of the definition of Design. The word-groups are listed according to their frequency, as shown in Table 4. The word groups with a higher frequency represent the “core,” while the “peripheral” is represented by the themes that prevent a clear definition of Design.

### 5.1 The Core: Shared conceptualization of Design

We interpreted the central conceptualization and shared keywords, which allowed explicating a semantic core of meaning and definition of Design. The first aspect indicates that Design is a set of specific ‘activities,’ a ‘way,’ and a ‘process.’ The second aspect is that designing incorporates various embodied cognitive activities, such as ‘crafting,’ ‘meaning-making,’ and ‘problem-solving.’ These activities have the aim to establish ‘new’ and ‘purposeful’ ‘change.’ The last aspect is that Design is not an ‘end’ by itself but a ‘means to an end’ to satisfy ‘needs’ and nurture ‘nature.’ These word-groups do not provide a general definition. However, they provide the corresponding bundles of interpredictable attributes (Rosch & Mervis, 1975). These attributes span epistemological (ways of knowing) boundaries and capture the fundamental embodied human cognitive activity and practice of Design.

#### 5.1.1 Activity, way, and process

At the core, design is an activity, way, and process, representing different ways of designerly knowing (Cross, 1982). Tomás Maldonado expressed that “Industrial
design is a creative activity whose aim is to determine the formal qualities of objects produced by industry” (Verganti, 2009). It is a “generative, transformative act” (Goldschmidt & Porter, 2004). This “generative activity is about creating order” (Sara Turnbull). This view of design as an activity is grounded in a pragmatist epistemology (Dewey, 1938). Design also incorporates a specific way of looking at the world. “[D]esign is really a way of looking at the world with an eye toward changing it” (Warren Berger). “It is a way of creating art that functions” (Michael Vanderbyl). “[D]esign is all about ‘defining a sensible way of building’” (Ove Arup). Such a view of design, such as sensemaking, is inherent in an experiential and constructivist epistemology (Arnheim, 2004; Piaget, 1981). Lastly, the process view of Design is based on a structuralist epistemology (Selz, 1922; Wallas, 1926). “[I]t is about the process of turning ideas into reality” (Gorb & Dumas, 1987). “Design is the creation process through which we employ tools and language to invent artifacts and institutions” (Owen, 1998).

5.1.2 Diverse activities. Design incorporates creativity, planning, forming, crafting, making meaning, sense-making, creating order, analyzing, and solving problems. “Design is the creative thinking process of delivering innovation” (Sohrab Vossoughi). It is “deliberate, purposive planning” (Ken Friedman & Erik Stolterman). It “is a matter of composition, of the integrated relation of all constituent parts in forming a whole” (Dewey, Boydston, & McDermott, 2008). “[W]here craftsmanship joined with technology through the use of design” (Florence & Hans Knoll). “[D]esign is making sense [of things]” (Krippendorff, 2006). It “is not about an aesthetic style, but problem-solving” (Robby Johnston). Design incorporates many complex embodied cognitive activities (design thinking) and actions (design practices) in generating change.

5.1.3 New and purposeful change. This change is new and purposeful. “It’s about creating new choices, not just choosing from things that already exist” (Tim Brown). “The central concern of Design is ‘the conception and realisation of new things’” (Cross, 1982). It is “a plan for arranging elements to accomplish a particular purpose” (Ray and Charles Eames). Milner Gray states that “design is an intention, purpose, plan and that good design is therefore by inference, where such plan has been well conceived, well executed, and of benefit to someone” (Moggridge, 2007). Such new and purposeful change is an end accomplished by a means.

5.1.4 A means to an end. Design is a means, including technology, objects, and things, to establish an end for the living world. “To design is to plan and to organize, to order, to relate and to control. In short, it embraces all means of opposing disorder and accident. Therefore, it signifies a human need and qualifies [hu]man’s thinking and doing” (Josef Albers). “Design is the response to a human need” (McKim, 1959). It is also “a mental project or scheme in which means to an end are laid down” (Collegiate Dictionary as cited in Goldschmidt, 2014). Underlying any design outcome (means) is a purpose motivating and leading designers, which can be the designers’ own needs (self-centered) or tensions in the environment or others’ needs felt by the designers (self-actualized) (Arnheim, 2009; Auernhammer & Roth, forthcoming).

5.2 The Peripheral: Fuzzy boundaries of defining Design

Clear boundaries of the meaning of Design are complex because of various dilemmas. Designers are reluctant to set clear boundaries to avoid limiting the creative practice, design is context-dependent and constantly evolving, and design is a fundamental human activity enacted by all people. This primary activity is inherent in both Science and the Arts, making it hard to distinguish it from both. Furthermore, different disciplines have cultivated their defined design paradigm. These dilemmas make it difficult to define a clear boundary of what design is.

5.2.1 Complexity dilemma. The first dilemma of establishing a universal definition for Design is the complexity dilemma. Designers and design scholars avoid providing clarity on the definition of
Design to avoid limiting designers’ creativity and its evolution. However, this ambiguity led to the mythification of Design. Nelson (1965) expressed that “[industrial design] is the only profession that became a myth before it reached maturity.” However, “designing is not a mysterious process, […] but it is complex” (Cross, 2011). “Designing is a complex and intricate task. It is the integration of technological, social and economic requirements, biological necessities, and the psychophysical effects of materials, shape, color, volume, and space: thinking in relationships” (Moholy-Nagy, 1969). Because designing requires considering these diverse aspects, no single explanation and process incorporate all aspects.

5.2.2 Zeitgeist dilemma. Design is also temporal context-dependent, and the artificial and cultural context is constantly evolving. New technology and cultural values produce new design activities and possibilities. Designers and design scholars constantly integrate new approaches to expand their creative practice. It changes with new technological possibilities. Owen (1998) expressed this as follows: “Design is the creation process through which we employ tools and language to invent artifacts and institutions. As society has evolved, so has our ability to design.” It also evolves through changing cultural values and emerging needs based on changing environments. “Design is reflective of its social, historical, and regional culture of production. This is manifest in specific cultural influences on the designer” (Micklethwaite, 2002). Similarly, Horst Rittel emphasized that “Design is directed towards a particular situation which is historically unique” (Protzen & Harris, 2010). Thus, design is a continuously evolving practice as newly designed technologies provide new possibilities and produce new emergent needs.

5.2.3 Expertise dilemma. Design is a profession and everyday activity and attitude (Lawson, 2006; Lawson & Dorst, 2009; Moholy-Nagy, 1969). This expertise dilemma exists because of the fuzziness of who designs. Lawson (2006) expressed this paradox of design as follows: “Design is now clearly a highly professional activity for some people, […] And yet design is also an everyday activity that we all do.” The discourse on who designs makes it problematic to establish a clear boundary. For example, Moholy-Nagy (1969) expressed that “Designing is not a profession but an attitude.” “[D]esign is basic to all human activity” (Papanek, 1973). Such an attitude can be learned and enacted by everyone. Another argument is that “design is too important to be left to designers alone” (Gorb & Dumas, 1987). However, Cross (2011) expressed that “everyone can design and expert designers exercise very developed forms of certain tacit, deep-seated cognitive skills.” This discourse implies a spectrum of design from everyday designing to professional design for specific domains. Like Design, creativity is defined within the spectrum of everyday creativity and culture-changing creativity, the capital C creativity (Kaufman & Beghetto, 2009). Underlining professional design is the development of specific cognitive skills and attitudes, i.e., creativity, which is combined with domain-specific knowledge of a specific domain, such as architecture (environment and buildings) or industrial design and engineering (products). Amabile (1996) discusses the same attributes of cognitive processes, domain-specific knowledge, and motivation in general creativity. From this perspective, creative or design thinking of converting parts to a coherent whole is the shared denominator among everyday design activities and diverse professional design disciplines with domain-specific know-how.

5.2.4 Identity dilemma. Designers and design scholars distinguish Design from Art and Science as either a combination of both, or a distinct paradigm. This dilemma generates fuzziness in defining Design. Scholars expressed that “design is the marriage of art and science” (Micklethwaite, 2002). While others emphasized that “design should not try to find a spot between engineering and art, but should be a separate discipline other than engineering and art” (Katz, 2015). Similarly, Lawson & Dorst (2009) expressed that “design is always to some extent grounded by functionality, […] art is not functional; it does not need to make ‘sense.’” Like with Art, Design is distinguished from Science. “Design is the opposite of the traditional scientific explanation” (Gero, 1990). However, Design is inherent in Science and Art. The scientist designs the scientific experiment to generate new
knowledge that brings about changes in the scientific discourse, while the artist generates and conveys new meaning through “designed” artifacts. From an evolutionary perspective, humans designed tools to satisfy needs before they produced art or developed rigorous knowledge systems. “Design is, if we look at it in this broad sense, one of the primary characteristics of the human race. It is the foundation of our adaptivity that we can learn about situations and plan for them in the future. It is the foundation of civilization, of art, of science” (Protzen & Harris, 2010). From this perspective, Art and Science are the offspring of Design as both inherent the human activity of designing. Design is fundamental in all human activity. This identity dilemma makes it impossible to define a clear boundary of what design is.

5.2.5 Disciplinary-perspective dilemma. Design is “to contrive for a purpose,” makes it equally the property of engineers, architects, advertising, artists, and dressmakers” (Dreyfuss, 1955). Design includes material objects, verbal and visual communication, organized activities and services, and complex systems or environments for living, playing, working, and learning (Buchanan, 1990). Each discipline produced its predisposed perspective on Design. The disciplinary perspective inherent in visual and graphic design is the focus on communication. “[Visual Design] is concerned with finding the representation best suited to the communication of some specific information” (Mullet & Sano, 1995). Service design focuses on “intangible experiences that reach people through many different touch-points, and that happens over time” (Moggridge, 2007). The perspective inherent in more technical rational disciplines emphasizes function and procedure. “Design is meant to enhance some critical procedure or function” (Norman, 2007). In this perspective, aesthetics serves as a support for the performance of the procedure and function. In contrast, the humanistic perspective focuses on human values, such as needs. “Design is the response to a human need” (McKim, 1959). “It is the making of plans to shape the world to our needs” (Protzen & Harris, 2010). “Design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange” (ICSD as cited in Verganti, 2009). Another perspective is market orientation. Carlotta Bevilacqua expressed that “Nowadays, every market-oriented company has understood that design is an advantage. As a result, all companies can use it. Design is not only a way to give a nice form, but it should rather anticipate a need, proposing a vision” (Verganti, 2009). In organizational design, design is seen as “the diagnosis of misfits and the action to fix them” (Burton, Obel, & Håkonsson, 2015). In this perspective, design matches internal to external environments. Each discipline has its own perspective that makes it impossible to set clear boundaries of the meaning of Design.

6 Conclusion and implications

The research presented in this paper explicated that the definition of Design is viewed from diverse perspectives. While shared words provide a family resemblance among different epistemological and disciplinary perspectives, it does not clarify what design is. The identified shared conceptualizations and boundary dilemmas have several implications for design thinking, research, and practice.

6.1 Implications for Design Thinking

The debate of definitions on the “semantic core” of Design is describing essentially productive or design thinking, the embodied cognitive activity of determining a meaningful or purposeful means within a specific situation, viewed from diverse epistemological perspectives (Dewey, 1938; Duncker, 1945; Eastman, 1970; McKim, 1980; Schön, 1963; Selz, 1922; Wertheimer, 1945). This human embodied cognitive activity of planning, forming, crafting, making meaning, sense, and order, and analyzing and solving problems brings new and purposeful change to situations and the world. Such
design thinking incorporates productive thought processes to make sense, meaning, and order of ill-defined and ill-structured design problems and situations (Auernhammer & Roth, forthcoming; Goldschmidt, 2014; Wertheimer, 1945). It requires many embodied productive thought processes incorporating various perceptual, cognitive, and physical activities, including analyzing situations and reorganizing parts into a new whole (Faste, 1994; Goldschmidt & Porter, 2004; McKim, 1980; Purcell & Gero, 1998; Rowe, 1987; Suwa & Tversky, 1996; Tversky, 2009). Such productive thinking can be an everyday activity as well as employed to solve open and complex problems, which requires diverse domain-specific knowledge. For example, productive thinking is part of designing scientific experiments (means) to collect and analyze data to advance the scientific body of knowledge (end) and generate an artwork (means) for the sole purpose of conveying meaning (end). It is inherent in designing illustrations, technology, spaces, and organizations (means) that empower people in their lives (end). This fundamental embodied cognitive activity of productive or creative thinking allows making sense of the world by designing it.

6.2 Implications for Design Research

This semantic analysis identified and discussed several boundary dilemmas of defining Design. These dilemmas have several implications for research. Research requires to construct clarity as otherwise examination and comparability are unfruitful. Referring to “design” without expressing the underlying epistemological and disciplinary perspective will result in blurry vision. We recommend that design researchers employ a strategy we call “un-naming.” Un-naming describes the activities, processes, and ways of looking at the world without referring to the “construct” Design. For example, researchers can refer to a specific professional practice to avoid the expert dilemma, outline their epistemological perspective to overcome the debate on the disciplinary perspective dilemma, and outline the specific context in which they examine “design” to overcome the Zeitgeist dilemma. Such a strategy will help to demystify Design. Furthermore, future research should advance this preliminary study by investigating a broader spectrum of Design definitions to incorporate a greater diversity of diverse perspectives. Such investigation can identify additional boundary dilemmas and a more comprehensive understanding of the essential semantic meaning of Design, providing further clarity.

6.3 Implications for Design Practice

The research outlined in this paper has several implications for practice. Design is a fundamental human activity in which professional designers bring unique abilities and domain-specific knowledge relevant for finding and solving specific problems and making sense in specific situations. Such practices will continuously advance with new emerging needs and challenges, new technological possibilities, and evolving cultural values. The disciplinary design practices developed over the last centuries may not serve as the necessary means to solve emergent challenges of limited resources, pollution, and social inequity. Therefore, there is the need to continuously “design” new design practices and education programs to enable a culture of design in which many people contribute to bringing about new and purposeful change. Otl Aicher (1991) expressed it best: “design transcends theory and practice and not only opens up a new reality but new insights.” With each new reality and new insights, new ways can be found to enact, professionalize, and advance the practices of design and its semantic meaning.

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What counts as design? No one right answer

Claudia Eckert\textsuperscript{a}, Chris McMahon\textsuperscript{b} and Martin Stacey\textsuperscript{c}

\textsuperscript{a} The Open University, Milton Keynes, UK, claudia.eckert@open.ac.uk
\textsuperscript{b} University of Bristol, Bristol, UK, Chris.McMahon@bristol.ac.uk
\textsuperscript{c} De Montfort University, Leicester, UK, mstacey@dmu.ac.uk

Abstract. What design is remains controversial. Views are shaped by people’s different perspectives, which depend both on the particular design disciplines they practise or study, and on the concerns and the theoretical and methodological concepts and tools of the intellectual disciplines they bring to looking at design. This paper looks at just how different some alternative views are and argues that the different types of design are too diverse to make agreeing on a crisp definition of design a feasible enterprise. Instead, we should accept that design is a family resemblance concept, and that different and seemingly contradictory views on what design is, can be valid. What follows from this is that we should focus cross-disciplinary studies on understanding the patterns of similarity and difference that connect different design fields, but do not apply to all types of design. Moreover, we should treat knowledge generation and problem-framing activities as legitimate and important parts of design.

Keywords. Comparative design research, definition of design, design practice, design process.

1 Introduction: The word ‘design’ and the goals of design research

The meanings of the terms ‘design’ and ‘designing’ and ‘designer’ – so important to so many people’s sense of who they are – have been the subject of decades of repetitive and seemingly endless debate (see Blackler et al., 2021). Can we end it, or focus it on a productive direction? We argue that ‘design’ has no one right definition and consider what follows from that.

In design research what is included in the term ‘design’ is approached from two fundamentally different angles. The first is “Everything that is associated to the design of an artefact”. According to this perspective, design is the process of creating plans for new artefacts or systems and may involve activities that in themselves would not be considered as design. The alternative view is to consider design as a distinct kind of human activity, restricted to the unique designerly activities involved in the process of designing (see Cross, 2006). As the call for the DTRS symposium states there has been an “expansion of what is understood as design (and design thinking), whereby many activities by professionals from different disciplines are seen as included in the term design”. This reflects the recognition that many fields not traditionally considered design disciplines address problems that resemble design problems and require methods used by designers; regarding them as design requires a broader view of what might constitute a designed artefact. Another view would be that the scope of design is defined by the distinctive knowledge possessed by designers and evidenced by their qualifications and participation in professional communities. Participatory design approaches have
increasingly involved users and other lay people in the design process – for some, this is as much an attempt to democratise the act of creation as an effort to get the user requirements right (see Luck, 2018). This would imply that design cannot be characterised by the knowledge a designer possesses. Over the last 60 years or so, design as a field of research and education has worked on establishing itself as an academic discipline. This has included attempting to define key characteristics and properties that all design processes share. However, this has proved difficult. To illustrate some of the difficulties, this paper draws on our studies of two industries: diesel engine design as a representative of traditional incremental engineering design, and sustainable fashion as example of an artistic craft-based domain. Both illustrate that design processes comprise many activities that would not intuitively be thought of as design, but, depending on the scale of the process, are carried out by designers. This raises the question whether these activities count as design and need to be included in the characterisations of design and be supported by generally applicable design methods. This paper argues that instead of trying to characterise design by what is common across all design activities, we should embrace difference between design processes to understand the rich phenomenon of design. It might therefore be more fruitful to think of design as a family resemblance concept, in the Wittgensteinian sense, where two instances do not necessarily share common features, but collectively all the instances covered by the term provide a rich and coherent picture. Only by taking a rich and inclusive view of design in this way can design research develop the nuanced support for designing in different situations that designers need in practice.

In recent years design research has pursued different goals. One aim of design research is to develop ways to support designers in their activities. To do this, we have to acknowledge that designers may spend only a fraction of their time designing, while also engaging in other artefact-development-related activities or working with people who engage in other activities related to the design of artefacts. Another aim of design research over recent years has been to find what is common across different traditional fields of design, despite huge variations between different design domains. Other researchers see design as a means to transforming our society and focus on what design should achieve, rather than what design is.

Regardless of the perspective in trying to understand design it is necessary to look both at the varied practices of design and at many different design processes. The practice might well be different from the rhetoric by which different domains present themselves; in this regard the rhetoric may not be helpful. Design domains with an origin in applied arts and crafts, such as graphic design or fashion design, often emphasise the creative aspect of their practice, in fact the designers often refer to themselves as “creatives”. By contrast, the discussion of complex technical products often centres on performance, cost, quality, safety, and reliability combined with focused innovation. Designers with a strong user involvement, such as in architecture or service design, often focus on user-centred aspects of design.

In section 2 we note the multiplicity of definitions of design and designing that have been proposed, and then introduce in broad terms some perspectives on design that illustrate the rich insights that have been arrived at by a wide range of design researchers. After a brief discussion of our empirical methodology in section 3, section 4 argues, drawing on our own case studies and experience of design, that synthesis, which is often thought of as the essence of design, is in practice remarkably elusive and that many designers carry out many important activities that have very little to do with creating new things, although they are an essential part of their work. Section 5 looks at how the boundaries of what we consider as design varies in different contexts. Section 6 argues that design is in fact a family resemblance concept and that what matters for something to count as design is often whether those who undertake the activity think of it as design. Section 7 draws out some implications for how we understand and use the concept of design. Section 8 concludes with a recommendation to action: to recognise and advertise the centrality to designing of analysis and knowledge generation.
activities and the people who do them; and to focus comparative design research on the patterns of similarities and differences between design in different fields.

2 Perspectives on design

Design – as the word is used in ordinary English – has fuzzy boundaries, which raises the question what should or should not be included in design. Typically, solving well defined problems, for example through the use of mathematical equations, would not be thought of as design. However, mathematics plays a very important role in many design processes and unsolved mathematical problems can be approached in a designerly way. Many people associate design with creating something new and thereby focus on the synthesis aspect of designing. Throughout the history of design research, the academic literature on design also offered a multitude of different complementary perspectives on design, which all capture important aspects of many design situations and problems, but do not fit others. Each perspective brings out facets of design that are extremely important in some fields, but much less so in others. The variety of perspectives is such that we hesitate to try to summarise them in a single short paper, so what follows here are only a few illustrative viewpoints; however, they are influential, and strongly flavour views of what design is. Although we observe that while research about the generic aspects of design processes across all different domains still continues (e.g., Daly, 2008; Reymen et al., 2006), the differences between design processes in different domains are however much less researched (Stacey & Eckert, 2010).

Herbert Simon called his well-known book on human-made systems “Sciences of the Artificial”. He distinguishes science, as concerned with what is, from technology, which is concerned with how things ought to be. He defined design as “to devise courses of action aimed at changing existing situations into preferred ones” (Simon, 1969/1996). Even after over 50 years of design research, the concept of design remains remarkably slippery. Fifty years ago, J. Christopher Jones’ influential book Design Methods (1970) listed a remarkably diverse collection of definitions; he wrote “There seems to be as many kinds of design process as there are writers about it” and we can say the same today. Writing about discussions on definitions of design over 20 years in a large email forum, Blackler et al. (2021), wrote “Despite robust discourse around relevant perspectives on design, the list discussions are and have been repetitive, with no significant progress made towards a consolidated definition of design”. The multiplicity of views is also intensified by the widespread use of the term “design” in everyday language. As noted by the system theorist Peter Checkland (discussing the related difficulties in defining the term “systems”) “there is no language available for serious discussion which is separate from everyday language … terms are fuzzy as a result of their unreflective use in everyday chat” (Checkland, 1999).

2.1 The emerging field of design

With the recognition that design as a professional activity shapes our world, it has been a subject of study for centuries, but it was in the 1950s and 60s that research into a theoretical understanding of the topic, and into methods and tools and other supports for design activities, really began to take off. From these early days, design was studied from a wide range of perspectives, with researchers coming from architecture, engineering, the applied arts, planning, computer science and other disciplines, and this has led to a multiplicity of views on the nature of design. The researchers came from different backgrounds and worked with different types of artefact. For example, the highly influential work by Pahl and Beitz (1977) came from huge experience with building specialist manufacturing equipment, that transforms inputs using a series of machines and machine elements, but is less well suited to highly integrated, complex and incrementally developed products like jet engines. Early theoretical
work on design has been strongly influenced by architectural design, for example in the work of Jones (1970), Schön (1983), or Akin (1986).

2.2 The rhetoric of design
The early research spawned a new emphasis on design in higher education as evidenced by the UK’s Moulton Report on engineering design education, advocating that design “should be a thread running through” courses (Moulton, 1976), and by new teaching programmes, such as the Open University’s Design and Innovation programme in the 1980s, supported by readers (such as Roy & Weald, 1986). A view of design that has emerged quite strongly in the 21st century, especially in public discourse, has been the association of design with creativity, and creativity with cultural products. The UK’s Cox Review of Creativity in Business (UK Government, 2005) proposed that “Design is what links creativity and innovation. It shapes ideas to become practical and attractive propositions for users or customers. Design may be described as creativity deployed to a specific end.” The UK’s Design Council has in recent years particularly highlighted the ‘creative industries’ as a driver for the UK economy (Design Council, 2018). The term was borrowed from the economist Richard E. Caves (2000), who used it to describe the subject matter of a study of the social and economic organisation of the production and marketing of art, focusing on the contractual relationships between artists and the commercial operations that act as facilitators and gatekeepers. Thus defined, the ‘creative industries’ included traditional design fields such as architecture and artistic design domains such as product design, graphic design, or fashion, as well as the creation of cultural artefacts such as advertisements, media, music, visual arts and books. This excluded engineering and much of software design because they have different economic models.

2.3 Design as/versus structured problem solving
In engineering there was a significant emphasis on the search for systematic, generally applicable approaches. Early engineering design theories, like the Theory of Technical Systems (Hubka & Eder, 1988) or Domain Theory (Andreasen, 1980), focussed on structuring products, relating design elements and their mapping to physical parts, and on the activities associated with their creation. Later theories like Axiomatic Design (Suh, 1980) also emphasised relationships between function and structure, advocating an alternation between the functional domain (derived from the customer needs) and the physical domain, but also placed a strong emphasis on the identification of axioms that were universally applicable such as the need to maintain the independence of functional principles. These approaches embody a view of design focusing on how decisions about what a product should do affect its structure and decisions about the embodiment affect what the product can and can’t do. George Hazelrigg (1998) put forward a view of engineering design as an application of mathematical decision theory, comprising a series of choices between alternatives that can be rationally elicited. The sequence of decisions may affect the result, and some decisions may need to be treated concurrently (Mistree et al., 1993). However, finding an optimal solution is rarely possible. In The Sciences of the Artificial, Herbert Simon (1969/1996) argued for seeing design as a rational problem-solving process applied to ill-defined problems, where designers act with bounded rationality (Simon, 1957). That is, the designers act rationally within the resource limitations of time and mental capacity that restrict their ability to gather information, explore problems and define optimal solutions, so they satisfice – settle for a satisfactory solution.

Design is not necessarily a structured and pre-planned process but is often an interactive engagement with the emerging design. Many analyses of design at different scales have drawn on Asimow’s

In *The Reflective Practitioner*, Donald Schön (1983) called this process “a conversation with the situation, where designers engage in two different kinds of seeing, “seeing that”, i.e., recognizing something, and “seeing as”, i.e., interpreting what they saw” (Schön & Wiggins 1992). Schön views designers as engaging in a process involving Naming, in which elements of the task are identified, Framing, in which elements of the situation are picked out and connected to construct the problem to be solved, Moving, in which the design is advanced within the current frame, and Reflecting, in which the design is evaluated before the next cycle begins. (The view is quite widespread that the Schön view is radically in conflict with the design-as-problem-solving view of Simon and followers, stemming from Schön’s own critique of Simon. We think it isn’t: this reflects a misinterpretation of Simon stemming from a lack of understanding of *The Sciences of the Artificial’s* radical abstraction away from a sophisticated understanding of the psychology of problem-solving; see Chua, 2009, who points out that the third edition of 1996 emphasises more the fluidity of design reasoning.)

Horst Rittel introduced the idea of a ‘wicked problem’ in the 1960s. Rittel and Webber (1973, p. 161) state: “The formulation of a wicked problem is the problem! The process of formulating the problem and of conceiving a solution (or re-solution) are identical, since every specification of the problem is a specification of the direction in which a treatment is considered.” Rittel and Webber were thinking of town planning, where problems are unique and have no definitive formulation or right answer or even clear endpoints, solutions cannot be tested and are irreversible, so the designers have one chance to get it right, and any change has serious consequences. Many later researchers and practitioners have viewed all design problems as ‘indeterminate’ and ‘wicked’; this is reasonable for town planning and systems engineering, not true of much of engineering, and absurd for fashion or knitwear or most of the ‘creative industries’. Buchanan (1992) influentially made this claim without connecting his arguments to any particular industry or type of designing. He sees design as thus in fundamental contrast to science, which doesn’t deal with radically indeterminate problems. The idea that design problems can’t be clearly formulated and subjected to rational problem-solving procedures has gained a lot of currency.

### 2.4 User-centred views of designing

Entirely different views of what designing involves emerge from fields and situations where the hard challenges come from understanding and meeting complex and non-obvious human needs. The term ‘design thinking’ has come to refer to a particular view and set of techniques for tackling design problems, especially when applied in fields not traditionally thought of as design. ‘Design thinking’ puts the interaction with users and figuring out user needs at the centre of design activities, and thereby de-emphasises the technical challenges in building complex systems. In his article with this title, Brown (2008) describes designing as an iteration between three pillars: *Inspiration, Ideation* and *Implementation*, with an emphasis on finding needs and opportunities and engaging with normal and extreme users throughout the process. The d.school at Stanford developed this into five phases (Plattner et al. 2009): *Empathize, Define, Ideate, Prototype, Test*.

In software development, user-centred design, organizing the design process around procedures and techniques for understanding user needs, predates the design thinking movement. Participatory design (Sanders et al., 2010), which is also closely related to cooperative design and co-design (Sanders & Stappers, 2008), goes back to the 1970s. It advocates bringing the user as an active participant into the design process including the generation of new ideas. Being part of the creation process also increases the willingness of users to accept the eventual result. Participatory design deemphasises the technical aspects of design, which designers carry out almost behind the scenes.
Products however rarely act in isolation but are embedded in user processes with other products. The design of Product-Service Systems (Baines et al., 2007) emphasises that the service provided depends on the characteristics of the product or system that enable service provision and involves the concurrent design of products and services. According to Mont (2004), “PSS is a system of products, services, supporting networks and supporting infrastructure that is designed to be competitive, satisfy customers’ needs and have a lower environmental impact than traditional business models”.

2.5 The granularity of views on design

Many of the differences in the perspectives on design arise from differences in the granularity in which design is studied, ranging from individual design activities, such as an episode in which a textile designers would sketch out the pattern for a fabric, to the design of systems of systems, such as new urban transport systems. This is a not only a matter of the granularity of the tasks in focus, but also of their description. As Wynn and Clarkson (2018) point out, models of design processes, which characterise design or are used to prescribe how designing is carried out, fall under three categories: “Micro-level models, which focus on individual process steps and their immediate contexts; Meso-level models, which focus on end-to-end flows of tasks as the design is progressed; Macro-level models, which focus on project structures and/or the design process in context”.

Of course, designers often operate at different levels of detail within one activity. For instance, Buchanan (1992) argues that design operates on two levels: a general level, on which the designer forms ideas and hypotheses about the nature of products or the artificial word; and a practical level, being embedded in specific circumstances.

2.6 Disciplinary perspectives on design

Analyses of designing taking a cognitive perspective typically consider how designing works at a micro-level, whereas sociological studies and product or organisational views typically consider activities at a meso-level or a macro-level. The cognitive perspective sees design as a sequence of mental activities or types of reasoning steps; much research has focused on identifying mental actions and the structure of design reasoning (for instance, Akin, 1986). The idea that design is a unique mode of thinking is widespread and influential. Cross (2006) argued, based on interviews with expert designers, that designerly ways of thinking are exploratory, emergent, intuitive, reflective and embracing of ambiguity. This perspective fits with concerns for creativity in design, where creativity is related to novelty of the end results or the process of generation (e.g., Boden, 1990). Theoretical approaches to understanding creative thinking such as conceptual blending theory (Fauconnier & Turner, 2002) or the reinterpretation of ambiguous information (Schön & Wiggins, 1992) place synthesis at the heart of creativity. These influence the studies of design that draw on them.

3 Empirical methodology

Our own empirical research is grounded in a cognitive perspective but has focused on meso-level analyses of design processes. The paper draws primarily on two very different sets of studies: diesel engine design (Eckert et al., 2004; Flanagan et al., 2007; Eckert et al., 2019); and recent studies of designer-led micro businesses in the fashion industry (Black et al., 2021). Diesel engines are an example of highly technical and incremental products, that has been optimised for efficiency and reliability, but also have been subject to significant innovations over the last 30 years to decrease their environmental impacts. Diesel engines are designed by large teams often involving hundreds of
specialist engineers. By contrast the designer-led fashion businesses were very small and the designers not only designed the garments, but also ran the businesses and organised the production. For these studies we conducted interviews with designers and followed their processes over several months. We have studied both sectors in multiple companies for 20 years and therefore can also observe long-term changes in industrial practice. We also draw on our much earlier studies of the relationship between artistic and technical design in the knitwear industry (Eckert, 2001; Eckert & Stacey, 2003), on our studies of information use in design processes (Lowe et al., 2004; McMahon, 2021) as well as observations of parts of the construction industry (Eckert et al., 2012; Jones et al., 2018) and the second author’s early experience of working in diesel engine design.

4 Finding the core and the boundaries of design

Design practice is extremely varied within different design domains and across domains. This section draws on our empirical work to bring out some of the differences between design practice in different contexts. Many insights into designing have been gained through detailed study of design episodes involving individual designers or small teams of designers, as exemplified by the original Delft protocol studies (Cross et al., 1996). In these studies, designers have been given specific design assignments and have been studied up to the point where they have generated a concept. This experimental set up also favours the study of synthesis tasks, as designers have little time to explore the problem, usually no access to users or clients; and little time to evaluate their solutions in detail. This can give a very misleading picture of where the effort and significant contributions are in developing new artefacts.

In the section we will argue that many designers spend only a very small fraction of their time creating something new or different, and rather more on making sure they can meet new requirements with minimal changes. The contrast between the different design examples also illustrates that design happens at different scales, from a large team working together, so that each individual has a specific role, to small processes where a single designer carries out most of the activities.

4.1 The elusive act of synthesis

At a sufficiently abstract level, professional design processes can be mapped onto a pattern of analysis, synthesis and evaluation (see Asimow, 1962). However, when studying professional practice, the moments of synthesis can be difficult to track down. The product or system architecture defines the mapping between functions and components and the interfaces between components (Ulrich and Eppinger, 1995); and thereby incorporates many of the fundamental design decisions. This makes system architecture design a prime candidate for study of synthesis in engineering design.

We (Wyatt et al., 2009) analysed how the system architecture of a diesel engine came into being. In the early 2000s the first author was invited to a large meeting, where the conceptual design of a new engine generation was presented by the conceptual design team in a diesel engine company. Based on this experience, the first author and her colleagues assumed that the company would go through a distinct activity where the system architect would design the system architecture. While this had been the case in the company for earlier generation engines in the 2000s, system architecture design was no longer a recognisable process. Through a series of interviews, it become clear what information was required to develop a system architecture and at which point the system architecture was established. However, when and how the system architecture was designed was strangely elusive. Through the analysis of the interviews, it become clear that the system architecture emerged as the by-product of a requirement cascade, where the company first assured that they could meet regulatory performance requirements, and then focussed on a prioritised list of bundled requirements (see Wyatt et al., 2009). Diesel engines are highly incremental products in which the fundamental solution principle remains largely invariant, but developments are made in embodiment – for example in part dimensions and
materials – and in components to deliver secondary functions such as fuel injection equipment and emissions control. They are often designed through the minimal amount of modification necessary from past designs but have to meet very stringent emissions regulations in each product generation. The company starts with tests of existing engines, and of modifications to them, to establish whether they can meet legally binding emission targets (Tahera et al., 2019). At the same time, they also try to minimise the ‘newness’ of the engine, in terms of newly designed components or existing components deployed in a new context. Very often constraints will be imposed by the production tooling required to make the engines, so things like bolting patterns or key dimensions may be retained. For existing components, the company also knows that the components are working reliably. Parameters of the reused components are entered into the requirement cascade as constraints on the performance calculations in the cascade. Through this process the system architecture is largely inherited from the previous product generation.

Synthesis can also prove difficult to pinpoint in the work of designer-lead fashion businesses. The “Rethinking Fashion Design Entrepreneurship: Fostering Sustainable Practices” project studied over 25 such fashion businesses in the UK (Black et al., 2021). The ‘fast fashion’ culture of recent decades has become highly unsustainable and many fashion designers and other industry experts see the industry as fundamentally broken for this reason among several others (Black, 2012). The fashion businesses, the projects studied, were largely set up by people with fashion design degrees, who wanted to make a living in their chosen profession in a way they could combine with their consciences. They aimed to produce garments that were environmentally sustainable and produced in an ethical way, while also being financially viable. In fashion there is also an element of cultural sustainability, where businesses want to maintain or connect to traditional garment types or production methods. The majority of the businesses studied were micro enterprises where the designers worked alone or with a small team of full-time or part-time staff. The survival of many small businesses is based on finding their niche in the fashion system. In some cases, this is centred around a specific product or small range of products, where the original designs are rarely updated. Designing garments only took a small fraction of their time for most of the businesses. Most designers were occupied with running the businesses and carrying out a multitude of business functions. A lot of time is taken up by organising production for the garments and dealing with sales and other customers facing activities.

Unlike large fashion brands, small fashion businesses tend not to renew their collections regularly. Rather they try to follow customer demand and keep designs that sell well in their ranges and replace designs that have either sold out or are not selling well. The successful businesses proved to be agile and adaptable. For example, several designers produced face masks in the Covid crisis using stock fabric. Others engaged in short term collaboration with designers with complementary expertise as a way of broadening their sources of inspiration and customer bases. Much of their creative energy goes into finding business models that enable them to operate in the fashion industry while being sustainable, finding ways to engage customers and transforming the fashion system. These fashion designers see themselves as designers and as “creatives”, but the generation of new product designs only takes a tiny fraction of their time.

4.2 Design at different scales

The two design processes in the previous section are happening at very different scales. While the design of an individual garment takes a single designer a matter of days, including the creation of samples, the design of a diesel engine occupies many people across a supply chain for some years. A diesel engine is also only a component of a product, such as a tractor or a truck. The products themselves operate as parts of systems and of systems of systems. A truck is part of the wider...
transport system and has to interact with other products or systems that are also part of the transport system, for example when it is unloaded or uses a ferry.

A garment is also not designed in isolation. The designer creates multiple designs either as parts of a coherent collection, as typical high street chains would do, or when they see a gap in their offering. This depends on the garments offered by competing companies and on the wider development of fashions. In fashion design an individual designer would need to understand this broader product context, whereas in engineering this would be split into many different activities carried out by different people. Whether all of these activities are included in the design is a matter of where the boundaries are drawn. Maybe in fashion one would intuitively include the research and understanding of the wider product context and market in design. While engineers need to understand the state of the art and the competition, many of these activities would be carried out by a marketing department.

![Diagram of the design process](Figure 3. Disciplines throughout the design process. From Eckert & Clarkson (2004))

The development of products involves a wide variety of actions that we would not intuitively include in design, carried out by experts from different disciplinary backgrounds. To illustrate, Figure 3 shows some of the disciplines involved in the course of the design of a complex engineering product. For example, the market research and trend analysis would be carried out in a sales or marketing department. Basic science, for example for new materials, would be carried out by scientists. The diesel engine company studied by Wyatt et al. (2009) typically centralises the R&D for their engines across the parent company and works with universities on the underlying science, so that only technology at a fairly high technology readiness level (see Mankins, 1995), i.e., technology that has been tested on engines, would be considered in the product development process. Would R&D be included in the design process? We might argue that there is design occurring in R&D, but R&D is typically not focussed at the development of a specific engine, so maybe it is not part of any specific design process. However, the research of the fashion context and many activities in the early stages of any fashion design process are not garment-specific either, yet they are recognised as a vital part of designing (Eckert and Stacey, 2003).

What designers include in the term design is also fluid depending on the context. For example, when fashion designers are asked to talk about the design process of a specific garment, they often start with sketching a specific design or looking for a specific source of inspiration. However, when they talk about their activities in general, it becomes clear that researching fashion trends or materials is a very
important part of their process, and that they come up with many ideas while they are carrying out
general research.
In all these cases we find that the designers are engaged in many activities that do not fall under the
cognitive definition of design. Fashion designers in high street brands usually spend a few days to
design their collection and then spend many months sampling and refining their products and setting
up the production for them. Small independent designers spend a lot of time running their businesses,
finding premises, getting grants, finding suppliers, writing invoices, marketing their product, to name
a few activities. They interact with their customers and suppliers and spend an increasing amount of
time on social media informing their customers about their businesses and values.
The range of activities carried out by the fashion designers, versus the high degree of specialisation of
the engineering design process is not an inherent difference between the domains, but between
working in organisations at a different scale. In small and often specialised engineering firms the
engineers also carry out a wide range of different activities including design and business tasks.
Conversely large fashion companies also have highly specialised designers who largely work on
specific tasks, and consequently do more designing.

4.3 Different roles of a designer
Even when the focus is placed on the development of a specific product, there are many activities that
that might or might not be counted as designing.
When the second author worked as a Design Engineer in a different engine company in the early
1980s, there were four groups of employees in the Design Office:
(1) Designers, who did the actual scheme development for the design work of the company – layout
drawings when he first worked there, then developing into CAD models of the artefact.
(2) Design Analysts, who carried out the calculations on the emerging designs – largely stress and
vibration analysis, some thermal.
(3) Design Engineers, who did a variety of work in the office – they could do some simple design
work, and design analysis, but mainly were collecting data, writing design guides, meeting with
clients, managing information resources etc. He was a Design Engineer.
(4) Design Draughtsmen (and it was all men then) who prepared the detail drawings of parts and
assembly drawings, from the layouts prepared by the Designers.
In addition, the company had Development Engineers who advised the Designers on parameters to
choose, especially for combustion systems, and did the development work on prototypes – including
combustion systems development (injection settings etc.) and durability testing.
This distinction still largely holds. A small group of (conceptual) designers oversees the development
of the system architecture, where the functions the product needs to carry out are mapped to specific
components and the interfaces between the components are defined. This was one of the teams we
studied (Wyatt et al., 2009). They really understand the users and, maybe more importantly, what
different types of users would wish to do with their engines, such as repair them with equipment and
clothing that impose the need for access space around parts. The modern equivalent of the Design
Engineers are component specialists, who become experts in particular subsystems, such as pistons,
and design these for multiple product generations, usually by making small but significant tweaks to
existing designs. Very often such specialists also interact with specialist parts manufacturers e.g., for
pistons, fuel injection equipment, bearings etc. The majority of their time is spent understanding how
their component needs to behave under particular circumstances and how it is likely to behave. They
analyse their components, their interfaces to other components and their role in other products through
the product platform. For each product generation the time they spend modifying the CAD models
might only be a matter of hours. The other role the Design Engineers carried out was the interaction
with customers; the modern company has given this role to application engineers, who handle the direct customer interaction and understand their customers’ products, needs and preferences. These are typically engineers by background who understand the significance of elements of the product, can explain it to customers and can negotiate with customers what can reasonably be accommodated for the engine.

At the diesel engine company where the second author was a Design Engineer, only the Designers (and to some extent the Draughtsmen) were actually doing the designing in the sense of creating the plans for an artefact, but all of the four professional groups in the Design Office, and Development Engineers and more, were involved in the design process. The role of the Design Draughtsman has largely disappeared as engineers make their own CAD models. However, the detailed design of many components from bearings to pistons, fuel injection equipment and turbochargers will be outsourced to suppliers, and design consultancies are also active in this field. The detail design of the product is also often changed by manufacturing engineers to suit the production process.

The group that has become much more influential, in the meantime, is the Design Analysts. Modern diesel engine design often starts with an analysis of the previous design and virtual or physical tests to see whether the desired performance can be achieved (Tahera et al., 2019). Through the entire product development process, the emerging design is analysed and simulated to understand its properties, typically making use of very sophisticated computational analysis tools. These engineers focus on all aspects of the behaviour of the engine, including thermal, stress and vibration analysis. Physical test and development are nevertheless still important, especially for such properties as durability and emissions performance, because until the product can be demonstrated to meet certain requirements, like emissions, the company cannot legally sell it.

In most engineering companies the analysis of the market, the logistics and the sales operations are carried out by the business functions in the enterprise. By contrast the fashion designers in the small sustainable businesses also had to take these roles on themselves. Even if they had staff who carried out the activities, these staff members also often had a design background.

5 Examples of changing boundaries of design activities

The previous section illustrated the range of activities carried out by designers, which further raises the question what a designer does. We can go back to J. Christopher Jones’ (1970) distinction between designing as the production of representations of the artefact and designing as contribution to the change in man-made things. In the narrower sense, designing is a small part of the designers’ activities. In the broader sense, they are designing much of the time. However, even if we are including everything a designer does under design, the boundaries are still fuzzy and constantly shifting. The above example of the diesel engine design also illustrates the changing boundaries of engineering design tasks. In the 25 or so years between the two diesel cases, the emphasis in design practice had shifted to some extent from designing the components to analysing the behaviour of the product mathematically and computationally. This section looks at two examples of these shifts, where other areas of experience, mathematics and customer relations, are brought closer into the design process than ever before.

5.1 Engineering and mathematics

The relationship between engineering and mathematics is changing as engineering becomes more driven by analysis. To minimise risk and maximise the reuse of existing components and subsystems, engineering companies design their products around key performance equations or models so that parameter values are cascaded through different levels of design, such that the form of the product is
to a large extent the response to performance equations and input constraints (see Eckert et al., 2012). This changes the skills profile of the engineers from many engineers having a holistic understanding of the product to engineers with a very high degree of numeracy and good computational skills but often a less well-developed ability to imagine and anticipate the behaviour of the design. Another shift away from traditional engineering to data analysis has already begun (see Isaksson and Eckert, 2020). Engineering companies collect a huge amount of data about their products. By the beginning of the century, diesel engine companies (for example) had already accumulated large quantities of warranty data from all of their past engines, which they tried to analyse to understand failure patterns. At the time this could be frustrating. It also took a long time to accumulate data, as faults in highly durable and robust products take a while to occur. This left the companies with a lot of data on old and therefore not particularly relevant products and not enough data on recent products. However, developments are taking place in two respects: analysis and simulation software and hardware is improving, and better, smaller and cheaper sensors enable the companies to gather much more data. The former means that trade-offs, design margins and uncertainties can be better understood and accounted for, while the latter means that the performance of real engines may be better understood, and feedback may be gained on the capabilities of analysis and simulation models (although what it is possible to sense may not always be what it is important to try to measure). The increased data collection will also mean that data analysts, who may have little understanding of the engineered products, will need to be employed, and data analysis will increasingly be a central part of design.

5.2 Fashion design and customer relations

The small fashion businesses studied by Black et al. (2021) have more and different interactions with their customers. Traditionally designers have studied the products of other designers and positioned their products in relation to these. The customers select the products that they liked out of the wide offering on the market. As concern for the sustainability of textiles is growing, some customers want to find out more about the companies they buy from, so that the designers find themselves spending time generating blogs or posting on social media about their designs, their values and their ideas. Designers see reaching out to the customers and educating them about sustainability as an integral part of their design activities and their contribution to changing the fashion system they want to change. They aim to build a relationship with their customers and respond to the customers wishes and desires to increase the time that customers wear garments and also the customer’s bond to the fashion brand. This becomes part of understanding needs and constraints on the designs. Interaction with customers on the design of specific garments has always existed (think of a traditional tailor), but the deeper interaction around the values and processes of brands is new. The customers are engaged in tasks that would traditionally be done by the designers, but does this then make them designers?

5.3 The boundaries of design

The scope of the words ‘design’ and ‘designing’ and ‘designer’ are increasingly in conflict. Our preferred definition of ‘designing’ is the creation of a plan for an artefact. Our everyday linguistic intuitions tell us that the synthesis steps of making moves in design space by envisioning new design elements is central to this, but that does not reflect the reality of design practice, where the development of understanding of the design problem is often crucial and sometimes the central challenge, and the development of understanding of the behaviour of proposed designs is frequently the most difficult and time-consuming part of the process. Making actual design moves in terms of specifying geometry through drawing or modelling may be comparatively trivial. For example, the
diesel engineers, who aim to carry as many parts across from one product generation to the next as possible (see Eckert et al., 2012), spend most of their time analysing whether the component could withstand altered conditions in the engine, e.g., higher temperatures or increased vibration. They also need to check all interfaces the components have to assure that modifications to the connected or adjacent components do not affect their component. In addition, they need to make sure that the component will still work under altered use conditions. After these evaluations they might make minor changes to features of the component or a particular interface, or just sign the component off to go to testing. For another example, the fashion and knitwear designers we have studied put a lot of effort into understanding the space of acceptable fashions and how to position their designs within it, and finding sources of inspiration, to construct the constraints that guide their designing (Eckert & Stacey, 2003; Stacey & Eckert, 2010.) As Vincenti (1990) pointed out, knowledge generation activities are central to how engineers produce new products; rather different knowledge generation activities are crucial for fashion and knitwear.

6 Design as a family resemblance concept

Throughout this paper we have highlighted different aspects of design and brought in different conceptualisations of design. The readers of this paper probably have their own examples they draw on when they think about design, which are very different from ours; and will agree with some of the definitions we cited from the literature on not others. Everybody who has studied design or is interested in design sees it through his or her own lens, and therefore sees different patterns and characteristics in design. In this section we will argue that these different personal notions of design can be entirely valid, because they all add to the rich picture of design and agreeing on a definition of design in terms of necessary and sufficient conditions has proved an infeasible enterprise.

Wittgenstein points out in *Philosophical Investigations* (1953) that we frequently use single terms to denote a range of concepts that overlap in their uses. In some cases, no single characteristic is shared by all usages. He points to the example of “game”, which we often think of in terms of winning or losing, but also covers a child playing with a ball. As in a family, some characteristics are shared with some members but not others. Yet putting all together we can see the resemblance across a family. In Wittgenstein’s conception of communities of language users, the concept is determined by usage with no standard of correctness over and beyond this. It follows that a requirement of understanding a family resemblance concept is that there must be intersubjective knowledge of its exemplars.

Many ill-defined concepts, such as power (Haugaard, 2010) or partnering between companies (Nyström, 2005) are defined in slightly different terms by different writers. Putting all of these definitions together provides a rich picture of the phenomenon. Ward and Scott (1987) point out that we learn family resemblance concepts both in an analytic mode where properties are analysed and extended and in a holistic mode according to global relations of overall similarity. Similarity, which is ultimately reducible to shared features, plays an important role in learning and establishing categories, but we are flexible in our similarity assessment and allow exceptions to our expectations (Goldstone, 1994).

Design is also such a family resemblance concept, that we learn from a sequence of experiences of uses of the word, where everybody has a slightly different understanding of what is meant by design. The examples have shown that there is very little that is shared across the activities that designers at the extreme ends of the spectrum carry out. Some people who think of themselves as designers might spend their time in highly mathematical analysis tasks, whereas others might be mainly engaged in customer interaction. Many are occupied with managing other designers. However, every designer shares many tasks and attitudes with many other designers, just not necessarily with all. We also have to accept that the activities that people called ‘designers’ engage in might not have one defining
characteristic making what they do designing. Designers in a wide range of fields perform very similar activities – at least when viewed from a sufficiently abstract perspective. But designers at the extreme points may not have activities in common, making ‘designer’ a chain concept – where each use shares many features with to its neighbours and fewer and fewer with others. However, the notion of design as a family resemblance concept allows for this.

Different disciplines describe design in different ways and emphasise different elements and activities, for example fashion designers would emphasise placing their work in the context of other designs, expressing the Zeitgeist and increasingly the need for sustainability, whereas product designers might stress user needs and desires, and engineers might focus on performance and safety. There is an element of rhetoric in how different design domains represent themselves, whereby artistic design domains tend to emphasise the novelty and creativity involved in their design whereas engineering designers try to emphasise their trustworthiness and rigour. Of course, rhetoric is inherently slippery, and people don’t say the same things all the time.

The fact that so many different people call themselves designers is significant. Being a designer is an important element of their self-perception. They studied to become designers, now they work in the area and now they are designers. This is particularly strong with the fashion designers in our case studies who actually did very little designing, as opposed to producing garments or organising the production of garments. They referred to themselves as “creatives” and looked for the company of other “creatives”, either other designers, crafts people or musicians, with little reflection whether these people were either designers or were in fact creative by any accepted definition of creativity.

7 Implications

The search for the essence of design or a description of design that covers all scenarios looks like a futile quest. However, if we accept that design is a family resemblance concept, then we can also see different conceptualisations of design as being valid, complementary, and enriching. This would also free us as a community from the desire and drive of particular subgroups to “own” the concept, define design, or speak on its behalf.

Rather it points towards accepting different takes on design as equally valid. This points to a different approach to looking for a comprehensive, cross-domain analysis of design: developing it incrementally by looking for what is similar and different in different design domains and what causes these patterns of similarity and difference (Stacey et al., 2002). Design research has for a long time focussed on what is common and in consequence has developed very high-level theories and conceptualisations of design. These achieve generality by being highly abstract; often, they are nothing like as general as they are claimed to be. Over the years many important insights into the behaviour of designers have been discovered, but they are not universal. For example, it is widely recognised that designers are “reflective practitioners”, going back to the work of Schön (1983), however this characterisation is not normative. Many designers engage in reflected action some of the time or occasionally, but not all do, and many people are also reflective in other everyday situations.

While these abstract conceptualisations of design are undeniably useful for design research or design teaching, their utility for design practice has often been questioned. Bryan Lawson (2006) put this very succinctly apropos of process maps as “…about as much help in navigating a designer through his task as a diagram showing how to walk would be to a one-year-old child. … Knowing that design consists of analysis, synthesis and evaluation will no more enable you to design than knowing the movements of breaststroke will prevent you from sinking in a swimming pool”.

What designers in practice want from design researchers and to some extent from each other is actionable insights and advice. Practically useful generalisations sit at a meso-level between the very detailed and domain specific accounts and the general abstract descriptions of design. Much of this
advice is formulated as methods or tools for design. However, these are only usable if the designers understand how they can be applied and deployed in a specific context. This is often a challenge for two reasons: (a) how to use the method is not well explained, and (b) a scope of applicability is not explained, which in some cases implies that the methods should be universally applicable (Gericke et al., 2020).

However, it is important to find ways in which designers in different contexts can learn from each other. Different areas of design have particular strengths that are often a direct response to the greatest risks or challenges of the field (Eckert et al., 2005). However, designers in other areas are often not aware of this and design subcultures may have a “not invented here” culture. The failure to look across different fields of design has also been a barrier to understanding the drivers behind different aspects of design behaviour. For example, all design processes generating safety critical products have many common characteristics, as do processes that interact with users directly (Eckert and Stacey, 2014).

Design in all fields is deeply embedded in the context in which it is operating. Many design problems are highly constrained, and designers need to make many trade-offs, as is the case in diesel engine design. The fashion designers are also constrained, by what they can do in a given time and at a given price point. They often have to make tough decisions about whether what they can practically achieve can be combined with their consciences. These concerns primarily affect professional designers. Amateur designers, such as hobby knitters and dressmakers, who also engage in designerly behaviour, might have a far greater flexibility. They can shift their own goalposts in a way that professional designers cannot.

Understanding the differences between different types of design and the drivers for differentiation is important. Bringing designers from different fields together also requires an appreciation of where the hard problems are in individual design fields and what they are good at.

8 Conclusion

The field of design research has gained a great deal from a very wide variety of attempts to work out what design or designing is. But what emerges from all these attempts is that design, and what people mean by the term, is far too diverse for any one definition to fit. Many characterisations of what design is have claimed to cover all design but are implicitly grounded in particular types of designing and just don’t fit many others. Design is best regarded as a family resemblance concept, where the many different instances of it have many features in common with many others, but there may be no characteristic that they all share. A better approach is to look at how and why particular types of designing are similar to and different from other types of designing and be very clear about the scope of any claims about the nature of design.

Whether an activity counts as design depends not so much on the nature of the activity itself, but also on the context in which it is carried out. A mathematical problem solved in a class might be just that – a maths problem – but in an engineering context it can become a design task. A making task can be just following instructions or a vital part of prototyping.

One characteristic shared across many very different types of designing is the crucial importance to the development of new artefacts of the analysis and knowledge generation activities that contribute to framing design problems and constraining the form of their solutions. How much these are regarded as part of designing depends on the field and on the self-understanding of the people who do them. They tend to get neglected in rhetoric about design and creativity.

One actionable conclusion we draw is that in the view of design as a cycle of analysis, synthesis and evaluation, all of these are part of design and are important and deserving of respect. For those of us concerned with what is or should be design, the challenge is to get problem framing, analysis and
evaluation activities given due recognition as central to designing. This requires increasing awareness among ourselves, our students, and the non-designing public that the knowledge generated about the problem the system is produced to solve, and the performance of the product, is an integral part of what is produced by a design process. This is true to some extent for under-constrained artistic design fields as well as tightly constrained performance-driven engineering design fields. In the latter we can call the generators of knowledge as well as the makers of moves in design space ‘design engineers’; in other fields the right terms giving appropriate status might be harder to find.

After 60 years it is time that design research embraces the richness and diversity of design and looks broadly at all design activities to address the imbalance in the research effort devoted to understanding and improving different aspects of design. For example, much research effort is invested in creativity and idea generation, but very little into the role of testing and validation in design, even though this takes up many more resources in practice.

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2 Text analysis
What design is not

Newton D’Souza\textsuperscript{a} and Tilanka Chandrasekera\textsuperscript{b}
\textsuperscript{a} Florida International University, ndsouza@fiu.edu
\textsuperscript{b} Oklahoma State University, tilanka@okstate.edu

\textbf{Abstract.} To bring disciplinary clarity to the boundaries of design, and to understand “what is design?” the study poses an antithetical question: “what is not design?” This negative question is examined through a semantic analysis of papers authored in the Journal Design Studies over the past 30 years. The objective of the paper is to revisit the past debates on what one considers as the boundaries of design, describe them and let design researchers formulate their own interpretation of its meaning in the contemporary context. Results are outlined through ten major themes that reflect the nature, product and uniqueness of design.

\textbf{Keywords:} Design, Design discipline, Design is not, Design studies, Semantic analysis

1 Introduction

The design discipline has undergone brisk changes in the past 30 years, evolving from a singular, technology-aided, trial & error based esoteric discipline to a more collaborative, technology-intense, evidence-based, and publicly accessible one. These changes have blurred the disciplinary boundaries of design. In critically examining such blurring, it might be prudent to pose the question “what is not design?” in the hopes that such a negation might bring disciplinary clarity to traditional questions asked within design research such as “what design is?” or “what design ought to be?”

However, such an approach is a daunting task given that design discipline has been shaped by different perspectives and philosophies emerging out of an essentially multidisciplinary domain area. Additionally, design has been referred to as a transitive verb (to create or plan), a noun (a scheme or an idea), a process (activities of design) or as a discipline. Traditionally design activity has been described in numerous ways ranging from design as creative problem solving (Chen and Liu, 2002), problem-framing, (Cross, 2001), puzzle-making (Archea, 1987), abductive reasoning (March, 1984), to a very complicated act of faith (Jones, 1970). Design behavior is described as a form unique inquiry which is characterized by the production of novel and unexpected solutions, tolerance of uncertainty, access to incomplete information, application of imagination, constructive forethought to practical problems, and the use drawings and modeling media solving (Cross, 2001). As an unique form of intelligence, design has been regarded as different from the scientific or scholarly thinking styles, but just as powerful encompassing “designerly ways of knowing, thinking, and acting” (Cross, 1982). Design is distinguished from other ways of thinking such as in accounting, finances, statistics, software engineering, and medicine (Chan, 2015).

While the uniqueness of design has been well explicated in design research, others have also argued against the notion of design as a special kind of knowledge accessible only to people trained in design. Rather, design is considered as a generalized process which even non-designers are capable of performing to some extent. For example, common folk of craft-based societies have been attributed to design that are not only highly practical but also very beautiful (Cross, 1990). Design is hence considered a generalized body of knowledge capable of bridging diverse
discipline prompting one architect to view design as last remaining of generalist professions (Cutler, 2016). The multidisciplinary view of design can be specifically evident in a field such as architecture, in which, building design and construction have increased in complexity (e.g., multiple materials, products, and project participants to coordinate), and designers are often expected to accomplish their work in shorter timeframes. The challenge of integrative project leadership has left designers to dawn the role of the traditional master-builder, that of an “integrator” of various skills and knowledge (Barrow, 2000).

In the lead up to discussions on what is not design, researchers have reflected on what constitutes “design proper.” Instead of a “hard dry ground” job description of an architect, design is viewed as e ambiguous as a “swamp” in which the boundaries are less delineated (Farbstein & Kantrowitz, 1991). Others have described design as a continuum of activities starting with pre-design, such as scenario planning (strategic activity) and programming (tactical activity), and ending with post-design activities, such as post-occupancy evaluation (Schermer, 2001).

2 Analysis

To bring in disciplinary clarity to the question of design and to gain insights into where scholars draw the line, a semantic analysis was conducted on negative connotations of “what is not design”. Initially three prominent design journals over past 30 years were considered as a subject of the study (1990-2020). However, as the study progressed majority of research yield was found in one specific source: the Journal of Design Studies and hence the inquiry was limited to it. The journal consists of relatively long history on design cognition and addresses design activity across multiple disciplines including engineering and product design, architectural and urban design, computer artefacts and systems design. Therefore, it provides an interdisciplinary forum for analysis, development and discussion of fundamental aspects of design activity. The semantic analysis consisted of the following steps.

• Initial data was elicited by using the “find” tool in Adobe pdf software. The search constituted of finding declarative clauses that imply negative connotations of design (e.g., not design, non-design, design is not, isn’t design, how not to design, design can’t do); phrases or idioms that imply how design is expected not to perform (short of design, unlike design, lack of design, design is more than); and prefixes that imply activities that occur before or after design proper (pre-design, post-design).

• The initial search led to about 600 papers. The papers were then manually coded for relevance using an open coding system. One of the challenges in this process was to distinguish between the conventional use of negative words (“hope not”) to the use of negative words in a design context (“design is not”). Once the negative words were identified, the individual papers were open coded to reflect the context in which the negative words were used. For example, “design is not problem solving” or “design is more than and artistic endeavor.” The idea was to capture design as the subject and the corresponding activity (for e.g., problem solving) as the object while being modified through a negative structure (for e.g., not or more than). The open codes resulted in reducing the total to 188 papers.

• Further thematic coding was conducted based on the commonality between the open codes. For example, papers that were open coded as “design as not problem solving” and “design is not merely craft skills but also problem framing” were grouped under a common thematic code
“problem/solution.” This resulted in 21 thematic codes. They were independently reviewed by two coders to check inter-coder reliability. The initial inter-coder agreement was about 80%.

- After the coders negotiated, the second cycle coding led to 72 open codes and 10 thematic codes.
- The codes were organized based on corresponding discipline from which the papers were elicited and chronology of when the papers were written. This provided further insights into contextualizing the codes.

3 Disciplinary and chronological trends

The findings show that the focus of the study of “what design is not” were evident in 7 different design and allied disciplines: architecture, computing, product/industrial design, engineering, philosophy, psychology, and technology. In the context of this paper, disciplines were identified based on the subject focus of the paper and the author’s expertise/affiliation. In cases in which there were multiple authors hailing from multiple disciplines, the codes were organized under their strongest affiliation of the first author. The 10 thematic codes are listed below under major themes addressing the nature, product, and design activities.

Nature of design

- Design is Not Science (although they share similar values).
- Design in More than Pure Artistic Creativity (it should address a problem).
- Design is More than Problem Solving (and a unique one).
- Design is More than a Mechanistic Process (it is a social one).
- Design is Not Merely Technical Process (it cannot be pinned down).

Products of design

- The Goal of Design is Not to Produce Knowledge (although knowledge is produced in some form).
- The Product of Design is Not the Artifact itself.

Design activities

- Design Activities
- Non-Design Backgrounds.
- Non-design Contexts.
- Non-Design, Pre-Design and Post-Design Tasks

Figure 1 shows the thematic codes in correlation to discipline and chronology. The year the papers were published in which the codes were identified is plotted on the ‘Y’ axis while the thematic codes are plotted on the ‘X’ axis. In this 30-year range, one can observe that the majority of disciplines discuss why design is not problem solving nor of technical nature. Specifically, the theme of problem solving has been most prevalent in the discipline of computing. This was also demonstrated through statistical significance for computing studies when a one-way ANOVA (F (10, 51) = 2.17, p = .035) was conducted comparing thematic codes of all disciplines. Besides computing studies, none of the other disciplines showed statistical significance in the distribution of thematic codes, this finding might suggest that because computing studies is traditionally affiliated with problem-solving, there was an internal debate within this discipline to go beyond that framework.
Figure 2 shows that three disciplines (architecture, product/industrial design and technology) led the majority of the discussion on what is not considered to be design. The papers show more robust discussions in recent years in the discipline of although no statistical significance was found between the year of publication and themes. Additionally, there was no significant correlation in the discussion of themes between disciplines. This was a little surprising result since we anticipated that thematic discussions would be correlated between various disciplines.
4 Nature of design

4.1 Design is not science (although they share similar values)

Number of authors advance the view that design is not the same as science although comparisons have been made showing similarities. Science is considered analytic while design is considered constructive. In the area of mechanical engineering, for example, engineering science, is located on the analytic side while engineering design is placed on the synthetic side (Owen, 1998). The scientific method is considered as a pattern of problem-solving behavior employed in finding out the nature of what exists, whereas design method is considered as a pattern of behavior employed in inventing things of value which do not yet exist (Cross, Naughton, & Walker, 1981).

Another paper on architectural design suggests that while scientists strive to isolate the "best" and the most superior option, architectural designers narrow down their options by satisfying what they can. Making a distinction between design and science others argue that the only way of knowing truth would be to put a scientific theory to the most stringent tests requiring the scientist to sincerely and vigorously become an antagonist to their own theories. On the other hand, the truth the architects seek are temporal and situated in a specific context (Akin, 2001).

In advancing the design v/s science distinction, the mental activities of a scientist are characterized by a “mind-to-world” direction of fit, while in contrast, a designer’s mental activities are considered to be dominated by a “world-to-mind” direction of fit (Helighen, Cavalin & Bianchin, 2009). In general, for a designer, it might be sufficient to propose a novel idea without actually designing the artefact, whereas the scientist must produce an artefact such as a scientific theory (Galle, & Kroes, 2014). Design is considered as an action process aimed at predetermined goals whereas science is aimed at creating knowledge about something. In this sense, design is considered a service discipline, unlike science (Jonas, 1993).

However, other researchers take a more conciliatory tone. They understand that much like science, design as a discipline, can be studied under its own terms, and within its own rigorous culture. A science of design is possible based on the reflective practice of design. The design process is therefore inherently fluid, because it is not blinkered by the quest to achieve one design goal; rather it is open to new goals that one discovers accidentally and unintentionally (Meng, 2009).

4.2 Design in more than pure artistic creativity (it should address a problem)

While the views in the previous section consider design not the same as science, opposing views neither consider design as pure art. In this view, design is intentional, hypothetical and predictive transcending creative intuition to include an explicit political dimension. It involves choosing a range of options to allocate material resources despite possible conflicts between the short and long-term requirements (Lawrence, 1993). In other words, design activities are considered not merely impulsive, habitual, or coincidental, but rather conscious, selective and intelligent (Uluoğlu, 2000).

Creative design is not necessarily considered “good” design in terms of quality. A designer aims to achieve a high-quality design, with creativity only as one aspect. In fact, creativity is not a condition unique to design since creativity is also involved in in scientific and artistic processes (Alexiou, Zamenopoulos, Johnson, & Gilbert, 2009).

Although the creation of design is considered simple, it’s however not considered a simplistic act. For example, in the case of wayfinding design, logic and efficiency are as important as making design products architecturally interesting (Passini, 1996). Some authors argue that creative design involves problem-framing ability (Dorst, & Cross, 2001) and creative designers attempt
more problem-finding segments (Liu, 2000). Contrary to the view that beginning designers are more creative, some researchers observe that expert designers, solve design problems in a more creative manner than beginners (Hanna & Barber, 2001).

Others consider design not just as an art, neither engineering nor science, but as integrative discipline. It is this generalism that is considered to make a good designer valuable (Owen, 1991). There is also the debate within the design disciplines about which disciplines are more artistically inclined than others. For example, some refer to architecture and industrial design as more artistic than engineering design, the latter being relatively constrained by the needs of customers and company shareholders (Eder, 1981).

4.3 Design is more than problem solving (and a unique one)

Some consider design is more than merely problem solving. It is the result that carries some part of the designer in it. In other words, beyond mere problem solving in design there is an “affective” requirement characterized by a leap of faith placing the designer in a creative situation and deriving vicarious satisfaction about the creation (Louridas, 1999). Additionally, design is not just about the creation of useful artefacts. It is equally about the creation of beautiful artefacts in which utility and aesthetics intertwine in the design process (Louridas, 1999).

Beyond mere problem solving, some authors suggest that the job of a designer is to give the client not simply what they want, but what they never dreamed they wanted; and when they get it, they recognize it as something they wanted all the time. In other words, clients want designers to transcend the obvious and the mundane, and to produce proposals which are exciting and stimulating. What this means is that design is not a search for the optimum solution to the given problem, but also exploratory (Cross, 1999). Similarly, other papers consider that the evaluation of the solution is equally important to the analysis of the problem. Hence designer is considered to be solution-led, not problem-led. Designers formulate and solve problems differently than other professions. In some cases, they generate conjectures about possible (partial) solutions and use these conjectures as a way of exploring and define the problem and the solution together (Restrepo & Christiaans, 2004). A problem-solving paradigm is apt where the problem is ‘fairly clear cut’, but that reflection-in-action is better suited to conceptual design. The process is one of a designer interacting with an external representation, performing a series of experiments, the results of which influence further experiments (Smith & Gero, 2005). Design processes are not problem solving in the orthodox form in which problem statements reveal solution paths; rather they are way of resolving conflicting criteria for validating results and multiple solutions (Bijl, 1985).

Creative design is not a matter of first fixing the problem and then searching for a satisfactory solution. It is a matter of developing and refining both the formulation of a problem and ideas for a solution concurrently, with constant iteration of analysis, synthesis and evaluation processes through a ‘co-evolution’ of the problem and the solution (Dorst, 2004). While much in design is conjecture, much is not. All designing involves some guesswork. But like medical research the texture of design is not literally trial and error, it is not merely unremitting guesswork (Bamford, 2002).

While design problems are generally considered as ill-structured problems, further distinction can be observed within them. The first difference is that in design, imagination needs to be applied right from the very fundamental level of the interpretation of concepts. A second difference is that design requires the use of experiments and simulation techniques. Thirdly, designing is fundamentally a social process. The stakeholders need to develop a way of reaching a solution, which cannot exist before the design situation arises (Dorst & Royakkers, 2006).
The distinction between design and problem solving is also made in studies of cognition and brain. Compared to problem-solving, studying design tasks require a more extensive network of brain areas. Although a problem-solving task may require creative thinking and hypothesis formation, the problem itself is well-defined. In the design tasks there is no predetermined final state or criterion for deciding the termination of the task (the task is open-ended). The task requires defining the problem as well as the solution space: it requires the creation and interpretation, as well as the creation of a function (criteria) for evaluating the solution (Alexiou, Zamenopoulos, Johnson, & Gilbert, 2009).

4.4 Design is more than a mechanistic process (it is a social one)

Some authors believe that design is not a mechanistic process which can be fully described in a manual, but a complex and elaborate socially mediated activity (Baird, Moore, & Jagodzinski, 2000). Even when design is conducted by engineers, it is not a mechanical or rational in the managerial or economist’s sense. Instead, design is a social process (Ball, & Ormerod, 2000). Design is not only individual action but has to be implemented on an organizational level to be effective. Good design practice requires more than individual strategies and methodology (Lauche, 2005). The conception of a design is not simply a representation in visual form of predetermined values, but a creative, catalytic process in which external factors interact with the beliefs, talents and skills of individual design groups and shaped by the designers’ own cultural and societal values (Razzaghi, Ramirez Jr, & Zehner, 2009). Descriptive studies involving design teams demonstrate that design is not only a complex technical process but also a complex social process. Modern multi-disciplinary design demands that engineers work in teams and to be successful the team has to reach some shared or commonly held understanding. Thus, design needs to address the design process as an integration of the technical process, the cognitive process, and the social process (Macmillan, Steele, Austin, Kirby, & Spence, 2001).

4.5 Design is not merely a technical process (it cannot be pinned down)

Several papers consider that design is more than a technical process and unpredictable. Design is not a straightforward process (Tilley & Burrows, 1995) and cannot be pinned down like butterflies (Margolin, 1992). Design is not a set of technical skills, but unique ways of knowing and thinking that form part of the process (Friedman, 2007). Neither is it a rule-based or symbol processing activity (Coyne, & Snodgrass, 1993), nor can it be reduced entirely to a set sequence (Dorst & Dijkhuis, 1995). A design is not an end in itself, but an input for the next step, which can consist of further detailing of the design (van Aken, 2005). Design is also not considered a single process, but a mix of activities that range from individual work to meetings and reviews in groups. Instead of the idea that designing is one ‘thing’ design consists of many ways of thinking (Lloyd, Lawson, & Scott, 1995). There are generally many iterations and cross linkages that take place all the way through the process and certainly at the front end (Turner, 1991). Furthermore, several design tasks can be carried out in different ways or styles, using alternative technologies. The various disciplines engaged in design differ in terms of the types of problems they address and the products they design, and the design process feeds on a continuing interplay between experimentation and what they disclose to our understanding (Akin, 1997). Design operates not on any single episode of design, but on the dynamics of how the problem responds to changes in its articulation by the designer (Newton, 2004). Additionally, design is not just a process or a profession, it is experienced as a situation that a designer finds him/herself in. As a designer, one is being continually faced with the very concrete
challenge of perceived design problem, and one has to decide on the kind and content of the action to take in specific situation. In most cases, considerations linked to the content of the design situation (the perceived design problem, the designer's goals and the perceived possibilities for the next step) will determine the 'kind of action' (Dorst & Dikhuis, 1995).

5 Products of design

5.1 The goal of design is not to produce knowledge (although knowledge is produced in some form)

There have been rigorous debates on the ultimate goal of design. For example, much different from the goal of science, which is to create knowledge, some consider that the goal of design is to change the environment. Knowledge is cumulative, and while it tends to produce higher levels of refinement and sophistication in design, the principal function of design is not to produce knowledge but to have an effect. It is through design that science exceeds being pure knowledge and participates in creating an effect (Willem, 1990). Similarly, design decisions are largely influenced by experience, creativity, innovation and other factors and it is not always possible to utilize these factors in a formalized knowledge base (Beheshti, 1993).

While knowledge on 'the way the world is' enters design decision-making at many crucial points and many different guises, in the early stages of the design process, when many critical decisions are made, designers are in no position to collect much relevant information anyway. Often all they have to work with are environments, paper designs, mock-ups and prototypes. While these yield useful information, that usefulness is directly proportional to the designers' ability to intuit potential scenarios by bringing their experience and cultural knowledge to bear upon the problem. In this case knowledge is bound to social processes much like law and medicine (Sharrock & Anderson, 1994).

While the goal of design is not to produce knowledge, designers have to accumulate the knowledge to make effective design. While the unselfconscious designer of the past could rely on tradition and afford not to have an explicit knowledge base, the contemporary designer has to have adequate design qualifications and be able to distinguish a design from the work of all other designers (Louridas, 1999).

5.2 The Product of Design is not the Artifact itself

While debates are presented on what might be the ultimate product of design, several authors suggest that the true product of design is not the designed artifact itself, but rather the change the artifact brings about in the world, and the experience it eventually provides to its users (Jackson, 2010). The philosophical argument is that the subject area of design cannot be the actual artefacts themselves because there are no such things at the time of designing. Instead, it is the artefact structure and their parts from which design is constructed. Design artefacts only gain meaning because they acquire their meaning from the structures they describe. Design is not about artefacts at all but is merely a play with symbols and patterns (Galle & Kroes, 2014).

Additionally, not all used objects are considered artefacts. Something that has been designed does not have a function yet and cannot be called an artefact. Artefact is action-theoretical rather than metaphysical. They have intentional history and role. This role may be different for different agents, and one object may even play different roles at the same time. This distinguishes them from non-designed objects, such as water and air because its use and function are intelligible to users (Houkes, Vermaas, Dorst, & de Vries, 2002).

Moreover, the primary concern in design is not about perfection of form and aesthetics, but rather
how it opens up for use. While the object itself is still quite central, notions of form and the finished-ness of the object also play an important role. In design, one has to accept roughness and improvisation as part of the design process (Redström, 2008). In other words, the object of design is not a real object; it doesn’t exist yet in process. What does exist are things like charts, acronyms, sketches, diagrams, models, mock-ups, product line, specifications etc. The emergent meaning is both referential and inferential: object (and concepts) acquires meaning by association with other objects (and/or concepts). The mockup itself may be minimalist in its rendering in material form and yet could be a vehicle for wide-ranging, energetic, and meaningful exchange (Bucciarelli, 2002).

Similarly, design products such as drawings are not as critical as the idea that the drawings represent (Medway, & Clark, 2003). Additionally, design is not just a copy of existing designs. They still need to be modified to satisfy aesthetic and functional requirements (Lim, Qin, Prieto, Wright, & Shackleton, 2004). Designers use the medium of representing massing elements, and in particular, elements of regulation to manage the design process itself. This includes management of part–whole relationships, hierarchy, topology–geometry relationships, scaffolding the design process, and structuring/ restructuring of problem parameters. Each of these is a separate facet of the same phenomenon of managing the design process through massing representations (Akin & Moustapha, 2004).

6 Design activities

6.1 Non-Design Backgrounds

Differing views have been presented on whether a distinction needs to be made between design and non-design professions. Some consider even proximate professions such as arts as hailing from a non-design background (Chung, & Whitfield, 1999). Others consider professions with technical skills in design as part of design discipline (for example, arts, crafts, advertising, interior design, etc.) in relation to non-design backgrounds (for example, toolmaking, electronics, mechanical engineering, etc.) (Yang, You, & Chen, 2005). Some question whether there is an empirical basis to such distinction. In one experimental study, senior design students produced more creative forms during a mental synthesis task than non-designers (law discipline) who focused on verbal concepts (Kokotovich, & Purcell, 2000).

The concept of “design thinking” has been adopted to infuse iterative and ambiguous nature of professions such as business management and entrepreneurial business innovation. There has also been growing interest on design thinking from sectors as education, health and information technology, environmental sustainability, welfare and social justice. These developments have caused concerns among the design professionals because they suspect an uncritical deployment of the term design thinking in contexts other than design as a fad, instead of being a real opportunity to explore and extend the possibilities of design in other sectors (Stewart, 2011).

6.2 Non-design contexts

Design is not purposeful without the environment and context within which it operates. Hence, some authors suggest a more wide-ranging view of design problem-solving which attempts to foster a recognition of the importance of contextualization in design cognition. They claim that in contrast to software design, design behavior cannot be isolated from its context and the need to remain aware of the social, educational and organization factors which mediate design behavior (Davies & Castell, 1992). Another study makes a distinction between non-design problems such as computer simulated scenarios (operating an engineering plant & firefighting exercise) to a
design problem (modifying height and inclination of a writing table). Opposed to the design problem, they claim that the computer simulated complex problems do not require specialized knowledge (Eisenstraun, 1999). Although designers do not always consciously use environmental factors in the process of designing, they have a very good mental model of the operating environment and use it to develop a workable proposition. After the design is completed, environmental context is used as measurable factor for evaluation and optimization (Hybs & Gero, 1992).

6.3 Non-design, pre-design and post-design tasks

A number of authors have made a distinction between tasks that are aligned to design and the ones which are not. Non-design activities are considered as activities that do not involve design. Design activities include problem definition, gathering information, developing alternative solutions stage, generating ideas, modelling, feasibility analysis, evaluation, project realization, decision and communication (Atman, Cardella, Turns & Adams, 2005). This is opposed to a non-design task that might include a linguistic interpretation and explanation of noun phrases (Nagai, Taura, & Mukai, 2009). Others view that research conducted in the social sciences are more aligned with non-design problems (Yang, 2010).

There are those who also make a further distinction between design and activities that precede or follow design proper. These are called as ‘pre-design’ and ‘post-design’ activities. The pre-design phase generally includes reasoning or organizing activities while the post-design phase includes evaluation tasks (Eilouti, 2009). The pre-design reasoning activity includes precedent case retrieval, organization of information, the representation of the extracted information into more accessible forms, and the prototyping of its representations for future design solutions. Post-design includes the comparison of a generated solution to other precedents that can be considered successful solutions, and the performance simulation of proposed scenarios of the generated design (Eilouti, 2009). The “design” proper include mapping of a precedent to a design problem, modification of the solutions, adaptation of the revealed sub-solutions, their synthesis and development, and the documentation of the selected solutions.

Some papers refer to pre-design activities as front-end activities. Subsequently design activities are classified as pre-phase (opportunity identification and idea generation), phase zero (product concept and definition, including market and technology assessment) and phase one (product definition, justification and planning) (Tzortzopoulos, Cooper, Chan, & Kagioglou, 2006). Others consider requirement management as a part of the pre-design services (Duerk, 1993). Requirement-driven design is an information-based approach facilitating consistent design rationale tracking and evaluation, verification, and validation of design (Ozkaya, & Akin, 2006).

The American Institute of Architects divide the design process into pre-design services, schematic design, design development, construction documents, construction administration and post-design services (Ozkaya & Akin, 2006). During pre-design phase, architects and other professionals on the planning team generally employ several interactive methods and techniques to collect information on the internal and external forces that impact a given project. Generally speaking, the planning team may conduct environmental evaluations and assessments, collect data, research best practices, interview different user groups, establish goals, and generate a list of technology and equipment needs. During this inquiry process, objectives are established, the context of the design problem is identified, and the performance requirements are defined (Maier, Fadel, & Battisto, 2009).

Pre-design is also sometimes used synonymously with research. Pre-design research is concerned with determining the requirements for organization and planning thus leading to a solution of the
project, and creating design guidelines (Johannes, 1992). One study claims that the success rate of design based on clear and well-defined specifications emerging from pre-design research is 3.3 times greater than a design without it (Chang, 2003).

In software design, some utilize pre-designed solutions of design elements such as libraries of borders. As software matures through the release of progressive versions, changes are often made which are direct results of feedback from professionals who have used the products. These progressive changes are often developed from ‘wish lists’ compiled by users forming the genetic building blocks, or memes that will carry the genetics of the software program (Cleveland, 2004).

7 Conclusions

To understand “what design is” or “what design ought to be,” this paper examined the negative question of “what design is not?” The summary of semantic analysis of negative connotations referring to design demonstrates that design has been traditionally described in various ways at different points of time. Researchers in specific disciplines have questioned internally about what design means in their profession, although a multidisciplinary meta-analysis was seldom undertaken. Historically the debates on the nature of design have focused on why design is not merely science, artistic creativity or problem solving. By negation, one could conclude that design is made up of these three ingredients in various capacities and specific to the discipline itself. The more recent discussions have considered design as a more social one.

From long-standing debates about science, art and problem-solving to more recent discussions on artifacts, products and technology, the design profession and its boundaries have been in constant flux. As much as there are intellectual debates about the true nature of design and what is meant by a design task or activities, the recent advancements in technology and collaborative designing have rendered design activities further blurred.

While the study shows that there is more understanding on what designers do, three recent debates have focused on the ultimate goal or products of design. Considering design as an instrumental profession, there seems to be mixed debates on whether design needs to result in a knowledge base or aim only for change, whether and which artifacts should design produce, and to what extent it should be a service-based profession. With the advent of co-designing, research and pre/post design activities, the profession is looking to further define who can actually function as a designer and whether or not professionals and public as a whole from non-design backgrounds can be productive partners. A discussion on inclusivity and exclusivity of the profession will take the design profession into a more philosophical and moral reckoning in the near future.

References


Analysing storytelling in design talk using LIWC (Linguistic Inquiry and Word Count)

Almila Akdag Salah^a^, Senthil Chandrasegaran^b^ and Peter Lloyd^b^

^a^ Department of Information and Computing Sciences, Utrecht University, a.a.akdag@uu.nl
^b^ Faculty of Industrial Design Engineering, TU Delft, {R.S.K.Chandrasegaran, P.A.Lloyd}@tudelft.nl

Abstract. Design thinking concepts such as storytelling, framing, and co-evolution, have been established from close readings of design activity. The increase in easy-to-use computational methodologies provides an opportunity to validate these concepts more widely. Among these concepts, storytelling is already operationalised through various computational approaches. In this paper, we create one corpus of design activity data from the four shared-data DTRS workshops and use Linguistic Inquiry and Word Count (LIWC) in attempting to automatically detect components of stories. However, the conversational nature of the data indicates that further development in methodology is needed. The contribution of the paper lies both in outlining how an automated method for identifying stories could work and showing how the DTRS corpus can be compared with other large datasets outside of the design discipline. This represents a further step on the way to understanding design thinking in conversational contexts.

Keywords: Computational Linguistics, Conversation Analysis, Design Talk, Design Thinking, Storytelling

7 Introduction

Over a period of nearly 30 years the Design Thinking Research Symposium series (Cross, 2018) has conducted four shared data workshops, generating data from design activity in a number of different contexts including: think aloud protocols (Cross, Christiaans & Dorst, 1996), designer-client discussion (McDonnell & Lloyd, 2009), design education (Adams & Siddiqui, 2010), and co-creation (Christensen, Ball & Halskov, 2017). In bringing different research groups and traditions together, the key achievement of these workshops has been to develop a common language with which to describe design activity. A central research thread of these workshops has been to consider the function of different words and the structure of different word forms in discourses of designing and evidencing specific ideas about what constitutes design activity with textual data has formed the basis of this inquiry. The concept of ‘framing’, for example, as it pertains to both Schon (1983) and Goffman (1974) has been explored by Dorst & Dijkhuis (1995), Glock (2009), Mabogunje et al. (2009), Secules, Gupta & Elby (2015), and Dong & MacDonald (2017). Such extensive exploration and development of a common language to describe designing through analysing common data can equally be applied to other now familiar concepts such as ‘co-evolution’, ‘problem-finding’, and ‘evaluation’.

One particular concept relating to design activity that has recently found traction is that of ‘storytelling’. This is the idea that significant parts of the design process, particularly in naturally occurring datasets, are taken up with narrative structures that place actors, objects and relations in specific contexts. Arguably the early DTRS analyses on episodic memory (Visser, 1995) and precedents (Oxman, 1994) established a foundation for later work on storytelling to emerge (Lloyd,
2000) and develop (Lloyd, 2009). Most recently – in terms of the DTRS – Lloyd & Oak (2018) identified ‘value tension’ as an important function that stories have in design conversations:
 “A story […] provides a dynamic structure through which values can be framed and categorised, and through which design-oriented arguments can be presented.” p.109

Concepts like that of storytelling, and the other concepts listed above, have given us a rich language with which to describe and present design activity, both within the DTRS datasets and more widely in the design research field. However, they are (necessarily) derived from the selective use of examples from design protocols. In this respect they represent the first phase of a research process highlighting general features of design activity. A general method of the DTRS workshops when looking at language use has been to ‘fit’ concepts with textual excerpts, showing how a particular linguistic mechanism might be in play. This is a manual process of close analysis and description, selecting self-defined points of interest in the discourse and describing them in abstract terms.

We might, then legitimately ask: are these concepts robust? Are they features of design discourse that can be readily and reliably identified? Can we show that they are necessary conditions of design activity?

More automated methods of textual analysis have begun to be applied to DTRS data to explore more general features of the design protocols (Menning et al., 2017). This paper extends this recent trend by treating the DTRS data as a single corpus, amenable to computational linguistic analysis. Rather than identifying specific discursive practices within a particular dataset, we seek both to characterise these DTRS data more broadly and begin to validate previously established concepts about designing. We do this particularly in comparison to other types of textual corpuses. With more and more training datasets becoming available and with analytical sophistication increasing rapidly (Archer & Jockers, 2016), it is now possible to use comparative methods to test both specific concepts related to the DTRS data - in the case of this paper that of ‘storytelling’ - as well as reveal more general regularities.

In this paper we first describe the constitution of the DTRS corpus that we have created. We then go on to describe the Linguistic Inquiry and Word Count (LIWC) methodology, illustrating how it can be applied to the DTRS corpus and compared to other large datasets. The main body of the paper considers the concept of ‘storytelling’, discussing how it can be constituted and operationalised to reveal narrative and emotional arcs in textual data. We conclude by saying that although we cannot replicate the significant results of others, we do show new methods for automated data analysis of design activity to facilitate cross-corpora comparison.

2 Building a DTRS corpus

The datasets from the four different shared-data workshops of the Design Thinking Research Symposium feature several different disciplines related to design: DTRS2 - industrial design engineering, DTRS7 - architecture and engineering design, DTRS10 - design education and DTRS11 - product design. These datasets encompass a variety of design activities from think aloud protocols (DTRS2), designer-client discussion (DTRS7), design education (DTRS10), and co-creation (DTRS11). Apart from DTRS10, which followed the design process of students and the feedback they received from their lecturers, all other datasets were collected from the meetings of design professionals.

The datasets differ in length and in the number of participants: DTRS2 is the smallest with one 2-hour ‘think-aloud’ design session with a single designer and another 2-hour session with three designers. The design conversation focuses on a bicycle accessory. DTRS7 has four 2-hour meetings, where two of these feature conversations between an architect and his clients. The other two are between a multidisciplinary design team working on the design of a digital pen. DTRS10 consists of 38 sessions of various lengths, and varying number of participants. As the sessions feature teacher-student
discussions in five disciplines (industrial design, mechanical design, service-learning design, entrepreneurial design, and choreography) a different conversation hierarchy can be observed. DTRS11 contains 20 sessions of varying length with a focus on preparing and discussing the results of co-creation meetings. In total, it has 17 participants. Together, these datasets contain a rich reflection of design activities that occur in diverse stages of design including how designers think, discuss, reflect, evaluate, and talk to their clients.

To build the DTRS corpus from these datasets, we first got the appropriate permissions and anonymized the data by rendering all datasets into a tabulated format with dataset name, session name, speaker, and utterances. We kept filler words such as ‘ehm, uhm’ etc. as well as descriptions of actions, such as [laughs], to maintain the conversational flow. The resulting corpus has 373,983 words spread across 64 sessions from the 4 datasets. A more detailed description can be found in Lloyd et al. (2021) and in our sister paper for DTRS13, Chandrasegaran et al. (2021). This corpus, though not big enough to be of use as a training dataset for an AI application, is nonetheless a valuable resource to explore hypotheses about the features of design discourse and dialogue.

3 The Linguistic Inquiry and Word Count (LIWC) Dictionary

Linguistic Inquiry and Word Count (LIWC) is a dictionary prepared by Pennebaker et al. (2015) with the purpose of studying the grammatical, linguistic and socio-psychological dimensions of textual data. LIWC provides a ‘gold standard’ of categories reflecting these dimensions through individual words (Fast, Chen & Bernstein, 2016) and has been used for more than twenty years to analyze a huge range of textual datasets. Over the course of these twenty years, the dictionary has been enhanced to its current format, which now has about 6,400 dictionary words and word stems in 91 categories and sub-categories. These categories cover linguistic (e.g., pronouns, prepositions), other grammar (e.g., quantifiers, common adjectives), and psychological processes (e.g., positive emotion, insight). Table 1 lists some of these categories with word examples.

Table 1. An overview of some LIWC categories with examples. See Pennebaker et al. (2015) for the full list of 91 categories

<table>
<thead>
<tr>
<th>Main Category</th>
<th>Sub-Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic Dimension</td>
<td>Function Words</td>
<td></td>
</tr>
<tr>
<td>Pronouns</td>
<td>1st per. singular</td>
<td>I, me, mine</td>
</tr>
<tr>
<td></td>
<td>3rd per. plural</td>
<td>they, their, they’d</td>
</tr>
<tr>
<td>Impersonal pronouns</td>
<td>it, it’s, those</td>
<td></td>
</tr>
<tr>
<td>Articles</td>
<td>a, an, the</td>
<td></td>
</tr>
<tr>
<td>Prepositions</td>
<td>to, with, above</td>
<td></td>
</tr>
<tr>
<td>Negations</td>
<td>no, not, never</td>
<td></td>
</tr>
<tr>
<td>Other Grammar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common verbs</td>
<td>eat, come, carry</td>
<td></td>
</tr>
<tr>
<td>Common adjectives</td>
<td>free, happy, long</td>
<td></td>
</tr>
<tr>
<td>Interrogatives</td>
<td>how, when, went</td>
<td></td>
</tr>
<tr>
<td>Quantifiers</td>
<td>few, many, much</td>
<td></td>
</tr>
<tr>
<td>Psychological Processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affective proc.</td>
<td>Positive emotion</td>
<td>love, nice, sweet</td>
</tr>
</tbody>
</table>
In comparison to coding frameworks introduced in the design literature, using LIWC as a coding tool allows us to explore a wider range of linguistic phenomena. Existing design process coding frameworks tend to focus on a particular aspect of design such as different types of reasoning, how the design object is described, or the design stages themselves. In contrast, LIWC identifies more general cognitive, emotional, perceptual and social processes. Since LIWC is a general dictionary used in various disciplines for many different purposes, a LIWC analysis of design discourse can be compared to other corpora, with the consequent potential to create new insights into what constitutes designing talk.

We first use LIWC categories to generate a network structure from text files. The LIWC dictionary assigns words to more than one category. For example, to think is both a verb (belonging to the ‘function’ category) and part of the ‘cognitive process’ category at the same time. Using these overlaps, we can build a network where categories are represented by nodes, and words that belong to more than one category, work as links between nodes. We analyse the DTRS corpus we created using this approach, as well as two further datasets for comparison purposes: the Internet Movie Database (IMDB) corpus with 1068 movie scripts (Danescu-Niculescu-Mizil & Lee, 2011) and a Written Corpora with 680,000 blogposts and 500 scientific books (Lloyd et al., 2021). The IMDB corpus gives insight to everyday conversations, and the comparison to DTRS dataset can highlight if there are specifics to designer conversations versus everyday language. Written Corpora in contrast follows rules of writing and constitutes a good example of carefully crafted sentence structure and text flow, which is lacking in conversational datasets.

Figure 1 shows these three datasets’ network structures. Nodes represent LIWC subcategories, their sizes indicate frequency of use, links indicate words shared by two categories (i.e., nodes), and proximity of nodes is determined by link strength. Subsequently, if two categories are frequently used together, they will appear closer in the graph, which is useful to visualise conceptual connections. As each dataset is defined by the way they use LIWC categories, the network maps provide us with an overview of both their similarities and differences. For example, the DTRS corpus uses more ‘cognitive process’ words whereas the IMDB database has more ‘biological process’ words. ‘Cognitive process’ contains words related to problem solving, so we might expect to see more of these words in design protocols, whilst the ‘biological process’ category covers ‘body-related’ events, which we might expect to find in the action of a film script. The Written corpus has a smaller ‘function’ category node, which means less use of pronouns, for example, and hence less ambiguity. Beside the node sizes themselves, how the nodes are connected also gives important clues. It is good to stress here that when the nodes are closer together, means that the corresponding categories share words more frequently. For DTRS, this is especially pronounced in the three closely connected categories: ‘cognitive process’, ‘relative’, ‘verb’. Among these categories, the ‘relative’ category covers time and space related words. We take the close connection between these nodes as an
indication that objects in time and space [relative] are being modelled [verb] through problem solving activity [cognitive process].

Figure 1. An overview of LIWC Category Network Maps for IMDB data (left), DTRS data (middle) and Written Corpora (right). Each network has 73 LIWC subcategories as nodes and coloured according to the top 12 categories to which they belong. Relative node sizes represent the number of unique words from the dataset that fall into the corresponding LIWC category. Similarly, link thickness between two nodes represents the number of unique words from the dataset that appear in the two corresponding LIWC categories.

In the following sections we explain how LIWC can be used to explore and analyse the concepts of ‘story’ and ‘storytelling’ as they appear in textual data. Storytelling is an activity that is, of course, not reserved for designing but is very much a part of everyday life. We tell stories for many reasons during conversations, however, the extent and instances in which we do this has not been quantitatively studied. To look at the idea of storytelling as it applies to the DTRS corpus we need also to look at other datasets with conversations and/or stories for purposes of comparison.

4 Analysing storytelling in conversations

4.1 The structure of stories

What is it that forms the structure of a story? The search to define the basic elements of what constitutes a story stretches back to Aristotle’s Poetics and the narrative arc of ‘beginning, middle, and end’. In the 19th Century Freytag (1960) argued that narratives consisted of five key components unfolding over time: exposition, rising action, climax, falling action, and resolution. The literature studies as a field offer more theories, but for the purposes of this paper, we focus on the types of narrative distinctions which are applied to quantitative textual data analysis. Boyd et al. (2020) identify three narrative markers – staging, plot progression, and cognitive tension – in several large datasets. van Laer et al. (2019) identify the degree of what they term ‘narrativity’ in a dataset of TripAdvisor reviews by tagging narrative content (i.e., affective consciousness, cognitive consciousness, spatial and temporal embeddings) and narrative discourse (genres such as drama, tragedy, comedy etc.). Finally, Reagan et al. (2016) classify computationally six types of ‘emotional arcs’ present in a dataset of 1327 works of fiction to reveal the affective complexity of narratives.

Of the three studies mentioned above, the study by Boyd et al. (2020) draws explicitly on the LIWC dictionary and is the analytical framework we adopt to look at the DTRS dataset. Following Freytag’s theory, they divide a story arc into five segments and map these to three story elements: staging, plot progression, and cognitive tension which can be identified in terms of LIWC categories.
Staging: the beginning of a story (i.e., the first segment) is usually reserved for introducing unknowns to the audience. To do so, the writer or speaker needs to use prepositions and articles more than other word categories. Once the staging is done, the number of words from these categories is expected to reduce in the following segments.

Plot progression: after the introduction of characters and the setting, the story moves along by using words from the function category. As an indicator of this, pronouns and auxiliary verbs are expected to rise from the second segment onwards.

Cognitive tension: each story sets up certain challenges and problems that are resolved through the unfolding of events and actions taken by the characters. These points in the story result in the usage of words from the cognitive processes category, with the peak coming in the middle of the story, after which the story moves towards the resolution.

Boyd et al. (2020) established these patterns for three different corpora in their paper resulting in the LIWC dictionary file being updated for this ‘story identification’ task. As shown in the LIWC network maps of Figure 1, words belong to more than one category. Boyd et al. found that this overlap between categories generates some noise when looking at a narrative, so they published two additional dictionaries to control for the overlaps. These dictionaries are called *Arc of Narrative (AON) with some overlap*, and *AON without overlap*. We used both AON dictionaries as well as the original LIWC dictionary for our analysis. The results between the three were similar, hence, we report the results for the *AON without overlap* as the results were more pronounced for this dictionary. Additionally, Malin et al. (2014) analysed the emotional tone of stories with LIWC, again by segmenting stories first into five equal length and then calculating the positive and negative affect of each segment with LIWC’s corresponding categories. They differentiate between redemptive and contaminative stories. Redemptive stories have happy endings, hence a positive emotional rise towards the end, whereas contaminative stories have a sad ending with a negative emotional rise at the end. Since we use the same segmentation in analyzing the narrative arcs, we will also follow Malin et al.’s approach to examine which emotional arcs are prevalent in the DTRS and comparison datasets.

4.2 A LIWC analysis of DTRS stories

For the purposes of this paper, we made the assumption that we would be more likely to find stories in DTRS if we looked at long utterances. We therefore filtered the DTRS dataset first by the length of utterances. As the conversations are between multiple speakers, the majority of the utterances were short. We extracted all utterances with more than 100 words, which returned 530 utterances. Manual inspection of these 530 utterances showed many instances where a description is given about objects, or users, but few full stories with all the story elements of staging, plot progression, and cognitive tension identified by Boyd et al. (2020). With this in mind, the 530 utterances were then filtered by one of the authors using manual annotation to check if the utterance contained story elements. This resulted in 267 utterances. 16 of these were tagged as ‘proper’ stories, roughly corresponding to the elements outlined above, whereas the majority were deemed as story snippets, i.e., textual pieces that contain one or more story elements, but do not follow the basic principles that are found in every story. The following two excerpts illustrate the difference:

Excerpt 1: Example DTRS story

“But at some point I think you feel like "I'm a human, I'm made to use my hands, I'm made to walk on my feet", and when machines start to do everything I think, at some point we reach a level where you say to yourself, "I want to use my hands, because that's what they're made for, I want to use my feet
because that's what they're made for", and I think they will reach that stage at some point, soon maybe. That's what we feel in Scandinavia, that we want to return to the original human, we want to go out and use our hands, work the old-fashioned way, eat like we did in one hundred years ago, so."

[Kenny, DTRS11, 127 words]

Excerpt 2: Example DTRS snippet

“This is the funeral that they had for this gentleman. And they may- these are the service sheets that they made up for him obviously showing in a sense his lifetime in pictures really and they had this on the wall itself and it just framed up and down and all the pictures just kept appearing on and off the screen and obviously in our chapel it’s so light it’s quite difficult to see some of them but this is, I mean this is this is sort of thing now this is started to move forward more now people wanted to do this and I mean in the back it says if you would like to receive a DVD please contact the family. Quite mad in a sense. But that's what you know this is where we are now with this. They're starting to ask for things like this and the concern I've got was that although this man came in to see me he had this erm screen that he had we’d have to bring in a little screen like this, a stand up screen and put it at the front which is again in our chapel quite light, difficult to see and he was then saying about the equipment that you would need. You'd need to have it really in the centre of the chapel sort of looking at the front or doing something and it would be quite difficult to do it in that. We’d have to put it at the side erm and he was then talking about all sorts of expensive equipment that we'd have to be leasing from him and you know all sorts of costs. But I mean what the, the idea is this is starting to become more the norm now. And like I say in Australia they- he saw it in Australia, and he wants to be the main agent in this country. And so obviously it’s something that he’s seen, and thought was a money spinner for himself I’m not saying that it wouldn't be for us”

[Female A, DTRS07, Crematorium Meeting 02, 347 words]

In the first story excerpt, an idea, or rather a question is introduced as the opening of the story: what makes one a human? The staging is done via the use of the storyteller’s emotional reaction to the question, as life has brought them to the point of asking this question “at some point I think you feel like”. Then the story unfolds, making the comparison between man and machine, and the resolution comes right after that: in order to keep your humanity, you should use your body, and not leave everything to the machine.

The second story snippet excerpt, although much longer, does not have the five segments and story elements outlined above. It looks like two stories merged into each other. In the first one, a funeral is depicted where technology is used to tell the life story of the deceased person with photographs. There is not a progression of the plot however: we do not learn the details of the deceased person’s life. Instead, we hear about the technical problems encountered in the chapel: “in our chapel it’s so light it’s quite difficult to see some of them”. The next part jumps back to the funeral, this time depicting the deceased’s friends and family asking for those photographs. Then a new story is introduced: the company that installs the technology, and how much they ask for this service is described. For a human reader, these snippets form the moral of the text: there is demand for such technology, but it is not clear if the storyteller will adopt it. At the end, a resolution does not flow out of these story elements, even for a human observer. The computational challenge is to try and capture these story elements automatically outside of the expected narrative arcs.
4.3 An example analysis

To demonstrate the Arc of Narrative LIWC dictionary in action, the following DTRS story is color-coded, with the words related to staging coloured in orange, the words that are expected to be used for cognitive tension colored in blue, and the words for plot progression colored in green:

"Things will be very different I think, cause like the current generation that we are talking to, are people who have experienced like theirs still have a little bit, right? I had an ex-colleague who was twenty-eight maybe and his dad is a lawyer, and he told me that when he grew up he still lived in the alleyways with no bathroom, so that everybody had a common bathroom, and now, you know, completely different, right?, and twenty eight is not that old, it's like our generation, so once you hit ten years from now, the people who already grew up with the bathroom in the house, they will have a completely different perception of this."

[Rose, DTRS 11, Recap with consultants]

Looking at the words highlighted in orange, we see that there is no extra staging in the first sentence, unlike the expectations. The use of article and prepositions is not higher than the remainder of the excerpt. On the contrary, towards the end, we see that articles and prepositions are used more.

Turning to the words highlighted in blue, we see that there are only three words related to ‘cognitive process’. Rose’s story does not ask the listener to engage in cognitive processes. She does not pose a problem or challenge that needs to be resolved throughout the story. Rose rather asks her audience to remember a time when people did not have toilets in their homes.

Lastly, if we look at words related to plot progression highlighted in green, we see that there are many of them distributed throughout the story. Indeed, there are so many that it would be better to use a quantitative approach to see the changing word use throughout the story. To do that LIWC offers diverse options such as giving the percentage of words appearing from a given category (like function-words) in a sentence, or in a paragraph, or the whole document.

4.4 Comparison datasets

To generate a baseline for datasets that contain short stories we made use of three existing comparison datasets. The reason for this was twofold: First, we would like to test if Boyd et al.’s (2021) hypothesis that certain LIWC categories capture certain parts of a narrative arc would work in conversational datasets, not just in single person monologues (Boyd et al used TED talks and Courtroom orders as data). So, our first question is: How does the conversation dimension affect how stories are told?

Second, since LIWC counts words given in a specific category, words used specifically during a conversation, such as filler words, does not constitute a problem. But since we extract only one utterance from a conversational flow, the different narrative markers of a story (staging, plot progression, cognitive tension) may occur over multiple utterances and hence be missed. So, our second question is: What is the effect of the length of a story?

Boyd et al. (2021) cap the minimum length of a story at 250 words, but conversations are dynamic, with turn-taking between participants, and utterances with more than 250 words rather rare. Still, a short story can be easily sketched with less than 250 words. If a story is told in less than 100 words, can LIWC still discern a change throughout the 5 story segments in relation to the 3 narrative elements?

Our first comparison dataset, known as the ROC stories, is a written corpus containing 50,000 stories, each five sentences long, and generated using Amazon Mechanical Turk as part of a study looking at automatic story closure by Mostafazadeh et al. (2016) at ROChester university (hence ROC). The
sentences in these stories are brief to the point that a story has usually word counts around 60-80. The ROC corpus has two important features: it imitates the causal and temporal common-sense relations that are found in daily events, coming close to mini stories that are told in everyday life. Even though these stories contain no conversational phrasing, due to their briefness they are expected to be similar to stories told within the flow of a conversation.

Our second dataset is the IMDB corpus, mentioned earlier in the paper, which contains 1068 movie scripts (Danescu-Niculescu-Mizil and Lee, 2011). The scripts are formatted to show the movie title, speaker, and the utterance. For the purposes of this research no further formatting is needed.

Our third dataset contains 20 years of radio interviews on the US National Public Radio (NPR) network and contains the transcriptions of over 10,000 hours of audio interviews (Zhu et al., 2021). The transcripts are formatted with the program name, session, and the speaker along with the utterance. We assume that, even though both the NPR and IMDB datasets are scripted in some form, they are a close approximation to everyday conversation.

We follow the same pre-processing steps that we applied to the combined DTRS dataset. For both the IMDB and the NPR datasets, we filter for utterances which were above a certain word count (WC). As these datasets are considerably larger than the DTRS datasets, we set the threshold to utterances with more than 140 words. After this filtering, the NPR dataset yields 8048 utterances, and IMDB 145 utterances. The results of filtering reflect the differences in the average utterance length of these datasets, and of course the differences between the different types of conversation flows. Before filtering NPR consists of 105258 utterances, so the dataset contains lengthy utterances. In comparison, IMDB dataset has almost three times more utterances with 304713, but most of the utterances are short, and the 140 WC threshold yields only 145 results. The utterances in the ROC dataset are more-or-less identical in length so we did not do any further filtering and randomly picked 10000 stories for our analysis.

To show the similarities and differences between the stories in our three comparison datasets, we show some an example from each one of them. The five sentence length ROC stories have the expected story-arc elements, i.e., a beginning, a middle and an end:

**An example ROC story:**

“Jennifer has a big exam tomorrow. She got so stressed, she pulled an all-nighter. She went into class the next day, weary as can be. Her teacher stated that the test is postponed for next week. Jennifer felt bittersweet about it.”

In comparison, the IMDB dataset contains stories that are more diffuse: sometimes the beginning or end is not so clear as the conversation takes a different turn, or the story is packed with filler words asking for participation from other speakers:

**An example IMDB story:**

“There was this kid that I grew up with; he was a couple years younger than me, and sort of looked up to me, you know. We did our first work together, worked our way out of the street. Things were good and we made the most of it. During prohibition, we ran molasses up to Canada and made a fortune; your father too. I guess as much as anyone, I loved him and trusted him. Later on, he had an idea to make a city out of a desert stop-over for G.I.’s on the way to the West Coast. That kid’s name was Moe Greene, and the city he invented was Las Vegas. This was a great man; a man with vision and guts; and there isn’t even a plaque or a signpost or a statue of him in that town. Someone put a bullet through his eye; no one knows who gave the order. When I heard about it I wasn’t angry. I knew Moe; I knew he was headstrong, and talking loud, and saying stupid things. So when he turned up dead, I let it go, and said to myself: this is the business we’ve chosen. I never asked, who gave the go ahead because it had nothing to do with business.”
NPR stories are similar to those of IMDB, especially when the speaker that tells the story is not a radio host, but they are more natural in terms of everyday conversation, with false starts, casual reflections, and repetition:

An example NPR story:

“I walked in and then I looked around. And I realized I was really out of place. These people were at an audition. I mean, the girls had make up. The guys had these sick outfits on. And I look like, pretty much, an athlete that just left the gym, un-showered - oh well. The music comes on and let me tell you guys. I was freaking living in these dance moves. I was like, I don't care what happens. They're going to remember me, even though I don't even live here. So there was like 200 people at this audition. At the end, there ended up being seven guys and five girls. And they put us on video and they were like, you know, if we want you, we'll give you a call in a couple weeks. And I literally left there like, whatever, this doesn't matter. I don't even really care. I went back home to New Jersey. Two weeks later, I was at the laundromat with my pocket full of quarters, when I got the phone call that the agency wanted me to move to LA to pursue a career in dance. So, I get there, I was dancing, I did some TV shows. I did some musicals. I was teaching a dance class and my dance class at the gym was really popular. So my big break came when a friend called me and said, hey, there's this company named Beach Body that wants you to see if you can develop a project with them. So, I go into the Beach Body office. I ended up being there for two hours and that day I left with my contract for Hip Hop Abs.”

As with the DTRS dataset, we used the LIWC AON without overlap dictionary to analyse the three comparison datasets. For the ROC dataset, each story is already clearly defined so can be used as a baseline for the other datasets. The ROC story dataset does not have any conversational noise and, even though short, contains the basic elements of staging, plot progression, and cognitive tension as well as having emotional valency. For all datasets AON automatically calculates articles and prepositions separately and reports them as “staging”. These words are expected to be used more in the first segment of a story. The rest of the function words (i.e., pronouns, auxiliary verbs, negations, conjunctions, and nonreferential adverbs) are calculated separately as well. These relate to plot progression and are expected to be higher in the middle of a story. Cognitive words are expected to follow a similar curve to plot progression and are the last category that is extracted using AON.

We remarked earlier that the stories told during conversations in the DTRS dataset do not necessarily neatly contain all elements that are used in defining what makes a story; these we define as ‘snippets’. One simple difference is in the type of words used: during conversation words that acknowledge the audience, or the interruptions that come from the other participants of the conversation, are common. The stories are often short with sometimes just a short story snippet enough to make the other participants take on the remainder of the story. A simple description of a character, a place or an object can be enough. This raises the question: Will AON categories capture all or some part of the conversational stories in the DTRS dataset?

5 Results

5.1 The narrative arc of conversational stories

For all four datasets the LIWC tool splits each story/utterance into five equal-sized segments. For each segment, the sum of all words relating to the narrative markers of ‘staging’, ‘plot progression’ and ‘cognitive tension’ are calculated and divided by the number of total words for that segment, giving a normalised percentage figure for each narrative marker. A mean percentage is then calculated
across all segments for each narrative marker. The results for each segment are then expressed as the standard deviation from this mean. This means that even if stories do have differences in length or have a higher percentage of word use in a certain category, they still remain comparable. The mean of all standard deviations for a particular segment, across all stories in the dataset, forms the final number on the y-axis shown in Figure 2. Table 2 shows an example of how this works for one story only.

**Table 2.** An example calculation of LIWC results for one story/utterance. Each segment is normalized by calculating the standard deviation from the mean of all segments for each narrative marker.

<table>
<thead>
<tr>
<th>Segment 1</th>
<th>Segment 2</th>
<th>Segment 3</th>
<th>Segment 4</th>
<th>Segment 5</th>
<th>Mean %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staging (%)</td>
<td>12.50</td>
<td>12.50</td>
<td>20.83</td>
<td>4.17</td>
<td>38.10</td>
</tr>
<tr>
<td>Normalized Staging (Standard Deviation from mean percentage figure)</td>
<td>-0.40</td>
<td>-0.40</td>
<td>0.25</td>
<td>-1.04</td>
<td>1.59</td>
</tr>
</tbody>
</table>

As noted previously, the DTRS, NPR and IMDB all contain various conversational filler words. The DTRS stories have the highest number, with utterances almost always starting with a turn-taking event acknowledging the previous utterance. As we have not cleaned the data for such conversational effects, we therefore expect to see certain differences from the ‘5 segment’ hypotheses relating to Boyd et al. (2020). Since, even though such filler words are not counted, they do take up space. If the first two sentences in an utterance are only conversational such as: “Well, yeah. I don’t know, maybe… But if you think… Let me put it this way…”, the first segment of the utterance will, then, have no staging words, which will appear later. Looking at the results for DTRS (top, left in Figure 2) for example, we see that staging starts in the second segment, rather than the first. Cognitive tension is highest in the first and lowest in the last segment, as the start and end of an utterance relates more to a change in speaker than to the story narrated within the utterance. We should also emphasize the confounding factor that the DTRS data shown in Figure 2 is for both story snippets and stories.

IMDB stories do also contain filler words, but not necessarily in the same way as the DTRS data. In contrast to DTRS, IMDB stories are often presented through monologue, and hence the narrative processes can appear similar to classical stories. Lastly, NPR stories, especially if coming from program hosts, follow a written narrative arc the best, though the 8000 utterances do contain a wide variety. ROC stories should in theory all have the same style, all being created from the same rule of being 5 sentences long and should mimic a classical narrative arc. So, we expect to see the most fluctuations from the norm in the DTRS dataset, followed by IMDB, NPR and ROC. Figure 2 shows that among all datasets NPR (bottom, right) comes closest to the expected narrative arc. After the first part of the story, words related to staging are used less and less, and the words for plot progression and cognitive tension are used more and more. The cognitive tension words are not used as expected, i.e., in the middle, and in general their usage is quite low.

ROC stories do follow the narrative arc for the plot progression and cognitive tension narrative processes, but not so much for staging which stays relatively constant. For both the IMDB and DTRS datasets we can say that although the ‘staging’ narrative process does take place, the ‘plot progression’ and ‘cognitive tension’ narrative processes do not follow any meaningful arc.
5.2 The emotional arc of conversational stories

Even though DTRS, IMDB and NPR are conversational datasets, their emotional tone is likely to be quite different. Of the three datasets, DTRS contains conversations recorded at various stages of the design process, and the stories (or story snippets) are told largely to further those design processes. As observed by Lloyd and Oak (2017) and described in the beginning sections of our paper, stories can be used to frame or negotiate “value tension” within the design process. By looking at the emotional arc of conversational stories, we explore the question of whether or not this putative ‘value tension’ brings with it positive or negative emotional content in the terms discussed earlier of Malin et al. (2014).

In contrast to DTRS stories, IMDB and NPR stories are told with a variety of purposes and to a far wider audience. IMDB, mimicking everyday life, has stories that enhance character, motive, and the overall plot of the film. NPR on the other hand is a radio program reporting newsworthy events along with everyday happenings. The appeal to a wide and diverse audience means that the use of emotional toning may be more pronounced in these datasets. The ROC stories are the shortest stories so their emotional arcs might be difficult to capture using this technique.
Figure 3. Positive and Negative Emotional Arcs for the DTRS, IMDB, ROC and NPR Datasets. The x-axis shows the segments, the Y-axis shows the mean standard deviation for each segment across all dataset stories, (narrative markers for each segment for a single story are calculated as the standard deviation from the mean percentage value of one narrative marker across all segments.)

Figure 3 shows the results of looking at emotional valence through the five segments of the stories identified in each dataset. For the DTRS stories (top, left) there is a regressive emotional arc, i.e., both for positive and negative emotions there is a fall throughout the stories and snippets. Conforming more to expectations, the IMDB stories (top, right) have a rise-fall shape emotional arc for negative emotions, with the opposite fall-rise shape for the positive emotional arc. This might indicate that in general the IMDB stories have happy endings.

With the NPR stories (bottom, right), the negative emotional arc is steadily rising but more or less stable, whereas the positive emotional arc demonstrates a fall-rise U-shape which can define a more dramatic affective trajectory, but again, largely ending happily. ROC stories do not show a clearly defined trajectory, though it is notable that both positive and negative emotional tone rises significantly during the fourth segment (sentence) of these stories.

For both Figures 2 & 3, although we can discern narrative shapes for the four datasets, they are much less significant than those reported by Boyd et. al. (2020). This may be due to their conversational nature (DTRS, IMDB, NPR) or length (ROC) making the variation of results very high and leading to generally low mean standard deviation rates. Boyd et. al. (2020) report differences of 2 standard deviations, while the biggest difference we found was 0.35 for narrative processes (DTRS) and as low as 0.03 for the emotional arcs (ROC).

6 Discussion and conclusion

Our overall aim in this paper was to create a corpus of the DTRS shared datasets and explore this in relation to well-established concepts relating to design activity. Previous DTRS studies have largely been within a set of data, but building a corpus allows us to compare design activity with other types of activity to reveal more general regularities. We showed how design activity differs from other
datasets by applying the LIWC dictionary to find that in general design activity demonstrates a closer relationship between time, space, cognitive process (problem solving) and verb (activity).

We went on to explore (and attempt to validate) one aspect of design discourse (and DTRS data) identified in previous studies, that of ‘storytelling’, to see what results a corpus level analysis might yield. We drew on very recent work using LIWC to look at stories, and again used comparisons with different corpora to explore the shape of narrative and emotional arcs in conversational datasets (as well as in DTRS). Even though previous studies indicate that systematic/automatic ways of tagging stories can yield significant results, our study did not manage to replicate these results in conversational data. We discussed why the need to maintain turn-taking in conversation may interfere with clearly defined stories. Story length also proved to be problematic, with very short stories not having enough linguistic markers to reflect the same scale of the narrative and emotional arcs captured for longer stories.

Before concluding that it is not possible to capture the stories that previous studies of design activity have identified, we must look at the methodology we used to recognise and calculate narrative markers. Though consistent with the literature, fixing utterance length and having equal segmentation may not be suitable for conversational datasets, particularly smaller ones, where stories are likely to be told over multiple utterances. As we noted, this tends to result in story snippets, rather than entire stories. In future studies we will explore the possibility of more dynamically identifying and extracting story shapes of narrative markers independent of fixed utterance and segment size.

LIWC has advantages that are hard to beat. LIWC as a tool is very easy to use, requiring no technical knowledge. The categories of LIWC need to be understood at the conceptual level: for example, what does it mean if someone uses more first-person pronouns? Or what happens linguistically when someone is describing an object? By studying example datasets, one can get acquainted with how these categories are distributed in different type of speech, writing, or even by individual speakers. Combining the use of categories as done by van Laer et al. (2019) enables one to generate complex models to analyse text by simply counting words.

What we hope to have shown in this paper is a new way to think about, and analyse, design protocol data on a larger scale than previously. As more and more datasets become available, the techniques we have used in this paper will become more common in determining how different kinds of design activities are constituted in text, and how they compare with other types of textual data. Our longer-term goal is to create a design dictionary as part of LIWC, to identify designerly ways of talking in large datasets.

In conclusion, although using a LIWC analysis to explore the DTRS data shows considerable promise, we found it difficult to validate the existing concept of storytelling (Lloyd & Oak 2018). Whether this would equally apply to concepts like ‘framing’ and ‘co-evolution’ is an open question, but the conversational nature of the data is likely to be a confounding factor, so methodology needs development. The question remains open as to what type of stories designers typically tell, and how they go about telling them. Despite this, we have shown how an automated method for identifying stories could work. Constructing a corpus of the DTRS shared data and comparing it with other large datasets outside of the design discipline is a further step on the way to understanding design thinking in conversational contexts.

References


A computational analysis of tentativeness and causation in design talk

Senthil Chandrasegaran\textsuperscript{a}, Almila Akdag\textsuperscript{b} and Peter Lloyd\textsuperscript{a}

\textsuperscript{a} Faculty of Industrial Design Engineering, TU Delft, Delft, The Netherlands, \{r.s.k.chandrasegaran, p.a.lloyd\}@tudelft.nl
\textsuperscript{b} Department of Information and Computational Sciences, Utrecht University, Utrecht, The Netherlands, a.a.akdag@uu.nl

Abstract. Analysing records of design activity such as transcripts or documents have typically involved close reading of transcripts and manual identification of concepts and behaviours. We explore the applicability of a machine-learning based computational tool—called Empath—in identifying high-level patterns in design talk. Specifically, we use it to examine the datasets from the Design Thinking Research Symposium (DTRS) workshops for two contrasting aspects of design talk—the expression of tentativeness that characterises designers’ exploration of the problem-solution space, and the expression of causal reasoning that characterises designers’ analytical thinking. We find that such a tool can be effectively used as a means of “distant reading”. However, the lack of design relevance in the tool’s training data results in ambiguities and mis-categorisations that still need resolution through close reading.

Keywords: Computational Linguistics, Conversation Analysis, Design Talk, Design Thinking, Machine Learning

1 Introduction

Is design activity characterised by an equal balance between tentativeness and speculation on the one hand and by evaluation and justification on the other? Models of designing that describe a ‘basic’ cycle of activity generally describe projective activity, characterised by tentativeness or epistemic uncertainty, followed by explanatory (or rationalising) activity, characterised by evaluation and justification (Lloyd, 2019). For example Schön’s (1992) description of designing as a series of reflective ‘moving experiments’ is premised on the idea that something has to materially be put into the world before the understanding of its implications can take place and therefore be justified. Similarly, Roozenburg (1993) describes a process initiated by the logic of abduction prior to a deduction of consequences. An equivalence of projective and explanatory processes in design activity is suggested by these models but is this borne out in actual practice? To attempt to answer these questions, we examine an aggregation of four datasets that resulted from the Design Thinking Research Symposium’s shared-data workshops, and computationally categorise sections of the data as indicative of tentativeness and of causation. We then observe patterns in which these two categories occur across sessions and examine the contexts in which they occur together or separately. In doing so, we also explore the advantages and disadvantages of modern computational analysis tools that can supplement a close reading of text.

Over a period of nearly 30 years the Design Thinking Research Symposium series (Cross, 2018) has conducted four shared-data workshops, generating data from design activity of largely professional designers in a number of different study conditions. These datasets include think aloud protocols (Cross et al., 1996), naturally-occurring designer-client discussion (McDonnell & Lloyd, 2009), design education (Adams et al., 2016), and naturally-occurring co-creation (Christensen et al., 2017).
The disciplines of design from which this data has been generated have been industrial design engineering (DTRS2), architecture and engineering design (DTRS7), design education (DTRS10) and product design (DTRS11). Sec. 2 provides a short summary of each workshop.

In previous work (Lloyd et al., 2021) we have explored the idea of epistemic uncertainty using Linguistic Inquiry and Word Count (LIWC) (Pennebaker et al., 2015), a tool with pre-defined and curated lexical categories used to tag, categorise, and classify text based on the association of the text content with these categories. Specifically, we focused on the ‘tentative’ subcategory of LIWC where we found words associated with hypothetical, tentative thinking such as “if”, “maybe”, “might”, “perhaps”, “possibly”, and “probably”. The use of a term from this set is typically an indicator that the designer is considering or suggesting the exploration of a possibility or future conditional. For example, in the discussion between an architect and their client concerning the design of a crematorium (DTRS7) the architect asks:

“...did you see this as a space that might have its own small lectern in it or some altar-like feature inside it?”

In this and a sister paper for DTRS13 (Akdag-Salah et al., 2021) we draw on a corpus resulting from the combination of the four shared-data DTRS workshops to computationally explore the concepts of “tentativeness” and “causation” related to designing found in prior studies. In doing so, we also explore the pros and cons of such a computational approach when used to analyse concepts relating to designing. This is something that has only recently become relatively easy to do, with analyses of designers prior to this mainly focusing on smaller design ‘protocols’, and the manual identification of textual excerpts to identify new concepts. This traditional way of analysing design activity is akin to “close reading”, a term in literary research where the goal is to focus on specific arguments, individuals, or ideas and trace their evolution across the document(s) (Jänicke et al., 2015). In contrast, “distant reading”, a term coined by Moretti (2005) is an approach to take a global view of a text or texts, visualizing its (or their) global features. Distant reading thus relies on computational analyses of large text, the results of which are presented graphically in the form of simple charts or complex data visualizations.

Our examination of tentativeness and causation outlined above follows this distant reading approach at first, looking at global patterns of occurrence of these categories across datasets and sessions. Specifically, we use a tool called Empath (Fast et al., 2016) and its pre-trained machine-learning model to first generate lexical categories containing words corresponding to the notions of tentativeness and causation, and then find matches between these categories and speech turns in the dataset transcripts. We then drill down to patterns of interest and examine them through close reading to critically interpret not only the context of the exchange underlying the patterns, but also the accuracy of the computational approach used to identify the patterns. We posit that such an approach can help expand the contexts in which one might expect to find instances of design thinking and help train the next generation of artificial intelligence (AI)-based conversational systems to recognise designerly talk.

2 The DTRS Dataset

The DTRS series (Cross, 2018) has held a series of “common data workshops” that have resulted in four shared datasets, created with a view that different perspectives, methods, and theories can be proposed and tested using these common data. The four datasets cover the disciplines of industrial design engineering (DTRS2), architecture and engineering design (DTRS7), design education (DTRS10), and product design (DTRS11). Some details about the datasets are provided below.

DTRS02 consists of one 2-hour ‘think-aloud’ design session with a single designer and another 2-
hour session featuring a team of three designers. Both sessions work on the same design problem, a cycle pannier, verbalising their thoughts.

**DTRS07** consists of four 2-hour meetings of ‘naturally-occurring’ design activity. Two of the meetings feature an architect communicating his designs to his client. The other two meetings feature a multidisciplinary design team discussing initial ideas for a ‘digital pen’.

**DTRS10** consists of 38 videos of varying length showing design reviews in five disciplines (industrial design, mechanical design, service-learning design, entrepreneurial design, and choreography). The videos are diverse and feature a range of interactions, but are primarily based around teacher-student discussion, both individually and in teams.

**DTRS11** features 20 video recordings, again of varying length (up to 45 mins). In the first sessions the design of two co-creation session for a large car manufacturer are discussed. The co-creation sessions are filmed, and these are followed by videos discussing the co-creation sessions and the possible design products that might result.

Table 6 shows the session numbers and lengths for each of the four DTRS corpora. At a combined 373,983 words, these datasets—specifically the types of discussions—provide a composite picture of design activity. Together, the corpora provide opportunities for examining different kinds of discussions at scale. However, most contributions that have arisen from the transcripts and videos have involved close reading and manual analysis of specific datasets and sessions. These contributions, such as analyses of framing (Dong et al., 2017), storytelling (Lloyd & Oak, 2018), and spiderwebbing (Mabogunje et al., 2009), provide conclusions in the form of hypotheses that need testing with larger datasets.

### Table 6. Dataset Statistics

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Sessions</th>
<th>Dataset Size (words)</th>
<th>Session Size (words)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>DTRS2</td>
<td>2</td>
<td>37,969</td>
<td>18,984</td>
</tr>
<tr>
<td>DTRS7</td>
<td>4</td>
<td>68,861</td>
<td>17,215</td>
</tr>
<tr>
<td>DTRS10</td>
<td>38</td>
<td>92,751</td>
<td>2,441</td>
</tr>
<tr>
<td>DTRS11</td>
<td>20</td>
<td>174,402</td>
<td>8,720</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>373,983</td>
<td>5,843</td>
</tr>
</tbody>
</table>

### 3 Methodology

To illustrate our approach of using computational tools to examine designerly ways of thinking, we look at two kinds of behaviours that have been examined in prior research through close reading and qualitative text analysis. The two behaviours we focus on are expressions related to causal reasoning—where designers express or enquire about the reasoning behind decisions or observations (Cardoso et al., 2014)—and tentativeness—where designers use downtoners and other expressions of vagueness to soften their language to strengthen social ties (Glock, 2009) or to express epistemic uncertainty (Ball & Christensen, 2009). Using a tool such as LIWC provides a scalable alternative—or at the very least, a complementary approach—to close reading, which has been the traditional way to analyse such transcripts. With LIWC, one can identify the parts of the transcript that contain terms that are indicative of “movement”, “positive emotion”, “cognitive processes” or any of the 91 categories and sub-categories pre-defined in LIWC. A simple way that LIWC achieves this is by looking for words in the transcript that match words defined in a category of interest.

However, predefined lexical categories may not always match categories that researchers are seeking to identify for their work. For instance, in our prior work, we found that the LIWC subcategory of
“tentative” did not exactly match the ways in which tentativeness was explored in the DTRS datasets (Lloyd et al., 2021). Empath (Fast et al., 2016) is a tool that seeks to address LIWC’s limitations of a predefined set of categories that may not address a researcher’s specific requirement. In contrast to LIWC’s human-generated and curated categories and associated dictionaries, Empath provides a set of nearly 200 machine-generated categories that are then validated by humans. Empath also provides users with the ability to generate a new category by supplying seed terms that they think are associated with the intended category.

Empath’s pre-defined categories are generated from dependency relationships in ConceptNet (Liu & Singh, 2004). Terms in each category are generated from seed terms that are in turn used to query a vector space model, which is a representation of documents as vectors in a high-dimensional space such that proximal vectors represent similar documents. The vector space is created by mapping the neural embedding of a neural network based on a skip-gram architecture (see Mikolov et al., 2013) trained to predict words that co-occur in a large corpus of text. Empath uses a dataset of modern fiction1 as the training corpus, as it (a) provides a better breadth of topical and emotional categories, and (b) correlates better with the categories defined in LIWC than corpora containing news articles or online discussions.

To generate a new category, the user provides a category name and a set of seed terms. Empath first generates vector representations of seed words based on the vector space model and sums the vectors to create an “analogy” vector that represents a combined association with all seed terms. It also queries the space for a vector corresponding to the category name and adds it to the above analogy vector. The vector space in the neighbourhood of this analogy vector is queried to find additional terms related to the category. For instance, providing a list of seed terms such as “twitter”, “instagram”, and “facebook” and a category name of “social media” returns such additional terms as “timeline”, “hashtag”, “notifications”, “direct message”, and “Tumblr”, all of which are terms associated with social media.

In this section, we describe our use of Empath to create lexical categories seeded with terms associated with tentative thinking and causal reasoning. We then use these categories as lenses with which to examine the DTRS datasets.

<p>| Table 7. Data format of the combined DTRS datasets used for the analysis in this paper |</p>
<table>
<thead>
<tr>
<th>Dataset</th>
<th>Session</th>
<th>Speaker</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTRS-02</td>
<td>Think-aloud</td>
<td>Interviewer</td>
<td>“Before I give you the design brief, are there any questions about the procedure?”</td>
</tr>
<tr>
<td>DTRS-02</td>
<td>Think-aloud</td>
<td>Dan</td>
<td>“Um No, other than the... I have these two references here, the file of information that you have Um.. I will just ask you for..what?.. identify..I say what kind of technical information I want?”</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>DTRS-11</td>
<td>Follow-up interview</td>
<td>Interviewer</td>
<td>“I understand that, alright, that was the end of it, eh anything you want to add? We’ve been through a lot, so I am gonna let you go”</td>
</tr>
<tr>
<td>DTRS-11</td>
<td>Follow-up interview</td>
<td>Ewan</td>
<td>“(laughs) no, I think I’m okay, I think that makes sense eh not anything related to this at least”</td>
</tr>
</tbody>
</table>

1 https://wattpad.com
3.1 Processing the Text

The transcripts for all 64 sessions across the four DTRS datasets were cleaned to remove time stamps, location descriptions, and descriptions of any seating arrangements since our focus was on the content and context of what was being said. For this same reason, in-line descriptions of subjects’ actions such as pointing, or gesturing were retained. The transcripts were combined in such a form as to enable analysis of the combined dataset, while still being able to filter for individual datasets, sessions, or speakers. The format of the data set up for analysis is illustrated in Table 7. As shown in the table, the order of rows follows the order of speech turns from each session’s transcript.

3.2 Creating Lexical Categories

To choose appropriate seed terms to create the lexical category of “causation”, we refer to Cardoso et al. (2014) and their study of the DTRS10 dataset involving design feedback sessions between students and instructors. The study revealed that questions that help students think about their design rationale, the potential effects of their design choices, their interpretation of related phenomena, and other forms of “deep reasoning questions” aid students’ reflection on their state of design. While their work involved qualitative coding of the transcript through close reading and reviewing of the corresponding video recordings, we attempt to explore the occurrence of such questioning or expressions of reasoning through a lexical category that we create through Empath.

Focusing on the “causation” (why) and “procedural” (how) components of rationale, we input seed words such as “because”, “effect”, “explain”, “how”, “why”, etc. to generate a category called “Causation” using Empath, resulting in a lexical category with the following 84 terms:

- because, given, moreover, regardless, though, yet, affect, affected, affecting, affects, appeal, attachment, basis, causes, circumstance, complication, concerning, conclude, conditions, consequence, consider, context, conversion, crisis, critical, crucial, depends, determine, disastrous, downfall, effect, effected, end result, essentially, experience, explain, extent, function, illness, implies, imply, influence, justify, killing, kind, knowing, magnitude, main problem, mean, meaning, means, meant, mental state, method, might, mindset, motive, necessity, occur, outcome, part, possibly, potential, predict, proves, purpose, real problem, reason, regardless, relation, relevant, result, side effects, significance, significant, situation, specifics, suppose, surely, telling, terms, therefore, though, understand

Though some words such as “illness” do not quite fit into the intended lexical category—and while the category can benefit from removal of such terms—for the sake of replicability and to highlight the shortcomings of such approaches, we make no modification to the generated set of terms.

The second lexical category of “tentativeness” is motivated by an emerging sub-field in design research known as “epistemic uncertainty”. This is the idea that creative behaviour is triggered in situations of uncertainty to lessen that uncertainty and progress the design process (Ball & Christensen, 2009; Ball et al., 2010; Cash & Kreye, 2018; Christensen & Ball, 2018; Christensen & Schunn, 2009; Paletz et al., 2017). Prior work examining the DTRS7 dataset (Ball & Christensen, 2009; Glock, 2009), the DTRS11 dataset (Christensen & Ball, 2018), and other studies (Cash & Kreye, 2018) have shown that designers typically use downtoners, hedges, modal adverbs and other expressions of tentativeness to express such uncertainty. This is linked to Schön’s model of “naming, framing, moving, and evaluating” (Schön, 1984) where a designer makes educated guesses and suggestions as a way of moving forward in the design process. In our prior work (Lloyd et al., 2021) we examine tentative aspects of design conversations and find expressions of possibility such as modal adverbs (e.g., could, might, probably) to occur prevalently across all DTRS datasets. Using seed terms such as “if”, “maybe”, “might”, “perhaps”, “possibly”, “probably”, etc. in Empath, we
use the category name of “Tentativeness” to generate the lexical category corresponding to epistemic uncertainty that includes the following 59 terms:

able, actually, afraid, also, although, any, anyone, anything, anyway, assume, assuming, because, besides, case, definitely, doubt, either, else, exactly, expect, figured, guess, hoping, however, if, knew, knowing, maybe, mean, meant, might, must, now, obviously, only, or, otherwise, perhaps, personally, plus, possibly, probably, should, so, suppose, supposed, sure, surely, though, thought, unless, wanted, well, whether, willing, wish, wonder, wondering, yet

We refer to this category as “tentativeness” in this paper rather than “epistemic uncertainty” for two reasons: to connect to LIWC’s “tentative” subcategory under “cognitive process” explored in prior work (Lloyd et al., 2021), and because the category name provided in Empath also influences the words generated. Since Empath is trained on domain non-specific text like fiction, “tentativeness” is a more interpretable category than “epistemic uncertainty”.

Using discussion turns as the unit of our analysis, we counted the number of matches between each lexical category and the words in the turn, and normalized the count for every turn, dividing the number by the total words in the turn. We only looked for whole word matches and chose not to lemmatize the words, neither in the turns nor in the lexical categories, as the sense of such words (e.g., modal adverbs) is often linked to the specific form of the word. In the following section, we use the measures of matches between speech turns and the two lexical categories created to examine the question of whether design activity is tentative or rational. We attempt to answer this question at different levels of aggregation: at the level of the dataset, sessions, and then individual speakers.

4 Results

Simply counting the number of turns that contain at least one match for each lexical category and normalizing this count with the total turns for each dataset, we immediately see a higher incidence of speech turns that express tentativeness exclusively. In other words, of the turns matching at least one lexical category, most of the turns feature a match with tentativeness while having no matches with causation (Figure 4). The next highest set of matches belong to turns that match both categories (tentativeness and causation), while only a small number of turns match exclusively with causation.

At the dataset level at least, design discourse appears to be characterised more by tentative thinking than it is by thinking about cause, effect, or rationale.

Figure 4. The proportion of speech turns in each dataset containing terms from the lexical categories of tentativeness, causation, and both. The highest proportion of the matched speech turns fall exclusively under tentativeness, followed by turns matching both categories. Only a small proportion of turns fall exclusively under causation.

Figure 5 shows a general overview of the degree of correlation between the two lexical categories for the average turn in each dataset. Each dataset is represented by a scatterplot, with each dot in the scatterplot representing a turn of speech, and the dot’s x- and y-positions corresponding to the normalised count of matches between the words in the speech turn and the lexical categories of
tentativeness and causation respectively. The slope of the regression line confirms what we see in Figure 4: on average a turn contains more matches with the tentativeness category than with the causation category. The counts for tentativeness and causation are not normally distributed, so correlations were computed using Kendall’s $\tau_b$.

![Figure 5](image)

**Figure 5.** Scatterplots for each dataset showing the normalised number of matches in the “causation” and “tentative” lexical categories for each speech turn. Each dot in the scatterplot corresponds to one speech turn. The x-position of the dot shows the total matches between the words in that turn and those in the “tentativeness” category, divided by the total number of words in that turn. The y-position of the dot shows the corresponding measure for that turn with the “causation” category. A regression line is shown for each plot, with the slope indicating a greater number of matches with tentativeness rather than causation on average for the speech turns. Kendall’s $\tau_b$ coefficients do not show a strong correlation between the two lexical categories for the datasets in general.

Since the chart in Figure 4 is normalized for the number of speech turns, we can compare across datasets and see if it aligns with our understanding of the datasets at this level. Of the four datasets, DTRS10 is the one that involves design reviews as teacher-student discussions. We thus might expect a greater proportion of turns in this dataset centered around causation with the instructors asking questions about design decisions and the students attempting to explain them. However, we see that it is DTRS11 that has a higher proportion of turns related to (a) only tentativeness (close to DTRS2), (b) both tentativeness and causation, and (c) only causation (similar to DTRS10). Perhaps this high proportion of tentativeness and causation is because of the sessions that compose DTRS-11, which include co-creation workshops followed by sessions that involve reflective activities such as debriefing, sharing insights, clustering insights, linking insights to projects, to name a few. We next examine the lexical category matches at a session level to verify some of these conjectures.

![Figure 6](image)

**Figure 6.** Scatterplots for four sessions in the entire corpus that show a moderate to strong association ($\tau_b > 0.34, p < 0.05$) between the normalised number of matches of the two lexical categories of “tentativeness” and “causation”, for each turn. The plot is similar to that shown in Figure 5, including the regression lines and Kendall’s $\tau_b$ coefficients. The plots are coloured by dataset.
4.1 Examining higher incidences of tentativeness and causation

Figure 6 shows four sessions whose speech turns show a relatively stronger association between their matches to both lexical categories. The correlations are moderate-to-strong (Kendall’s $\tau_b$ ranging from 0.34 to 0.63). However, we refrain from making claims based on statistics alone, choosing instead to examine some of the exchanges in the sessions.

Figure 7. Speaker-wise turn counts for the four sessions identified in Figure 6 showing relatively higher association between causation and tentativeness in spoken turns. The proportion of turns that include a match that is exclusively with the tentativeness category (orange), exclusively with causation (blue), and with both categories (purple) are shown. Some anomalies are immediately revealed; for instance, all of Don’s speech turns in Emily’s final review session (DTRS10) have at least one match with the tentativeness lexical category, while Derek and John have no matches at all with the causation lexical category for the same session.

Figure 7 shows the speaker-wise turn counts for these four sessions. Right away, the reason for the correlation is evident: there are almost no speech turns that match exclusively with the causation category, which means that if a turn matches with causation, it almost certainly also matches with tentativeness. DTRS7’s first crematorium meeting has the highest correlation between the two categories and looking at Figure 7, it is possible to guess why: the overlap between the categories is the highest among the four sessions shown in the figure. DTRS10’s client review session for Sharon comes close, but the turn count for the DTRS7 session is an order of magnitude higher, resulting in a stronger correlation between the two.

Examining the turn distribution among the speakers, as well as the proportion of tentativeness and causation (and both together) across speaker turns gives us an interesting perspective of the speakers themselves. For instance, in DTRS7’s crematorium meeting 1, the two most dominant speakers are AA (the client) and AM (the architect). We can see from Figure 7 that a greater proportion of the architect’s turns are associated with tentativeness, which makes sense: the architect is proposing a number of ideas based on requirements posed by the client, and is thus using expressions of tentativeness as part of the “naming, framing, moving, and evaluating” process (Schön, 1984). Consider for instance the exchange below. Words that match with the tentativeness category are highlighted in orange, words that match with causation are highlighted in blue, and words that match with both are highlighted in purple.

AM (ARCHITECT): So you could have your cremulator as a bit at the back of the cremator
AA (CLIENT): Yes, what happens, what happens is when you rake down you rake it in to a cremulator on each machine so you don’t have the removal of cremated remains until they’ve been cremulated and put in to a powder, it’s all done on the machine itself, so you rake it in to an area and obviously the problem with that is that there’s some issues with removal of large metal joints and hip joints and leg joints and other things, and also the concern of servicing each cremulator on each machine, quite a lot involved with it, they haven’t got those quite up and running at the moment so it could be, by the time we get to this it might be, yep.

AM (ARCHITECT): Right, we’ve allowed a cremulator room anyway if you want a separate cremulator that would be like close raking but that would probably used for storing

AA (CLIENT): Where would the operators, would they have a separate office to sit in to, there’s a switch room, control room would it be any, an area, or would the operator sit within that one area.

AM (ARCHITECT): We show a control desk here but certainly if you didn’t need a cremulator room that could easily be converted into a control room, you could even have a glass wall on it if you wanted

AA (CLIENT): Are we talking about the room still being chilled there by the, because that was the original chill room wasn’t it, but that’s not now going to happen

AM (ARCHITECT): No we don’t have a chill room, we have coffins stores as such here because forgot to mention those, the idea was that, erm, that if you did have Sikh funeral you wouldn’t really want to see other coffins hanging around, the idea is that you would store coffins in racks in here

In the above exchange, the discussion around a cremulator—a device that is used for further processing the remains after cremation—follows a pattern of the client declaring requirements and asking questions, with the architect responding to the questions with design proposals or explanations. The responses by the architect show instances of tentativeness (e.g., “that would probably (be) used for storing”) and some causation (e.g., “because... if you did have Sikh funerals you wouldn’t want to see”). The questions and declarations of the client show similar patterns, with tentativeness indicating their interest in alternatives and causation when they are explaining the reasoning behind a requirement. What is interesting here is the text highlighted in purple, indicating that the word (“because” in the above exchange) appears in both categories. This overlap of words is not always the reason why the turns are shared with both lexical categories. Consider an exchange that happens earlier in the discussion between the architect and the council officer (CL).

CL (COUNCIL OFFICER): We’ve got an issue [inaudible] considering following a training session that the staff went on this week at Stevenage crematorium to look at use of the audio, the new audio, digital audio system that had been installed, and a particular issue is the accommodation, and having accommodation where they can work almost like a theatre technician so that they can be part of the service yet be divorced from the service so that they can operate PCs and things but also be in sight of what’s going on, so being more involved. So we’re currently looking at bringing stuff out the back of the existing chapel so that they can sit at a desk away, but part of –

AM (ARCHITECT): Well that’s the desk that I thought they could work at, I saw this as being combined organ and AV control, so someone might sit here and play the organ and there might be

AV controls here, but essentially all the spaghetti and all the amplifiers and CD players, cassette players, you name it, computers could be in here –

The exchange concerns the creation of a space for the crematorium employees for managing the audio/video aspects of a funeral service. As in the earlier excerpt, there is an aspect of causation in the council officer’s request: provide facilities so that the employees might be able to work at the equipment while monitoring the proceedings. The architect’s response is a classic example of speculation and exploration of possibilities with terms such as “I thought”, “might”, and “well”. There is an expression of causal reasoning as well, with “so” and “essentially”—used in the sense of “in effect” here—to explain the implications of the proposed choices. While both turns in the above exchange are categorised as belonging to both tentativeness and causation, it is not because the matched words themselves belong to both categories. When examining the matched words, the sense of causation is evidenced more in the word “yet” rather than the other matches (“part” and “also”).
The main word that conveys causation ("so") forms part of the *tentativeness* category but not the *causation* category. The words "yet" and "might" do overlap, i.e., they are present in the lexical categories of both *tentativeness* and *causation*. We discuss possible causes and the implications of such terms in Sec. 5.

Visualizing the turns aggregated at the level of the speakers for each session also helps us identify any patterns or anomalies. In Figure 7 we saw some patterns, such as the greater incidence of tentativeness-related turns and the lower incidence of turns related only to causation in these datasets. The figure also helps identify anomalies. For instance, Glen and John from DTRS10’s final review session for Tommy speak very less and neither of their speech turns are associated with tentativeness nor causation. This is a less interesting observation, but another anomaly can be seen in Don’s speech turns in another DTRS10 session—the final review for Emily. All of Don’s speech turns in this session—and he is one of the dominant speakers—are associated with tentativeness, either exclusively (orange), or along with causation (purple). In the following excerpts from the session, we focus only on Don’s speech turns, with the rest of the speakers greyed out. We highlight only Don’s speech turns in the way that we did earlier: words that fall under the categories of *tentativeness*, *causation*, or *both*.

EMILY: So you could make it personalized or whatever color material

DON: *Maybe* different tops with the color—

EMILY: Mm-hmm.

... 

STEVE: – start point, could you have a start at one end there –

DON: And then you go back and you put the radius on the top back edge after the fact, *possibly*.

JOHN: Instead of putting a joint there?

[Crosstalk—more than one “Yeah”]

DON: That’s the only way I could see it. Even then, I’m not sure –

... 

DON: *I guess* the question would be is could you do it a little differently again instead of laying entire thickness of sheets of plywood, could you have external solid wood frame cut out, and then your draping the plywood skin to solid wood.

JOHN: So each veneer bowed on you can get tied [unintelligible]

[Crosstalk]

JOSH: Well, we’d have to – well, I mean [unintelligible] –

DON: *Just the outside? I mean* that’s close –well, that bottom one’s probably [unintelligible] Even though these speech turns are largely stripped of context in the above exchange, it is clear that Don is providing some feedback to Emily about colours, finishes, and material for her design. The feedback takes the form of suggestions and not questions: he is not challenging Emily to articulate her rationale but offering ways to perhaps improve her design and share his knowledge, and in this way his role appears to be more of a design consultant rather than a design teacher. The high matches with *tentativeness* are indicative of this role, and the words that are categorised as *causation* are also categorised under tentativeness. These overlapping words—“possibly” and “mean”—in this context are indicative of tentativeness rather than causation.
4.2 Examining lower incidences of causation

In this section, we will examine sessions where spoken turns showed a lower correlation between the two lexical categories. Figure 8 shows four such sessions. In other words, there is no consistent co-occurrence or separation between the two lexical categories for a given speech turn.

Figure 8. Scatterplots for four sessions with low-to-moderate correlation between the normalised number of matches between each turn and the two lexical categories of tentativeness and causation. Kendall’s $\tau_b$ and regression line are shown for each session. The plots are coloured by dataset.

Sessions with the lower correlations tend to belong to the DTRS2 and DTRS11 datasets, while higher correlations are seen in the case of sessions from the DTRS7 and DTRS10 datasets. This is perhaps because there was a greater opportunity to explore questions of causation and tentativeness together in a real-world designer-client discussion (DTRS7 crematorium meetings) or a teacher-student feedback session (DTRS10 datasets), as there would be more opportunities to challenge, question, and explain decisions. In contrast, perhaps co-creation sessions (DTRS11) or individual/collaborative design sessions (DTRS2) offer fewer opportunities to challenge and explain when exploring design processes? Answering such a question requires analysis that is beyond the scope of this work. However, we can examine these four sessions in closer detail to see if they share any patterns.

Figure 9. Speaker-wise turn counts for the four sessions identified in Figure 8 with lower correlations between causation and tentativeness matches. The proportion of turns that include a match that is exclusively with the tentativeness category (orange), exclusively with causation (blue), and with both categories (purple) are shown. A comparison with the sessions in Figure 7 shows a higher proportion of turn counts that match exclusively with the causation category, though this proportion remains the lowest of the three.
Figure 9 shows the turn counts aggregated by speaker for each session. The first attribute of this figure that contrasts with Figure 7 is the greater proportion of “causation only” turns, especially for the dominant speakers. At first glance, this implies that at least some turns in these sessions relate to causation without relating to tentativeness at the same time. Examining these sessions at a turn-level, we see some evidence to support our conjecture about challenging vs. supplementing. Consider the following exchange from DTRS2. The discussion concerns the design of a bicycle pannier, with this part of the discussion concerning brazelons—parts of a bicycle such as water bottle cage mounts, gear shifter bosses, or bicycle pump attachment pegs that are permanently attached to the frame. No matches for tentativeness are evident in this exchange, but the matches for causation and for both categories are highlighted below.

JOHN: Ok they’re a given I, I think we need a solution for people who don’t have brazelons, what if you don’t have them

KERRY: there are solutions for that they they already make little bracket things that kinda

IVAN: Little junk

JOHN: They’re kind like “wree wree” IVAN: Yeah just little junk things that y’can  JOHN: I don’t understand

KERRY: This goes around your tube that comes here

JOHN: Don’t they seem cheesy though to you?

First, the exchange itself is one where one speaker (John) is proposing the exploration of a certain solution space, and then challenging or questioning the suggestions from his teammate (Kerry). Kerry in response explains his solutions to John, who continues to pass judgment. On the face of it, this exchange is understandably one where John’s questions and challenges might be categorised under causation, but let us take a closer look at the words that are tagged. The contexts for the utterances “kinda”, and “kind” suggest the tentativeness and vagueness associated with designerly thinking. Yet “kinda”, which is a contraction for “kind of” is not part of the Empath category of tentativeness, and “kind” is part of the causation category. The final two turns by John asking for explanation and then judgment are closer to a reasonable interpretation of causation. Yet the last turn is categorised as both tentativeness and causation as the word “though” exists in both categories. As we noticed in the previous section, this miscategorisation can be attributed to the overlap of terms in the two lexical categories, though we do find evidence of “causation” in the snippet as a whole.

Compare the above snippet to the following exchange that occurs some minutes later:

JOHN: We can assume Kerry has expert knowledge (laugh)

KERRY: But um we’re gonna need to assume that but since we know the Batavus guys and the buddies with the backpack guy that, um, that we could design for that bike frame end

IVAN: Well, look the frame comes in different sizes, so—

KERRY: Yeah it comes in different sizes but that distance stays pretty constant, maybe we can still make it—

IVAN: Yeah, let’s assume it’s just this horizontal

KERRY: Maybe we can make it independent of this dimension somehow but I’m not sure if that’s—

This exchange is more collaborative: the designers are affirming each other’s suggestions and building on each other’s ideas and assumptions. As is evident from the highlighting, this exchange is entirely categorised under tentativeness. The categorisation here is fairly accurate with the exception of the word “so”, which in this case could be seen as causation—the implication of the frame being offered in different sizes. Thus, a cursory inspection of the categorised turns appears to support our...
conjecture: a stronger association between tentativeness and causation appears to occur when the discussion involves opportunities to challenge, question, and explain. These opportunities appear to arise more when people are explicitly or implicitly involved in roles to challenge or question—such as clients and teachers.

To further support this conjecture, let us examine one final exchange from DTRS-11, involving the clustering insights from a co-creation session.

EWAN: I almost had this golden thing up here, like advertisement wise. ’Cause like everyone can buy a diamond, no one can buy commitment. (laughter) It is– and then it was like the next line “buy the company-product”. (laughter) That was why it failed! “So buy our product!”

ABBY: “It’s not a diamond, but eh”

AMANDA: “It’s the commitment!”

EWAN: Yeah, it’s embodied, it is yeah tangible commitment (laughter)

ABBY: It’s a beautiful commitment!

EWAN: Yeah yeah, yeah. And the thing is- was that we elevate the eh, the kind of the exclusivity and the premiumness to the- it’s not tangible anymore, it is the, it’s a single value,

ABBY: Mhm.

EWAN: Eh, which is far beyond the golden diamond, which is like in the excessive part.

ABBY: (...) yeah.

EWAN: So I write here on the- yeah?

ABBY: But I kind of agree with will or whoever it was, asking if commitment and responsibility are-or how to make responsibility and commitment sexy.

Putting aside the categorisation, we see that the exchange very much follows the affirm-and-build-upon pattern that we saw in the previous exchange. Abby, Amanda, and Ewan take turns to build on a take-away message (“it’s not a diamond, it’s a (beautiful) commitment”) from Ewan’s story and link it to the problem they are working on, which is to make responsible decisions (similar to “commitment”) surrounding the choice of a car to purchase more desirable. We would expect to see more tentativeness than causation here, and indeed we do, except they are not tagged as such. The words “kind of” and “almost” can be association with tentativeness, but “kind” is categorised as causation while “almost” is not categorised at all. On the other hand, “so” and “if”—words associated with causal reasoning—are both tagged as tentativeness.

It is evident that the lexical categories offered by Empath hold promise when applied to design discussion but require refinement when examined at the level of detail of close reading. In the next section, we discuss the implications of our approach and examine ways to address the nuance needed in applying lexical categories that are more relevant to design discussions.

5 Discussion

The goal of this paper was to illustrate the opportunities provided by new computational approaches for analysing design discourse through distant reading. To do this, we examine the balance between speculation on one hand and justification on the other, defining a lexical category of tentativeness as a marker for the former, and causation as a marker for the latter. We use Empath (Fast et al., 2016), a tool that provides a set of predefined machine-generated and human-refined categories and uses machine learning to generate new categories using seed terms. We use prior work on studying causation (Cardoso et al., 2014) and tentativeness (Ball & Christensen, 2009; Christensen & Ball, 2018; Glock, 2009) to provide seed words for Empath and generate the corresponding categories. We
use text-matching at the level of speech turns and aggregate categorised turns, visualising these categorisations at the level of datasets and sessions of interest.

While there is not a strong association between turns being categorised under tentativeness or causation, we find some patterns: higher incidences of both categories are found in sessions where the participants have roles and opportunities to challenge, question, and justify choices in addition to the user designerly approach of exploring the problem and solution space. We thus find a higher proportion of turns containing words from both categories in sessions under DTRS7—especially the exchanges between the client and the architect in the crematorium meetings—and DTRS10—with its teacher-student feedback sessions.

At the other end of the scale, the sessions that show a weak correlation between the two categorisations are characterised by more collaborative exchanges between participants where they affirm and build on each other’s suggestions rather than challenge them. Such sessions—typically those under DTRS2 with its individual and collaborative design session, and DTRS11 with its co-creation sessions—exhibit exchanges more characterised by tentativeness than causation.

When drilling down into these exchanges, we also find cases where speech turns are miscategorised, due to the co-occurrence of words in both categories of tentativeness and causation. A close examination of both lexical categories reveals the words because, knowing, mean, meant, might, possibly, suppose, surely, though, and yet that appear in both categories. Polysemy—the existence of multiple meanings and/or senses for the same word—can be used to explain some of these co-occurrences. For instance, the word “mean” when used in the phrase “I mean” can be indicative of tentative thinking, but when used in a question, say, “What does this mean for the project?” can refer to the effect of a decision or choice. However, it does not explain the association of such words as “because” with tentativeness or “suppose” with causation. Perhaps the limitation is that of the training data. As mentioned earlier, Empath samples the vector space around the combined vector representations of a category name and seed terms. This vector space is created using a corpus of fiction as the training dataset. Are associations of tentativeness and causation in fiction the same as they are in design? Perhaps not. Fast et al. (2016) explain this limitation in their paper with the example of gloveboxes: it is possible that the word glovebox often co-occurs with the word gun in fiction with characters often taking guns out of gloveboxes, creating a strong association between the two that may not exist in other domains outside fiction. Thus, association-based lexical category population would work better if the associations in the training data are similar to the associations in the data to which the model is applied.

With the advent of new vector representations that provide different associations for the same words in different contexts of use (see Devlin et al., 2018), it may be possible to create design-specific word associations by using a vector space trained on design-related corpora such as designers’ interviews, lectures/talks, as well as recordings of design discussions similar to the DTRS datasets. The pattern of examining the data at an aggregate level using visualizations, and then drilling down into detail for a closer inspection and verification of data is one that is well-established in the visual analytics community. Applications for interactive visualizations that combine distant and close reading of text data have gained traction in the digital humanities for examining documents (e.g., Jänicke et al., 2017; Jänicke et al., 2018; Koch et al., 2014) and conversations (e.g., Chandrasegaran et al., 2019; El-Assady et al., 2016). To a lesser extent, these approaches have been applied to examining design sessions (Chandrasegaran et al., 2017a; Chandrasegaran et al., 2017b). In the future, we plan to integrate computational approaches such as Empath with visual analytic approaches such as these to provide a fluid and interactive way for researchers to analyse design discourse at scale.

Our approach of combining distant reading approaches enabled by computational analyses of designers’ speech with traditional close reading approaches has implications for pushing the boundary of our understanding of where design thinking may or may not occur. Qualitative analyses of design
thinking concepts have typically focused on explicitly “designerly” talk such as those captured in the DTRS datasets. There is now emerging work on studying design thinking concepts in ostensibly non-design scenarios such as, say, parliamentary debates (Umney & Lloyd, 2018). Our approach can provide researchers with ways to scale up such studies, to “search” existing records of conversations for occurrences of concepts relating to design thinking. Our work has also the potential for labelling larger conversation datasets, which can be used to train artificially intelligent conversational agents to interact and work with designers productively, especially if the agents can recognise and respond to certain kinds of designerly talk.

6 Conclusion

In this paper, we present an examination of speculation contrasted with justification in design activity at a larger scale than typically conducted for such analyses. To do this, we use a machine-learning-based tool called Empath that we used to create lexical categories of words commonly associated with “tentativeness”—linked to speculation—and words associated with “causation”—linked to justification. By examining the matches between speech turns and these two lexical categories aggregated and visualized at the dataset level, the session level, and finally a close reading at the turn level, we identify patterns of dialogue between designers and clients or design students and their teachers that have a stronger association between speculation and justification. We also find patterns of dialogue between designers in collaborative sessions and co-creation sessions that are mostly speculative and only weakly associated with justification. Both these findings illustrate the value of using computational analysis for identifying patterns across design discourse and analysing associated text via a combination of distant and close reading techniques. Using examples of miscategorisation of speech turns in the same datasets, we also highlight the pitfalls of using lexical analysis incorporating machine learning data (fiction) that is different from the application data (design discussions). We propose a regular updating of such machine-learning models with contextual data, combined with a human-in-the-loop approach to verify the patterns highlighted by computational models. We close by discussing the implications of such work in expanding the boundaries of where one can find instances of design thinking, and in helping train AI agents to recognise and respond to designerly talk.

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3 Cultural and social concerns
Design practice, professional responsibility, and self-enactment

Ariel Guersenzvaig\textsuperscript{a} and Jonathan Ventura\textsuperscript{b}

\textsuperscript{a} Elisava Barcelona School of Design and Engineering, Spain, aguersenzvaig@elisava.net
\textsuperscript{b} Hadassah Academic College, Israel, jonathan.ventura@mail.huji.ac.il

Abstract. This paper argues for a reconsideration of what it means to be a responsible professional designer, all while steering away from examining ethics in terms of obligations and facing the fact that current professional design often involves working in, with, and for the industry. While lenient in its understanding of design, it presents a normative framework that conceptualizes professional design as a practice; i.e., as a coherent, complex, socially established, and cooperative activity with its specific intrinsic rewards and standards of excellence. By discussing responsibility as a virtue, the paper makes the case that a designer’s personal investment in the design profession can be seen as a way of self-enactment, which provides strong motivating reasons for responsible action. The thrust of the argument retains the notion of responsibility understood as the readiness and willingness to convert care into design and to work on the constraining conditions of a design situation or process.

Keywords: care, design ethics, practices, professional ethics, responsibility,

1 Introduction

\textit{I believe that people are far more aware of the impact or import of design than they realize, though they don’t know how to describe it} (Paula Scher, quoted in Millman, 2007, p. 56).

Consider this, construction workers around the world die every day from the lack of adequate protective gear, the negligence of irresponsible managers, or general institutional recklessness. Naturally, the death of a worker is woeful, and the private and public sectors must tackle the issue and implement a plan to reduce this ever-growing death toll fast. However, from a moral perspective, who is responsible for these deaths? The answer is far from self-evident. Because of the number of actors involved, it is very difficult to hold one specific party reasonably responsible. Yet going over an intuitive culprit list, a case could be made that architects should be at the top or even the middle of the list. As planners and designers of our built environment, don’t they possess some level of responsibility for the way their vision is materialized? And on the same note, aren’t graphic designers responsible—at least partially in so far as they create elaborate ways to make consumption better and more effective—for health-related problems, poverty, and the overall addiction to the rush of purchasing something new (not to mention the staggering environmental impact of purchasing an endless parade of useless objects just for the sake of doing so for the right price)?

One possible way for a designer to quickly deal with these quandaries would be to disregard them altogether and pass over the matter. On the other extreme, another direct approach would be to try to find another, less harmful way to earn a living and exit the profession altogether, avoiding thus being tainted by its moral entanglements. Yet, an exit could hardly count as a solution at all as it solves none of the underlying problems it purports to address. Quitting the design profession—whether to move to a spiritual retreat or to work at a ‘green’ company outside the design field—might be individually and socially beneficial, yet effect not so much a deeper change at the professional level as the situation than needs change is fundamentally systemic.
In the following, we shall take a different path and face the fact that professional design in its current state inexorably involves, at some point or another, working in, with, and for the industry. We bite the bullet and don’t argue for an exit of our pledged profession, but for a reconsideration of what it means to be a responsible designer, thus changing the discipline from within rather than exiting it to harbor a stance of grudging outsiders.

For good or bad, the current global pandemic has shaken our fundamental views on human nature, social and communal responsibility. Many of us, as design scholars and practitioners, believe the very foundations of our discipline need to be re-examined and reformulated. In a way, we find ourselves at a historic crossroads, similar to the one presented to the two headmasters of the Ulm School of Design during the 1960s in post-WWII Germany: should designers be agents of the industry, facilitating the production of goods, or should they become a social agent of change (Segal & Ventura, 2019a). Since the dynamics of consumption—perhaps even its very essence—has changed in the COVID-19 reality, we believe the second choice is the most relevant as we find ourselves at a critical juncture. Yet, as practitioners, it’s hard to change things and we still find ourselves working with and for the industry. But this juncture is a chance not to rewrite history, but to look at our profession from a different perspective. Once again, we strive to redefine our discipline echoing the Sisyphean struggle to offer answers for the vexed questions of design—not how to design (which is a technical ‘how’) or ‘what to design’, but rather deciding ‘why to design’ and ‘when not to design.’ Moreover, we need to figure out how can we keep connected to one’s ethical bedrock while still earning a living as a practitioner (this is a moral ‘how’). Facing the current reality, and from a normative perspective these questions can be posed as: what kind of responsible designers should we imagine?

In this paper, we would like to propose a novel approach for discussing issues of responsibility in design, centering our focus on a less-well explored dimension of the professional practice of design, which is its moral kernel. We will offer a normative philosophical perspective to the issue; different, and at times complementary theoretical and analytical approaches can be found in the field of the sociology of professions, but this is not the approach we have chosen here. We shall make the case that a designer’s personal investment in the design profession can be seen as a way of moral development and self-enactment. This investment, in turn, furnishes the designer with strong motivating reasons for responsible action; i.e., reasons ‘for which someone does something, [reasons] that, in the agent’s eyes, counts in favour of her acting in a certain way’ (Álvarez, 2017). To strengthen the analytical validity of our thesis, and to make our case more persuasive, we will provide different quotes from various graphic designers elaborating on their intricate relationship with clients and the industry, which support our conclusions and contribute to the general cogency of our argument. Finally, we hope that this normative conceptualizing of design ethics (understood as the ethics of designing) and of responsibility, in particular, will enable design researchers to theoretically anchor future descriptive, evidence-based examinations of the professional practice.

2 Premises for analysis

Before we dive deeper into the intricate possibilities of integrating responsibility and professional practice, let us introduce and clarify several key concepts, some of which, due to the length and nature of this paper, will not be argued in detail, yet are concisely laid out here as premises for the analysis that will follow.

The thrust of our argument rests on seeing professions in general, and design in particular, as essentially moral projects. Also, by being part of a reflective practice, the ethical considerations and the decisions that are made during design activity are mostly inseparable from the context in which they arise and can thus seldom be explored and resolved beforehand (e.g., by following declarative ethical principles). What’s more, professions, in the classic normative understanding, need to be
understood as being involved in more than just getting paid for a job or doing a job skillfully in a technical sense. Naturally, not all occupations are professions. In philosophical terms, professions could be described as those occupations that are primarily concerned with helping others attain certain strategic goods (for which expert knowledge is typically required) that play a crucial role in their lives. Along this line, some philosophers have argued that ‘A good profession is one which involves a commitment to a key human good, a good which plays a crucial role in enabling us to live a humanly flourishing life’ (Oakley & Cocking, 2001, 74). Though there is no specific and agreed-upon definition of what exactly is a profession, the notion is commonly associated with occupations ‘that both require advanced study and mastery of a specialized body of knowledge, and undertake to promote, ensure, or safeguard some aspect of others’ well-being’ (Whitbeck, 2011, 77).

That professions are not primarily about getting rich can be inferred from the cases of teaching and nursing, which both epitomize commitments to key aspects of human existence while highlighting a negative correlation between social and moral importance and paid salaries. Interestingly, the moment professions transform their venue from the good of society to the good of private players, their moral and ethical structure comes under strain. For example, when healthcare research is conducted under the umbrella of big pharmaceutical companies, or an applied anthropologist conducts research for a big beverage firm, the very ethos of these professions comes under deep questioning. However, in these professions, unlike design, a strong ethics tradition has been established (also in terms of formal oaths and codes of ethics), amidst a lengthy historical process of debate and philosophical interdisciplinary examination of human-centered involvement.

Another premise is that design is a profession, as it falls well within the margins stipulated above for what counts as a profession. Design rests upon a considerable learned body of practical and theoretical knowledge, and its influence on others’ well-being is enormous and undeniable (for a comprehensive discussion, including arguments in favor and against considering design a profession see Guersenzvaig, 2021, 61-119). Design, however, differs from nursing, teaching, and other established professions in two crucial manners. First, it is a rather young professional discipline, and second, it was historically developed to help and contribute to the industry. Famously, Franklin Delano Roosevelt harnessed the evocative power of design to jumpstart the American economy out of its 1929 slump. Dwight Eisenhower took a similar path when mass consumption was presented as a civic duty, and design was mobilized during the Cold War. Top designers of those days such as Buckminster Fuller, the Eameses, and George Nelson actively participated in the American National Exhibition in Moscow (Castillo, 2010, 148-149).

For this paper, we are rather lenient in our understanding of design. On the one hand, it can be understood in a narrow sense associated with form-giving, planning, and creating new material and immaterial artifacts. On the other hand, design can be construed more broadly; i.e., as the prefiguration and reconfiguration of new ways of living, or, in other words, as the envisioning of new possibilities, new ways of being and doing (Dong, 2008; Manzini, 2015). Indeed, contemporary design deals not only with problem-solving, but rather with reshaping and reframing daily situations and activities. Design is everywhere: from the coffee mug upon which we start our day, through the vehicle transporting us to our daily chores, to the digital platform on which we read the news, find entertainment, and communicate with others. The purview of design is located, to paraphrase Ernesto Rogers’ famous dictum, from the spoon to the global supply chain. The upshot is that the designer transcends the simpler task of coupling shapes, materials, and colors to acting as an interpreter, gatherer, and co-shaper of (social) meanings. For example, French designer Philip Starck in a somewhat humorous yet truthful manner accepts the role of the super-star designer as a central player in the global consumer culture. Relating to his famous Juicy Salif, designed in 1991, Starck commented that its purpose is not to help squeeze lemon juice, but something totally different:
Sometimes you must choose why you design – in this case not to squeeze lemons, even though as a lemon squeezer it works. Sometimes you need some more humble service: on a certain night, the young couple, just married, invite the parents of the groom to dinner, and the groom and his father go to watch football on the TV. And for the first time the mother of the groom and the young bride are in the kitchen and there is a sort of malaise – the squeezer is made to start the conversation (Philippe Starck, in Lidwell and Manacsa, 2009: 100).²

The Salif lemon squeezer exemplifies how from a classic Marxist lens design can’t be neatly situated in either the superstructure (i.e., culture, norms, identities, and so on), or in the economic base (i.e., the means and relations of production), but rather as a bi-directionally connecting the two as active shaper and maintainer of both. Along these lines, design is not a mere byproduct of the superstructure. It goes beyond economic causes alone and can rightly be seen as the framing, planning, and conceiving of ‘the complex wholes that provide a framework for human culture [...] to support human fulfilment’ (Buchanan, 2001 p.38). Seeing design as a strategic activity at the intersection of economics, social life, culture, and politics underscores its moral import. The words of Deyan Sudjic (2008: 48) serve to eloquently illustrate design’s significance:

*Design is the language that a society uses to create objects that reflect its purposes and its values. It can be used in ways that are manipulative and cynical, or creative and purposeful. Design is the language that helps to define, or perhaps to signal, value.*

While lenient in our understanding of design, we are not referring here to design as a basic human capability (as a basic functional human trait), but to design as a professional practice. Our locus of concern here is professional designers, i.e., practitioners deeply rooted, albeit not exclusively, in an economic-market-oriented system. Naturally, we must surmise that designers are just one amidst many other players that participate in a design project. Yet, as mediators, professional designers orchestrate a complex motion between generating need, desire, and socio-cultural norms, to technology, modes of production, market value, revenue, and more. In a previous publication (Segal and Ventura, 2019b), the call for ‘value-oriented design’ has been emphasized as a key notion to navigate between the landmines which are design practice. I.e., working inside our trade yet cultivating a clear moral and ethical core. Here we integrate the concepts of responsibility and professionalism to navigate between the conundrums of the practice.

In his landmark study of professions, Schön (1983) emphasizes the substantive field of knowledge commanded by a professional, and the mastery that is required to apply that knowledge. Among the various classic professions, Schön famously highlights the importance of design as a ‘special’ profession, in which the crucial link of the imagined correlates with the real, where the theoretical is interwoven with the applied. Along with design’s unique temporal trait—designers design for a near or distant future while being situated in the present—thus making it crucial for designers to serve as reflective practitioners. Their reflective skills are much needed to navigate the various practical difficulties inherent in their profession.

As in other professions, design consists of various and sometimes conflicting elements, intertwining theory and practice. According to the philosopher Alasdair MacIntyre, a practice can be understood as a specific type of social cooperative activity with specific intrinsic rewards, its own standards of excellence, methods, tradition, vocabulary, and values (MacIntyre, 2007, 187-203). Practices are always embedded in larger social contexts and require at least a minimally shared conception of the goods that are pursued by their practitioners. At the same time, practices are intrinsically integrated

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² Interestingly, Starck’s client in this case—Alessi—attested a different approach towards the product, claiming it works wonderfully (the actual case is that as a functional juicer, the Salif is a terrible product, but as a discursive object or social status symbol it is exemplary).
into the practitioner’s own quest to lead a good life as an individual. In this sense, the practices to which we belong mirror our worldview, belief systems, and core values. To put it differently, being a part of a profession means not only earning a living but being a part of something bigger and taking part in ways that shape our current reality and daily life. What’s more, practices are spaces of dialogical encounter, where the intersubjective commitments to key shared purposes are constantly being discussed, developed, and revised, determining thus the practice’s ongoing traditions and standards.

3 Design and responsibility

It is a truism that every professional must acquire a sense of responsibility because professions have a massive impact on our daily existence. However, how this translates into practice is not obvious to all. Professionals such as Zaha Hadid reject having anything to do with the death toll of workers in her sites, deflecting the charge and redirecting it towards regulators, among others (Riach, 2014). Due to its elusive and somewhat broad meaning, the concept of responsibility is worthy of a few brief clarifications.

Responsibility is often understood as having to do with blame or praise, as when a person is retrospectively held responsible for having done something or for failing to act as expected (e.g., having failed to deliver a project on schedule). Conversely, responsibility can also be understood prospectively as a relation between a person and a state of affairs or act, in the sense of being responsible for doing something. I.e., a person having an obligation to an individual or collective entity such as a client, a company, or society at large (e.g., not overcharging clients, avoiding conflicts of interest, not denigrating the reputation of a fellow professional, considering implications of professional work and minimizing the adverse impacts. and so on) (for a detailed treatment see Melé, 2020, 60-65; Van de Poel, 2015).

Responsibility as an obligation is frequently encountered in discussions about responsibility in design, yet it is ‘problematically understood and defined, mostly not going beyond the terms of “professional due diligence,”’ according to Fry (2004, 146). Two main concerns have dominated the understanding of responsibility as an obligation: on the one hand, those linked to proper professional conduct towards clients or the public; and, on the other hand, concerns related to a wider social responsibility of designers (Fry, 2004, 146). Along these lines, when we talk about practice-oriented responsibility in design we generally mean the professional inclination to present a good product, suitable to the requirement presented by the client. Responsibility becomes thus almost a technical notion. Furthermore, abiding by local or national legislation is indeed a part of the designer’s legal responsibility—health and safety, accessibility, inclusivity, and sustainability procedures are all a part of a designer’s professional responsibility.

Typically, the concept of responsibility regarding design brings to mind tragic vignettes like safety issues in construction or designing weapons. However, while responsibility might occasionally have to do with life and death quandaries, it’s more often related to more prosaic issues such as whether to manufacture more chairs into a world cluttered with plastic garbage or designing ads for online gambling platforms.

There is another alternative way to look at professional responsibility, which is seeing it as consisting of three distinctive, yet integrated dimensions. First, an almost objective set of norms and conventions stemming from the technical characters of the profession. Arguably, sub-disciplines of design will entail a (partially) differing set of responsibilities.

Second, there is the subjective layer of professional responsibility stemming from a person’s integral set of identity-oriented world views, principles, and values—what some would colloquially call their ‘personal ethics’—which can also be linked to how the profession is individually exercised. One
designer could abide by a strict vegan code for their designs, another by fair trade, while someone else will focus on universal accessibility.

The third dimension is the most crucial one. Here we have responsibility understood as a virtue connected to the professional practice (especially its larger purposes, excellences, and intrinsic rewards). The central aspect to grasp from responsibility as a virtue is that being responsible is a character trait of the practitioner that’s not determined by a set of declarative obligations the practitioner is bound to, but rather by the entailments of belonging to a professional practice. The layer of subjective values acts in combination with the shared purposes of professional activity and accumulates to a more holistic understanding of design responsibility: responsibility as a virtue.

In the remaining sections, we shall leave aside the understandings of responsibility as praise or blame, and as an obligation, as well as the subjective layer grounded on the designer’s ‘personal ethics.’ Instead, we shall focus our attention on responsibility as a virtue intimately linked to the professional practice and its shared purposes. Our analysis concentrates thus on how shared professional purposes manifest in will, thought, and action at the individual level. Despite this focus on the individual designer, it’s critical to keep in mind that this account maintains that the practitioner’s ethical reasoning and willing are relational, i.e., to a significant degree determined in relation to others. In the professional sphere, when a professional designer wills to attain an end, they do so guided by the profession’s overarching purposes in interdependence with the wills of other designers, who mutually and dynamically shape these purposes. In the last section of the paper, we will briefly revisit the collective level, but this clarification suffices for now.

3.1 Professional responsibility and care

To elaborate further, we need to add the concept of ‘care.’ Care must be understood as an ongoing, relational practice that ‘shows us how to respond to needs and why we should. It builds trust and mutual concern and connectedness between persons’ (Held, 2005, 42). Care is something in itself, but it also is a key component of responsibility as a virtue. For the ethicist Jessica Nihlén Fahlquist (2015, 194), ‘to be a responsible person is to feel responsible and to feel responsible is to care about others’ wellbeing and how one’s actions affect our fellow human beings.’

Thus, for example, inclusive design cares for marginalized social groups, not by labeling them as such, but rather by following the dictum that ‘by understanding the extreme you innovate for the mainstream.’ Similarly, inclusive designers do not act out of pity or compassion, but rather out of a sense of social justice, following the principle that every person deserves the same services. Rather than fighting stigma by creating other stigmas, designers might reframe marginalized groups to a part of the mainstream as a strategy to product and service innovation (Coleman et al., 2016). Moreover, when designing for global development a responsible designer does not ‘empower’ or ‘assist’ the local populations but seeks to work ‘with’ design partners towards establishing caring relations based on mutual concern, harnessing their unique knowledge to create together a suitable outcome. Be that as it may, the essence of imbuing care among designers as practitioners may need a process of reframing and restructuring the very role of designers in society.

A short detour through history might illuminate the predicament in which design as a discipline found itself not so long ago. Specifically, three globally influential events offered a change for designers—the economic collapse of 1929, the war effort of WWII, and specifically in the production of an array of vehicles, technology, and weaponry, and the new world trying to redefine itself after the end of WWII. For the purposes of this article, suffice it to say that these events triggered a complex shift linking design and capitalist values, as an inherent and almost automatic correlation (Ventura and Shahar, 2021). In other words, design has since then become a marketing instrument meant to motivate consumers to purchase more goods and replace their old models every few months with a
newer model. Thus, raising the very essence of care and responsibility vis-a-vis design is not a simple nor a trivial matter.

Another key event lies in Germany’s efforts to return to the global center stage as a humanistic cradle of design. Heralding a new and improved German stance and heritage, this effort brought to life the New Bauhaus or the Ulm School, three decades after the Nazis shut down the Bauhaus—the first socially-sensitive school, still influencing designers 100 years after its inauguration. Interestingly to this context, the school’s two headmasters symbolized the two paths of design as a discipline. Mired by its near history, Ulm’s first headmaster, Max Bill opted to focus on functional, affordable objects, rather than politics, values, and ideology (contrary to the Bauhaus’ approach). However, following internal and local strains, at the beginning of the 1960s the school’s second headmaster, Tomas Maldonado, raised various issues presented in this paper, more than 60 years ago (Maldonado, 1965; 2018)—what is the role of the designer in society? Should design as a discipline trigger political debate and social change? Why should designers design and how?

The story of responsibility then follows an unfortunate short path through the second half of the 20th century, offering few elaborate answers. Yet at no time as the current reality does these questions resonate more clearly—how could designers care for and about, and what must they be responsible for? Indeed, adjacent paths, triggered by these vexed questions, from the Scandinavian social approach in the 1960s, through the UK strive for healthcare design and thinking of the other 99%, culminating with inclusive design and the appraisal of care vis-a-vis design all stem from these influential historical events (Clarkson et al., 2013; Sparke, 2013).

3.2 Designing as self-enactment

As designers moved away from being ‘mere’ problem solvers to also focus on the ‘fuzzy front end’ of open-ended processes (Manzini, 2015, 40-43), so did the very scope of the profession change. Roughly, two main approaches came to dominate the discipline, albeit not remotely equal in influence—the designer as a marketing agent, versus the designer as a social agent. From a historical point of view, however, dealing with care has not been the purview of designers, nor was it a point of interest till the later decades of the 20th century, when the aforementioned shift took place.

Contrary to theoretical disciplines, or even other professions, because of their connection with production, designers can transform caring about into actual caring for. For instance, caring about the environment can be transformed into caring for the environment. In this manner, designers hold a unique stance to influence the daily lives of millions. An environmental agenda from IKEA’s designers to stop manufacturing chairs could have a global impact, just as setting a global standard for laptops’ charging cables, and these examples do not even scratch the social and deeper ethical dilemmas of practitioners in this discipline. Furthermore, caring about the environment can be actualized differently: some argue that better than creating innovative, sustainable solutions it is to just stop designing new things altogether to focus on maintenance (Vinsel & Russell, 2020).

Yet our argument goes in a different direction, which is not in the least incompatible with priming maintenance or social and environmental justice. However, while the focus on others and the environment is surely very important and it requires further treatment (see Ventura and Bichard, 2018), here we want to make and defend a different assertion from arguing for the necessity to consider others as active subjects of care in design. We posit that design as a profession is itself a reasonable object of care for a responsible designer to have. Responsible designers care about and for others also because they care about and for their profession. We’ll explain.

Considering the ability of design to influence many aspects of others’ lives, the designer’s role must be examined along a continuum ranging from the designer as a technician (mainly bounded by legal and general moral duties) to the designer as a responsible professional in the virtue sense we explored
above, in which duties are still important but not the whole of what responsibility is about. Because being a responsible professional plays a key part in the designer’s own quest to lead a good life, the profession itself—design—can be an object of care, which provides sufficient motivation for acting responsibly. In other words, responsibility is linked not only to an external dimension of care (others, the planet as a whole, etc.), but also to an internal one related to the role one’s profession plays in one’s self-enactment. Naturally, this requires further elaboration.

For the responsible designer, hiding behind empty excuses such as ‘I just work here’ does not cut it when influencing the visual and material reality of millions of people around the world. Typically, designers ‘are better able to discuss the principles of the various methods that are employed in design thinking than the first principles of design’ (Buchanan, 2001, 36-37). It is perhaps because of this that some often eschew deep discussions of ‘ideology’ and ‘ethics’ and prefer to draw an all too easy red line over designing weapons, ads for tobacco products, or pornographic websites. On the other hand, working mindlessly without impacting our field or social sphere, or keeping a safe distance from the theoretical outskirts of the discipline does not cut it either. A responsible designer seeks to articulate a different path altogether, bringing together the concept of ‘responsibility’ with that of ‘care.’

From a philosophical point of view, a person that is ‘responsible’ is personally invested in what they care about. Philosopher Harry Frankfurt posits that ‘we identify with what we care about’ (Frankfurt, 1999, 111). When our object of care is harmed, we experience that as a personal loss; moreover, when our object of care flourishes we see that as a personal gain. This can be illustrated with the example of a design instructor or teacher. An invested teacher sees it as their personal gain when a student advances, learns new skills, and acquires abilities they didn’t have. Conversely, a teacher who cares will often experience a sense of personal loss when their students fail to connect and apply their learned subject matter. The upshot is that a responsible teacher is invested in their objects or subjects of care, and it is because they care that a sense of loss or gain is experienced.

Something similar happens in professional design activity. As we advanced above, it is because the practice of design personally matters to us as designers that we are driven to act responsibly. This could be articulated through the ‘external-internal motivation’ concept in pedagogic philosophy (Harpaz, 2013). While monetary incentives are welcome, it is a personal set of values or aims that will enable a learner their needed motivation to excel and shine amidst other learners. While this may seem the case in other professions as well, design is once more different in the designer’s special position as mediator and facilitator. Being a key agent mediating between policymakers, industry and marketing leaders, and the ‘ordinary people’, to use De Certeau’s (1998) description, only raises the importance of caring for design on the designer’s part.

Indeed, while working in the industry’s top, graphic designer Milton Glaser (quoted in Millman, 2007) stresses his approach to the designer’s intricate relation with earning a living and keeping a value system as a key notion in design practice:

Money has never been a motivating force in my work. I am very happy to have made enough money to live as well as I do, but I never thought of money as a reason to work. For me, work was about survival. I had to work in order to have any sense of being human. If I wasn’t working or making something, I was very nervous and unstable (p.32). […] Acknowledging that the world exists, and that you are not the only participant in it, is a profound step. The impulse towards narcissism or self-interest is so profound, particularly when you have a worry of injury or fear. It’s very hard to move beyond the idea that there is not enough to go around, to move beyond that sense of “I better get mine before anybody else takes it away from me” (p.34).

In his down-to-earth approach, Glaser foregrounds the dilemma of countless designers even today—are we working for ourselves, to make a lot of money or create a name for ourselves, or do we work for something more, for a purpose that is more dear and profound to us.
Thus, responsible professional designers are personally affected when their object of care (the design profession or, even, design as a whole) is advanced or hindered. Hence seeking to realize specific purposes and design solutions matters to them. If you will, design empathy does not only deal with caring about and generating empathy towards other design partners, but also to the discipline itself, and the very definition of design practice (see Segal & Ventura, 2019a).

Designer Michael Bierut, who worked with leading companies and agencies, expresses the concern designers feel when their own beliefs conflict with the clients’ or a shifting reality:

_In terms of design, I really admire and envy designers who always must do it their way and can walk away from a job if it’s not done on their own terms. I remember early on in my career, I worked with a guy who was absolutely secure in his convictions; though he liked it when people agreed with him, it wasn’t necessary in order for him to feel that he was right. Whereas if I go into a client meeting, and I can’t sell something, I feel like I’ve failed and my convictions get shaken_ (quoted in Millman, 2007, 6).

Once more, a sturdy belief system is all well and good, yet when working in the industry, not a gallery, designers find themselves in complex situations, leading to difficult choices and requiring _rotten_ compromises. Interestingly, even such a star designer shares his uncertainty of acknowledging a clearly defined hierarchy of beliefs. Should we focus on being paid, on sustaining our reputation, or perhaps something bigger yet ephemeral?

Bierut also expresses his concern with the struggle between professional responsibility and the need to earn a living or simply keep the lights on in your studio:

_Most of us would say that our ideals, whether newfound or long held, give way at the end of the day to the pressures of running our businesses; that the sanest course of action is to push environmental activism or social consciousness as far as you can and then back off to fight another day; and that a client’s a client and an invoice is an invoice. In the end it’s all about money, isn’t it? Well, maybe not. Maybe it’s about something else, something that hasn’t changed, something to do not with money, but with the very structure of the relationship between designers and their clients_ (Bierut, 2007, 19).

Responsibility as a virtue is expressed by asking oneself questions about what choices are compatible with desirable aspects of one’s identity, and about the pursuit of what purposes contribute to one’s development as a person. A question like ‘could I stand to be the sort of person who can do that?’ is a question we, albeit tacitly, often ask ourselves, yet perhaps not often enough. Moreover, due to its broad and overreaching nature, design can and often does lead to thorny questions around equality, gender, identity, legal boundaries, and more. As such, dealing with responsibility is not a hypothetical or theoretical conundrum, but a significant matter influencing one’s identity and ongoing process of _becoming oneself_, from both a professional and a personal point. Therefore, the classic question of ‘what would you not design’, might trigger an answer of ‘what is not necessary’, rather than the abovementioned redundant clichés (e.g., ‘weapons’). Moreover, setting aside the designer’s perception of an ego-driven creator in favor of a complex action of design to contribute to others’ flourishing might help in strengthening one’s character, securing one’s set of values and essence of responsibility. Indeed, while professionally caring for others (either individuals or marginalized social groups) may fall to the hands of dedicated professionals (inclusive or social designers), the responsible necessity of defining one’s influence on the industry and the market should fall under a necessary process for all practitioners.

### 3.3 From caring about to caring for

As we explained, the external and internal sides of responsibility are basic necessary traits of design as a practice. Yet, when moving from this starting point to a deeper and more significant stance, we
must reconsider the essence of care. The notable addition to this factor is the consideration of an even more complex notion of empathy, identification, social virtue, global and unequivocal beliefs, and emotions. While the status of emotions as a valid source of moral knowledge is a hotly and widely contested issue in philosophy, the character-based perspective we present here leaves plenty of room for considering them as a relevant input for moral reasoning. Again, transferring the designer’s creativity from linking emotions and creating evocative objects, to the deeper and relevant link between care, empathy, and phenomenology. In other words, the designer’s understanding of the design partners’ needs and constraints, viewed through a research-based understanding of feelings, memories, and experiences will help in securing one’s subjective set of values as well as their sense of responsibility and care, which is firmly anchored in the very profession they are committed to. This shift could be articulated through a simple choice of color in the design process—am I choosing orange because it sells more, or because it will help my design partners confront shame and stigma?

In short, what we care about and, more importantly, what we care for is paramount in our ethical life, and even helps define our professional expertise (social design or marketing-oriented design, for example). Ethics is not about following rules, but about pondering on the effects of our daily existence in the world as well as about our reasons and purposes, which is why design as a daily, routine-led action is so relevant. Indeed, Milton Glaser accentuates the importance of ‘what not to do’ when designing, not but a set of rules, but simply following the principle of ‘do no harm’:

*Designing a package aimed at children for a cereal whose contents you know are low in nutritional value and high in sugar.*

*Designing a line of T-shirts for a manufacturer that employs child labor* (Glaser, 2004).

While the latter dictum is fairly uncontroversial, the former tackles a related topic but from a more elusive perspective. Should designers design a technically well-designed product, for which they are handsomely paid, to harmfully yet legally influence the end-users? Glaser’s words are ethically relevant in that they remind us of what to care about, he is not providing a set of dos and don’ts to follow or adhere to blindly but making us question what we should care about.

Imagine the following scenario: an interface designer, suppose their name is Chris, feels uneasy and troubled regarding a client asking for the inclusion of so-called ‘dark patterns’ in the design for an app they are working on. Imagine also that Chris seeks to negotiate with their manager or client and argues for a different design, one that is not manipulative and does not trick (potential) customers of a digital service into engaging in determinate behaviors that are not beneficial for them.

In line with our arguments, it is the way Chris approaches and deals with this situation that is central to ethics. The result they might obtain in their negotiation is naturally relevant but is also highly contingent on many factors outside Chris’ sway (first and foremost, power dynamics, influenced by race, gender, or age, as well as an institutional culture and so on). The upshot is that Chris shows moral and emotional maturity by recognizing and facing a difficult, ethically fraught situation. In this way, Chris’ character is further developed and strengthened as they seek to balance as a whole person the multiple demands they face: not doing as a professional designer something (a manipulative design) they reject as a person (manipulation). Chris is willing and able to engage. They avoid shutting off the uneasiness and being mindless not necessarily because they have an obligation towards the customer, but because in their view a responsible designer would not manipulate a person or user. What’s more, Chris would not bear to become that type of designer who does that.

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3 We call it ‘uncontroversial’ because child labor is globally accepted as a curse for every child and the world as a whole. However, child labor is still one the most critical unresolved issues humanity faces. In 2020, according to UNICEF, 160 million children were forced to work.

4 Dark patterns are design tropes that seek to promote business objectives such as increasing revenue by exploiting cognitive biases and psychological mechanisms.
This complex scenario is mirrored in the assertion offered by the designer James Victore that ‘the unspoken part of what we do is compromise. Clients don’t just come to me and say, [...] “we’ll let him do what he wants’” (quoted in Millman, 2007, 107). Victore thus truthfully summarizes the daily essence of design, one which is typically not told to design students: design practice is not a magical and instantaneous process, but a rather arduous, conflicting, and time-consuming process of negotiation and conversation. Like swimming against the current in a shark-infested sea, the designer materializes or visualizes an intricate compromise, mediated by the value systems of a plethora of design partners.

Another vignette could be articulated through industrial design. Imagine Lucy, another hypothetical designer, who receives a commercial brief to design a plastic chair. For here, several possibilities arise. First, they can design the chair restricting themselves to the consideration of the technical aspects of the brief without appraising further implications. Second, they can outright reject the brief Quixotically, stressing that the project is beyond rescue because the world is already filled with chairs and there is no need for another. Third, they can suggest alternative and more plausible approaches. For instance, subtracting an amount of plastic from the mold (i.e., ‘dematerializing’ the chair, which makes it lighter), designing for longevity and repairability, placing the chair into a circular business model (such as ‘Product Service Systems Models’), and so on. Evidently, there are many other possible courses of action, some of which might end up in not designing the chair at all or in firing the client or in Lucy quitting their job, but this would be outside the point we try to make here, which is not about advocating sacrifices to uphold one’s values whatever the cost. The point is that Lucy’s consideration of the possibility of different alternatives is what instantiates responsibility. Joseph Weizenbaum (1976, 241) affirmed that ‘the myth of inevitability is a powerful tranquilizer of the conscience. Its service is to remove responsibility from the shoulders of everyone who truly believes in it.’ Through the conception of alternatives, Lucy embraces responsibility as they resist thoughtlessness and fatalism, not in the harsh Marxist binary perception, but rather as a protest through everyday choices and actions (De Certeau, 1998, 34) that allow her to face the difficult issues and come to terms with them. This scenario focuses on environmental aspects but Lucy, being the responsible designer they are, is not naïve about design and knows that its effects are often broader than the environmental layer.

4 The perils of compartmentalization

In general, personal identity is made out of the different roles we adopt (professional, friend, parent, sibling, daughter, employee or employer, lover, citizen, and so on). This division entails that the ethical deliberations one performs often generate irresolvable tensions and conflicts between one’s different social roles. However, truly acting in a way one can live with means making it personal and owning the decisions one makes. This means reflecting the power dynamics of the situation and on which important things are at stake and must be balanced, as well as what gets lost in the process and for what greater good. This reflection requires moral and emotional maturity. Especially in the form of emotional regulation skills, which help us avoid being overwhelmed and alienating ourselves from what is important to us in order to cope with the complexity of work life. Victore (quoted in Millman, 2007) articulates the difficulties of navigating internal conflicts between one’s personal and professional roles:

Professionally, I don’t really have any worries. Any. I like what I do. But I am worried about what the state of the profession will be in the future. I’m worried about the state of the world. My concern now is to make a little bit of money. And for the first time in my life, I feel guilty about it (p.108). [...] I like what I do, and I seem to have a reputation for altruism and telling the truth; but at the same time, all that work I do for free. Or I pay for it with my own money. And now I’m worried about making a
living for my family. And this bothers me because I don’t know how to do both. And I want a hot rod! (p.109)

With candor, Victore highlights the classic dilemma of designers rooted in the industry—trying to navigate between one’s moral code and red lines yet upholding the professional commitment and sense of shared purpose that is related to a practice as well as to maintaining a sense of self. To cope with this difficult position, people often, willingly or not, turn to compartmentalization; that is, dividing one’s life into ‘segments, each with its own norms and modes of behavior. So work is divided from leisure, private life from public, the corporate from the personal’ (MacIntyre, 2007, 204). This means doing something as a professional that one finds ethically inadmissible as a friend, citizen, or parent. While allowing one to function and—often only fleetingly—resolve one’s dilemma, a fragmented self is seriously diminished as a moral agent, and it is incapable of bridging the limitations foisted by its own different roles. When designers compartmentalize, they typically tell themselves that ‘design is just a job’, ‘I am not my job’, ‘I’m a designer, my job is to help companies with whatever they ask me, whether I like it or not’, and so on and so forth. Again, as we have seen in the Ulm School’s conflicting worldviews, design as a discipline needs to decide whether it is in exclusive service of the industry, or perhaps something else altogether. This second option does not necessarily entail becoming a pro-bono designer or a secluded hermit. First, we need to acknowledge the harmful influence of a fragmented self and try to determine a path that would be acceptable in both a professional and personal manner. Every designer constantly negotiates and compromises in their daily work about technical, formal, or aesthetic issues. This stems from the fluid and temporal nature of the discipline, in which designers find themselves working in various fields of production and facing conflicting demands, according to their current clients. But it is our contention that this negotiation involves the responsible designer as a whole person, implicating their different roles when relevant. The role that negotiation plays in responsibility and the designer’s personal investment is illustrated by the words of the designer Paula Scher (quoted in Millman, 2007: 50–51):

There are all kinds of problems and compromises that [one] must negotiate. Things that have to be held on to, things that have to be protected to make something move forward. And it’s very, very, very hard work.

These words are important because they can be understood as highlighting that Scher is not merely wishing to hold on to these elusive things – these things truly matter to her and are worth working hard for. She makes these things especially her own. And they seem to be truly important because she fully identifies with them. It would be a personal loss for her if what she cares about was diminished. Designing as self-enactment and self-development lies in perfecting a billboard with poor legibility, as it does in developing a virtual solution for an inclusive clinic or a banking app that allows those who suffer from gambling addiction to block transactions relating to gambling (some banks already offer a tool like this, see Monzo, n/a). A responsible designer who cares would realize that even if this blocking feature won’t resolve the underlying gambling addiction, it will add a layer of ‘friction’ that can contribute to reducing the impulsivity that is afforded by the immediacy of digital tools. This view is articulated in another quote by Scher (quoted in Millman, 2007, 44):

I consider the fact that I have been able to continue to grow a very important part of how I perceive success. To me, success is not about money, it’s about what I design. If I get up every day with the optimism that I have the capacity for growth, then that’s success for me.

5 A disclaimer: we want to illustrate a point and we might be wrong in our interpretation of Scher’s words, the point we make about self-enactment stands regardless.
As we see, even among the Olympus of the designers, there are relevant and important issues larger than answering a client’s brief. Therefore, we can surmise that becoming a responsible designer means learning to recognize, appreciate and care about and for these elusive things. What we do as practitioners is an important part of our narrative quest as individuals. It is a part of how we want to be and who we want to become. At its most general, the virtue of responsibility is expressed in truly caring for certain things because they are seen to be directly connected to the attainment of the internal goods of design—the exclusive rewards that design as a practice offers its practitioners, which can only be obtained by designing (Guersenzvaig, 2021). In other words, money or fame, however important, don’t make the cut to count as exclusive to design. Internal goods have more to do with ‘those things that have to be protected’ (to use Scher’s words) than with a high income or prestige, which can be attained through any other means.

Indeed, while designers differ from artists in their need to correlate with their client’s brief, this should not serve as an excuse to annul all other value systems. Designers must acknowledge and articulate a system of responsibility and values, for both themselves and the discipline. Responsibility as a virtue revolves around a readiness to care and a willingness to respond to a plurality of often conflicting demands. Of course, this readiness is bound by the true ability one has to responsibly deal with those demands. In other words, internal capacities such as imagination, perseverance, or judgment, as well as the external institutional dimension of one’s circumstances (Williams, 2008, 459).

What can be done, then? We sketch two boundary conditions for action. First, leaving designers to decide between two unproductive courses of action—either leaving the industry or embracing carelessness. This is, to reiterate, simply not a reasonable option. Designers work in, with, and for the industry. Any viable professional ethics must recognize this fact and preserve the ability to make a living through the profession while staying connected to the industry. Second, as many authors have vigorously argued from different political and theoretical perspectives, it is necessary to act in order to change our relation to the discipline (e.g., Boehnert, 2018; Bruinsma, 2000; Costanza-Chock, 2020; Dreyfuss, 1955; Garland, 1964; Irwin, 2015; Maldonado, 2018; Margolin, 2002; Monteiro, 2019; Papanek, 1984). Moreover, the understanding and triggering of a holistic professional change must come from within design practice because crucial insights into the ethics of designing can be obtained by practitioners examining the practice from within to recognize what designers already do that amounts to what design can be at its best (Guersenzvaig, forthcoming). Change from within also requires reflecting on and taking responsibility for design’s role as a marketing-oriented and consumption generator agent to the industry. It is from this awareness about the practice that we can change our relation to the discipline and transform the caring about into the actual caring for that design is about.

In sum, avoiding compartmentalization asks us to ‘stay with the trouble’, to state it using Donna Haraway’s formulation. Attempting to change the practice while maintaining integrity does not require, even in urgent times like these, to ‘clear away the present and the past in order to make futures for coming generations’ (Haraway, 2016, 1). A more modest yet promising individual and collective commitment to change is to engage in practices of responsibility—and responsibly looking at the past is included in these—without futilely expecting as a precondition that our practice is pure and free from everything we repudiate, because it will never be. Design is too complex and fraught to be cleansed and purged of its ethical entanglements.

5 Conclusion

Our approach avoids the well-trodden, yet unfruitful, paths of either succumbing to the industry and coping with it from a disengaged and fractured self or exiting the profession altogether. We suggested
a different course of action in which a responsible designer is aware of what bounds and constrains them morally and furthermore invests a lot of effort in changing the constraining conditions. All this out of a readiness to care and a sense of integrity. The words of Milton Glaser serve to highlight this avenue for professional responsibility:

*I think I stand for an attempt to think responsibly about the practice of design in terms of its effects on society. I don’t say that self-righteously. I believe that you have to think about the consequences of what you do. I try to be conscious about this and raise the issue wherever and whenever I can. I also think I stand for an openness about what the design profession can be, and how things beyond the practice affect and modify both society and the way we think about design* (Milton Glaser, in Millman 2007, 39).

Milton Glaser’s words highlight the need to embrace introspection and reflection on the nature and effects of design, but they also underscore the need to implicate ourselves in the effort to change the constraining conditions under which we operate. This effort consists primarily of engaging in difficult negotiations and persuading others (the client, project managers, marketing experts, etc.) into a consensus about what counts as possible. The narrower the conception of what counts as a valid expected outcome (that is, one that is accepted by the client as a project result), the more constrained the space of true possibilities and, in turn, the designer’s true options for moving from caring about to caring for.

The effort to change the constraining conditions resonates with what Paul Dourish (2001, 172) calls the ‘designer’s stance’; i.e., the designer’s own conception of what they are doing, to the particular perspective they adopt regarding the role they play in a given design situation. A responsible designer has a stance that enables them to make the effort to design as to ensure that the possibility of care becomes an actuality. It has to do with a sense of integrity and identification with what they care about—in this case it is design, their profession, its rewards, as well as its larger purposes. One of the reasons why a responsible designer strives to broaden the solution space becomes clear: it’s because it personally affects them whether care is realized or not. The responsible designer finds motivating reasons for ethical action because they care, and they care because designing is a constituent part of who they are and who they aspire to become. Designing responsibly brings them closer to becoming the person they want to be, thus actualizing their stance, which will help nudge the scales from a short-term focus on external goods such as money or prestige to the purposeful and long-term investment in the internal goods of design. The virtues of responsibility and practical wisdom allow the designer to know what to do by developing attachments to what matters and by enabling them to rank goals, purposes, and rewards that are to be pursued and held to.

This account enables us to retain the notion of responsibility without implying that a designer is wholly responsible for an outcome. Arguing that designers have full control over both process and results would be absurd. Instead, responsibility is about actualizing care when one has the effective capacity to respond and about not eschewing to seek out ways to be less constrained by the circumstances when one doesn’t have those effective capacities. When responsibility is understood as the readiness and willingness to convert care into design under complex and dynamic circumstances, acting responsibly does not seem farfetched, but rather plausible even in a market-led environment.

### 6.1 Clarifying remarks

Before concluding we want to make three clarifying remarks even though we don’t have the space left at this point that would be necessary to consider these threads with the attention they deserve.

First, caring in the sense outlined in this paper is not necessarily selfless, altruistic, or out of a sole aptitude for empathic concern for others (though it can and in some cases should be). Caring is, however, unquestionably personal. A caring stance is characteristic of how a responsible designer
engages in the pursuit of the internal goods of design, and this is part of their narrative quest, not only as a professional, but also as an individual. Being responsible and being invested in one’s profession is fundamental for enacting one’s life plans as a professional, as well as for advancing design as a profession. In this sense, our approach shows a plausible way in which responsibility can go beyond being a remote aspirational ideal for the design profession, but a purpose that is both reasonable and worth pursuing. This understanding, however, entails constantly reevaluating and adjusting the broader, abstract goals we give ourselves—such as belonging, happiness, authenticity, transcendence, success, and many others—and how they fit together with our own narrative quest and the other practices we participate in.

Second, we wish to zoom in to and acknowledge once more the dynamics of current professional design, which is embedded in for-profit organizations. There are huge constraining conditions (political, organizational, and economical ones) that a professional designer faces in the context of contemporary modern capitalism. Everyone who has a job knows that market forces affect and tend to reduce all spheres of human activity to that which can be exploited for profit. We believe, however, that all this does not invalidate our proposal, which is more about how to navigate these tensions than about resolving the problems of designing in times of capitalism.

Moreover, influencing the field through its hardcore industrial sphere creates another sort of impact than choosing the safer approach and influencing through design venues that are already deeply rooted in moralistic-humanistic roots (i.e., inclusive, empathic, human-centered design, etc.). Designers (and especially our students as designers-to-be) would do well to realize that, beyond market forces, our deeper reality is anchored in interdependency and vulnerability, which inescapably require care (MacIntyre, 2001; Held, 2005). What’s more, capitalism itself is sustained by all sorts of care activities, which take place against a backdrop of unequal class and gender relations, without which capitalism can’t survive. Think of unpaid or low-pay care work, which is mainly and disproportionately carried out by women: all that cooking, cleaning, and caring for children, people with special needs, and older adults. For many scholars, this is no coincidence, but a basic condition of capitalism (Müller, 2019). This instrumentalization, however, doesn’t detract any value or goodness from care itself—whether realized through design or child-rearing—but it makes us recognize, question, and reject the parasitic nature of the relationship.

In 1964, Dutch graphic designer Jan van Toorn lambasted: ‘It is not our job to please business’ (Crouwel & Van Toorn, 2015, 55). Can he be right? It certainly is our job as designers to deliver work that meets the requirements stipulated in the design brief and for which we were hired in the first place. This might seem to contradict van Toorn’s defiant words, but despite this apparent contradiction, he has a point: meeting business goals can’t possibly be the designer’s only job. Professional designers have many other goals and purposes, among which contributing to others’ flourishing is paramount—of course, how this task ought to be carried out in practice is a perennial matter of discussion among practitioners. To clarify, we are not arguing against increasing a company’s revenue or market share (or seeking fame for oneself, for that matter). We posit that this turns problematic when achieving external rewards like these become the designer’s main concern that systematically overrides more strategic professional purposes. When this happens the practice itself is debased and derailed. The pernicious consequences of pleasing business no matter what are evident: not only does the practice of design suffer but its claim to professional status becomes moot.

Third, despite self-enactment being our unit of analysis, it would be mistaken to view this account as putting forward a view of designers as self-absorbed selfish co-operators. Responsibility, as we presented it here, is a disposition, rather than a matter of convenience. Furthermore, an individualist interpretation can’t possibly be a correct reading, as our account relies on an at least minimally shared conception of the goods that are pursued by the profession in practice. While responsibility as a virtue
surely arises from discovering what it is to be ourselves, many of the issues calling for responsibility are not resolvable individually. Nonetheless, a shared purpose doesn’t tell the whole story because actual and genuine participatory engagement with the practice is indispensable to realizing the ends we pursue as designers. Yet, acting upon shared purposes is not, in the words of Charles Taylor (1991, 8), ‘just a matter of changing the outlook of individuals, it is not a battle of “hearts and minds.”’ The sheer size and influence of the market forces we alluded to in the previous paragraphs nudge us in the direction of atomism and hopelessness, where we often abide by the rules of market efficiency, even when they conflict with our own views (Taylor, 1991, 97). It would be naive or even cynical to deny this. Nevertheless, there is no other use in fatalism, thoughtlessness, and passivity other than further reinforcing the vicious circle of inevitability and the abdication of responsibility. Coming to enact responsibility and to understand the shared nature of the practice of design and its purposes are ways of resisting those forces and changing the practice from within. In so far as this common pursuit strengthens the practitioners’ identification with the practice and the mutual attachment to fellow designers, the atomism and fatalism that makes us hopeless weakens. Along this line, a shared purpose transcends individual practitioners and substantively connects them to one another, which makes self-enactment a collective quest as well as an individual one: as professional designers we enact ourselves with and through others.

References


Auditing design justice: The impact of social movements on design pedagogy at a technology institution

Madhurima Das\textsuperscript{a}, Anastasia K. Ostrowski\textsuperscript{a}, Shelly Ben-David\textsuperscript{a}, Gillian J. Roeder\textsuperscript{a}, Kimberley Kimura\textsuperscript{a}, Catherine D’Ignazio\textsuperscript{b}, Cynthia Breazeal\textsuperscript{b} and Aditi Verma\textsuperscript{c}

\textsuperscript{a}Massachusetts Institute of Technology, \{rimadas, akostrow, sbendavi, groeder, dignazio, breazeal\}@mit.edu
\textsuperscript{b}Wellesley College, kk3@wellesley.edu
\textsuperscript{c}University of Michigan and Harvard Kennedy School, aditive@umich.edu

Abstract. The purpose of engineering is to solve consequential, real-world problems in service of society. To be effective problem-solvers in societal contexts, engineers and designers ought to be trained to conceptualize and operationalize ethics, equity, and justice in their practice. Our work develops a methodology for an ethics, equity, and justice audit of design pedagogy that can also be extended to design practice. We develop this methodology by drawing on and extending the Design Justice framework, which we then use to assess design pedagogy at a technology institution – the Massachusetts Institute of Technology. In addition, we explore how design and critique courses engage with ethics, equity, and justice content in course syllabi and examine the impact of social and racial justice movements on design pedagogy. Our audit of design pedagogy, the largest such audit of its kind, serves as a proof of concept of how this methodology can be applied more broadly to design education and practice.

Keywords: design, equity, ethics, justice, pedagogy

1 Introduction

Engineering design pedagogy largely focuses on building scientific, engineering, and design expertise in future engineers (Bucciarelli, 1996; Cross & Cross, 1998). This focus on analytical and technical rigor, while essential, does not generally take into consideration the vital and complex role of social context in the design of technology (Rittel & Webber, 1973), and imparts an incomplete understanding to future designers and technology inventors of the role and purpose of the engineer, and engineered artifacts and systems, in society (Verma & Djokic, 2021c). Given that the shared purpose of engineers and of engineering is to solve consequential, real-world problems, our research project takes as its starting point the need to train engineers to conceptualize and operationalize ethics, equity, and justice in their work, especially their design practice. To that end, through this paper, we explore whether engineering design pedagogy equips engineers with the necessary intellectual frameworks to consider questions of ethics, equity, and justice. Engineering education and design researchers generally agree that pedagogical innovations are needed in order to ensure that current and future technologies are imagined, designed, built, managed, and disposed of in equitable and just ways (Riley, 2008; Gallimore, 2021; Costanza-Chock, 2020). In this paper, we audit design pedagogy and the inclusion of ethics, equity, and justice therein to provide a baseline from which to commence pedagogical innovation and renewal to better prepare engineers of the future. In our work, we draw and build on the pivotal work of Sasha Costanza-Chock (2020) which proposes design justice as a “framework for analysis of how design distributes benefits and burdens between various groups of people.” Design justice researchers, such as Costanza-Chock (2020) and D’Ignazio & Klein (2020),
and practitioners urge designers to consider the ways in which design can perpetuate or challenge systems of oppression and discrimination in contemporary societies (Costanza-Chock, 2020; Collins, 2002). Doing so requires that designers explicitly consider design justice principles such as: which values are encoded in design work, who is paid to do design (and recognized as a designer), where design is done, and who the design work is done with and for (Costanza-Chock, 2018). The focus of our work is how the normative logics underpinning design are rationalized and perpetuated through pedagogy (Costanza-Chock, 2018), particularly in light of Black Lives Matter (BLM)-led social movements and an unprecedented amplification of justice in the social consciousness in the United States starting in 2020. We explore the impact of these rapidly mainstreaming social movements on design pedagogy at a technology institution—in this case, the Massachusetts Institute of Technology (MIT). Our audit of design pedagogy at MIT, our shared home institution, is carried out in the spirit of constructive critique and transparency, as a call to design instructors to reflect on the ways in which we can better train engineers of the future to serve society. The overarching aim of our research endeavor is to inform and stimulate the creation of design pedagogy that creates engineers who, through their design practice, aspire to advance equity and justice. We make the four following contributions through our paper: first, we extend the design justice paradigm for assessing design pedagogy; second, we explore which design justice paradigms are embedded in design pedagogy and how they engage with ethics, equity, and justice; third, we investigate what impact, if any, the social movements of 2020 have had on design pedagogy between Fall 2019 and Fall 2020 at MIT; and fourth, we demonstrate a proof of concept design justice syllabus audit methodology that can be used at institutions of higher education. Such periodic audits can be used to understand, measure, and orchestrate systemic and institutional shifts towards educating and training future designers and engineers who are better able to engage with ethics and justice. The first ever design justice audit of design pedagogy at MIT carried out in our work creates a baseline for comparing future pedagogical improvements and innovations.

2 Related Works

Design justice is a framework of analysis as well as a community of practice that “ensure[s] a more equitable distribution of design’s benefits and burdens; meaningful participation in design decisions; and recognition of community-based, Indigenous, and diasporic design traditions, knowledge, and practices” (Costanza-Chock, 2018). A design justice analysis of technological design examines whether a particular technology challenges or reinforces existing and systemic forms of oppression and suppression or the matrix of domination (Collins, 1990). Costanza-Chock’s book on design justice proposes seven questions to critique existing technologies and institutional systems in which they operate, or to consider as part of the practice of designing new technologies. These questions include: (1) who gets to do design and whose work is recognized as design (Equity), (2) what users and communities do we design for and with (Beneficiaries), (3) what values are embedded implicitly or explicitly in technological artifacts and systems (Values), (4) how do we scope and frame design problems (Scope), (5) where is design work done and how does the location of the design work impact which sites are privileged whereas others are marginalized or ignored (Sites), (6) who receives the benefits of design work and how can the work be owned by communities instead of individuals (Ownership, Accountability, & Political Economy), (7) how do we rationalize and remember how and why technologies are designed as they are (Discourse) (Costanza-Chock 2018). In order to add greater granularity to our analysis and pay particular attention to discussion of past harms of technology, we separated “Discourse” into two distinct categories of “Discourse” and “Histories.” Universalist, standardized, and one-size-fits-all approaches to design are too often prescribed as part of engineering pedagogy. These methods overlook how the potential benefits, burdens, and harms
created by technologies are distributed on the basis of race, ethnicity, class, gender, disability and sexuality. While prior design epistemologies and paradigms—including (but not limited to) value sensitive design (Friedman, 1996), values in design (Knobel & Bowker, 2011), resource-constrained design (Anderson et. al., 2012), human-centered design (Buchanan, 2001) and others—have sought to center users and communities, none have aspired to achieve intersectional equity as part of design work, as design justice does. Examples of well-intentioned but flawed engineering efforts aimed towards development abound in engineering practice and pedagogy. In a critique of such engineering-for-development initiatives, Nieusma and Riley (2010) observe that these engineering initiatives often make inaccurate and problematic assumptions about the role technology can and should play in development. Technology-for-development efforts also frequently ignore the power relations they create or perpetuate and forsake meaningful community engagement. This ultimately privileges technical performance and functionality as an end rather than a means towards achieving development. Similarly, Schneider et al. (2008) critique the colonial undertones of university-led engineering development projects through which students from Global North universities seek to launch development initiatives in the Global South. Here too, because of the limitations of their own training and the constraints of the development initiative as undertaken in a pedagogical context, student engagement with communities is fleeting and lacking in depth. Communities are designed for, and not with, as advocated by the design justice framework.

These efforts by engineering educators and students to engage in development work can be situated in a broader movement within engineering that Mitcham and Munoz (2010) describe as humanitarian engineering. They write that humanitarian engineering can be described “as working to escape what has been called the ‘social captivity of engineering’ by capitalism or nationalism or some other form of wealth and power” (Mitcham & Munoz, 2010; Goldman, 1991). Indeed, a pursuit of humanitarian engineering, or more broadly, humanitarian design, calls not only for an examination of our current design curricula but also reckoning with problematic practices taught to prior generations of engineers which continue to inform our design current practice and pedagogy (Lucena & Schneider, 2007). Understanding and addressing the limitations of engineering pedagogy specifically and design pedagogy broadly requires that we examine it through new conceptual lenses that bring social scientific and humanist ways of knowing to bear on the role of science and technology in society (Verma, 2021a). Pritchard and Baillie (2006) carry out such an analysis through a survey of Science and Technology Studies (STS) faculty and identify participation, politics, and citizenship as key analytical themes. Our paper builds on this work and adds additional analytical themes from the design justice framework—such as Values, Scope, Discourse, and Histories—for analyzing design pedagogy.

While Costanza-Chock’s Design Justice scholarship (2018, 2020) was published relatively recently, it coalesces under one framework of ethics, equity, and justice considerations that have long been foregrounded by engineering ethics and engineering education researchers (Baillie and Pawley 2012; Riley 2008). For this reason, we believe that a 2019 and 2020 audit of design pedagogy using this framework is apt. Our work marks the first scholarly effort to extend the design justice framework for assessing design pedagogy. While no previous work has explored how design justice is embedded in design education, prior studies have developed methods of reviewing course syllabi to find patterns concerning how particular topics, such as ethics, are covered in curricula. Syllabus analysis is an established, useful method of identifying areas of emphasis in curricula (Chong, 2016). Fiesler et al. (2020) conducted an analysis of syllabi with a focus on ethics curricula in computing education. They investigated whether ethics courses were typically standalone or if the topics were being integrated into core computing curricula. Through their analysis of 115 syllabi, they found that there is a myriad of ways in which instructors are engaging with ethics topics in their curricula and with a variation in the depth of these engagements. Their recommendations for integrating ethics content into computing
courses include emphasizing the idea in introductory courses that even a small design artifact like code can have social consequences so that students understand the responsibility of working in computing early on in their education. We conducted an audit of design courses using a similar methodology to investigate the ways in which instructors engage with ethics, equity, and justice in design pedagogy in both engineering as well as non-engineering departments of a technology institution. The design justice audit was guided by the following research questions in our study:

**RQ1: How, if at all, are design classes engaging with equity, justice, and ethics considerations?**
We hypothesize that most design classes are not directly engaging with equity, justice, and ethics considerations. We expect to see wide variation across classes and departments in their levels of engagement with these topics: from no presence to integrating equity, justice, and ethics as main focuses of a course.

**RQ2: Which design justice paradigms are implicitly or explicitly embedded in design pedagogy?**
We hypothesize that each department will have different design justice paradigms embedded in their pedagogy based on the parts of design they naturally already engage with. For instance, Mechanical Engineering courses may include more Beneficiaries since engagement with users is a common part of design courses in the field. Similarly, Nuclear Science and Engineering courses may include more Histories since some design courses involve critique of historical nuclear failures.

**RQ3: What impact, if any, have the BLM-led social movements of 2020 had on design pedagogy?**
We hypothesize that the BLM-led social movements of 2020 will have minimal impacts on design pedagogy. We expect that due to the COVID-19 pandemic, courses may incorporate more practices that indicate social mindedness (such as extension policies, explicit disability accommodations, etc.) but we do not expect this to permeate into pedagogy.

### 3 Methodology
To answer our research questions, we analyzed the design courses and the design principles (Fu et al. 2016) embedded therein at a technology institution (MIT) through a novel design justice centered syllabus auditing methodology that we developed.

#### 3.1 Syllabus Auditing Process
Our initial approach included performing a keyword search of “design” in the course catalog for Fall 2020 after the BLM-led social movements of winter, spring, and summer 2020. However, initial results (1006 courses for Fall 2020) did not comprehensively encompass design pedagogy at MIT. Recognizing the importance of design and critique as part of a reflective design practice (Verma, 2021b; Bardzell, 2010), we were interested in identifying not only design courses but also courses which taught the students to think critically of design. In our analysis, we refer to these as “critique” courses. In order to capture design justice considerations as they appear in both design and critique courses, we extended the design justice framework and developed elaborations of the design justice questions as they apply in the context of a design and critique course respectively. These elaborations of the design justice questions in design and critique pedagogical contexts, which we refer to as the design justice and pedagogy framework, are shown in Table 1.
<table>
<thead>
<tr>
<th>Question</th>
<th>Design example</th>
<th>Critique example</th>
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<tbody>
<tr>
<td><strong>Equity: Who gets to do design?</strong></td>
<td>The course considers how identity and background (race, class, ethnicity, gender, disability, and sexuality) shape who is able to do design and be recognized as a designer, or the course explicitly treats users and communities potentially impacted by a technology as its designers.</td>
<td>The course critiques how identity and background shape who is able to do design and recognized as a designer. The syllabus critiques design practices that do or do not view users and impacted communities as co-designers.</td>
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<td><strong>Beneficiaries: Who do we design for or with?</strong></td>
<td>The course considers how designers identify users and whether user identity and background impact who is considered as a potential user for a new design and whose preferences and needs are accounted for as part of the design work.</td>
<td>The course includes theoretical or methodological resources or itself critiques design processes that give differential access to individuals (who is designed for and with), or individual preferences, based on their identity and background.</td>
</tr>
<tr>
<td><strong>Values: What values do we encode and reproduce in the objects and systems that we design?</strong></td>
<td>The course teaches student designers to reflect on their own biases, assumptions, and values and how these might become embedded in the artifacts or systems they design.</td>
<td>The course includes theoretical or methodological resources that students can use to examine or critique the values that are implicitly or explicitly encoded in technologies, and/or the course itself includes this critique.</td>
</tr>
<tr>
<td><strong>Scope: How do we scope and frame design problems?</strong></td>
<td>The course teaches students to pay attention to the ways in which design problems are framed and the extent to which justice, equity, and ethics considerations shape those framings.</td>
<td>The course includes theoretical or methodological resources that students may use to examine and critique the framing of design problems—focusing on whether those framings are attentive to justice, equity, and ethics,—and/or the course itself includes this critique.</td>
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<tr>
<td><strong>Sites: Where do we do design? What design sites are privileged? Which sides are ignored or marginalized? How do we make design sites accessible to those who will be most impacted?</strong></td>
<td>The course asks students to consider as part of their design work how their own design site may be privileged whereas others are overlooked or marginalized.</td>
<td>The course includes theoretical and methodological resources that enable the students to critically examine and interpret how the site of the design work shapes the designed artifact, and/or the course itself includes this critique.</td>
</tr>
<tr>
<td><strong>Ownership, Accountability, &amp; Political Economy: Who owns and profits from design outcomes? What social relationships are reproduced by design? How do we move towards community control of design processes?</strong></td>
<td>The course asks students to reflect on who may ultimately own the artifact or system being designed, what social and power relationships the designed artifact may either reproduced or create anew, or how the ownership of the artifact or system being designed can, over its full lifecycle, be held by communities instead of by individuals.</td>
<td>The course includes theoretical or methodological resources that enable students to critique the designed artifact or system and its maintenance, by examining its ownership structures and social and power relationships created or reproduced by the design, and/or the course itself includes this critique.</td>
</tr>
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</table>
**Discourse:** What stories do we tell about how things are designed?

The course asks students to consider how the technology or artifact being designed may be interpreted and/or rationalized, and it’s raison d’être described by future users.

The course includes theoretical and methodological resources that enable students to critically examine how and why prior or current technologies are interpreted, rationalized and the raison d’être described by past, current or future users, and/or the course itself includes this critique.

**Histories:** Acknowledging unequal histories and/or historical harms arising from technology design, use, or diffusion.

The course asks students to consider the historical harms that may have arisen from prior versions of the technology being designed.

The course includes theoretical and methodological resources that students can use to examine the historical harms that have arisen current, prior, or future technologies, and/or the course itself includes this critique.

Though we initially started with a keyword search for “design” in course descriptions, in order to capture the broadest possible range of design and critique courses at MIT, we developed a more thorough approach that consisted of reviewing course listings across six departments. The departments chosen for our analysis are representative of our (authors’) expertise and are known for their emphasis on design at MIT: Mechanical Engineering (MechE), Electrical Engineering & Computer Science (EECS), Nuclear Science & Engineering (NSE), Architecture, Urban Studies & Planning (DUSP), and Media Arts & Sciences (MAS). Across these departments, we logged courses for Fall 2019 and Fall 2020, collecting the course descriptions, syllabi, and any additional course materials available. Additionally, we identified courses taught in both Fall 2019 and Fall 2020 for comparison. We iteratively identified and agreed (two coders per course description) upon which courses were design and/or critique courses that included aspects of ethics, equity, or justice to include for further analysis. We engaged in this form of “purposeful” sampling (Patton, 1990) in our qualitative research approach to ensure we captured the variation of design courses at MIT and to test developing ideas of the presence of Design Justice at MIT. This approach in turn helped create a valid dataset with the potential for generalizability and expansion to other pedagogical contexts (Maxwell, 1992). This detailed approach enabled us to gather all course syllabi that had a design or critique component across the six departments. We gathered 121 course syllabi from Fall 2019 and 119 syllabi from Fall 2020—a total of 240 unique course syllabi. Of these, 65 were courses offered in both semesters and thus could be directly compared. Table 2 depicts the course distribution across departments and the corresponding number of syllabi that were analyzed.

**Table 2.** Number of total classes in each department of interest in Fall 2019 and Fall 2020 along with number of syllabi requested and number of syllabi analyzed for each department of interest

<table>
<thead>
<tr>
<th></th>
<th>Fall 2020</th>
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<th>Fall 2019</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number of classes</td>
<td>Number of syllabi requested</td>
<td>Number of syllabi analyzed</td>
<td>Total number of classes</td>
</tr>
<tr>
<td>MechE</td>
<td>130</td>
<td>89</td>
<td>34</td>
<td>128</td>
</tr>
<tr>
<td>EECS</td>
<td>161</td>
<td>48</td>
<td>26</td>
<td>152</td>
</tr>
<tr>
<td>NSE</td>
<td>41</td>
<td>9</td>
<td>6</td>
<td>38</td>
</tr>
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</table>
3.2 Analysis

We analyzed all course descriptions and syllabi to identify the inclusion of ethics, equity, and/or justice content within design and critique courses. Each syllabus was analyzed comparatively by two coders using an iteratively developed rubric, similar to the rubric development process in Das (2021). A draft of the rubric was created after the research team conducted a preliminary review of the dataset across the departments to gain an initial understanding of syllabi organization and content styles. The rubric was then iterated upon four times and piloted on a subset of the syllabus dataset including nine syllabi gathered from across four of the departments (NSE, MechE MAS, and EECS). The rubric is composed of four sections: (1) Introduction, (2) Course Description from Course Catalog, (3) Syllabus, and (4) Summary.

The Introduction section of the rubric gathers background information (i.e., year course was taught, name of the course, department, etc.). This section also asks about whether the course syllabus features any statements related to justice, ethics, and equity, including land acknowledgments (statements recognizing Indigenous Peoples as traditional stewards of the land) and statements concerning mental health and disability accommodations. The Course Description section uses a Python script to read the course description and record the presence of 26 terms that relate to design justice themes (e.g., “stakeholder,” “participatory,” “inclusive,” “intersectionality”), gathered from our rubric development process. The Syllabus section’s questions examine the implicit or explicit presence of the design justice questions and design paradigms included in the syllabus (e.g., human-centered design, complex system design, value centered design, etc.). The Summary section of the rubric records whether external community partners are involved in the course, the core learning methods employed, whether and how the design course is designing and/or critiquing a design topic and/or object, and an overview of whether and how design justice principles are explicitly/implicitly and meaningfully/superficially incorporated into the course. We define “implicitly” as a consideration of design justice questions but without labeling them as such and without any inclusion of theoretical and methodological resources. “Explicitly” is defined as direct mentions and considerations of design justice questions with exposure to theoretical and methodological resources. “Meanfully” and “superficially” were defined across a range from “no mention in the syllabus” to “a cursory one-liner in the syllabus” (superficially) to the course being “focused on design justice” (meaningfully). The coding using the rubric was completed by two team members for each course syllabus. Each team member coded each syllabus independently using the rubric in the format of a Qualtrics survey. Researchers discussed the results and resolved any disagreements, similar to Daly et al.‘s (2012) coding approaches. After all syllabi were coded through the rubric, we analyzed the results in several stages. The first stage involved aggregating numerical data from each department to track how many syllabi in each department were addressing each design justice question. We also recorded the implicit/explicit engagement levels, meaningful/superficial attention to design justice principles, and where design justice principles and questions were an afterthought vs. where they were thoughtfully integrated in the course syllabus. A final question on the rubric asked the respondent to reflect on opportunities for the inclusion of design justice considerations in the course being analyzed. Responses to this question were used to identify exemplar courses described in Section 4.2. These
results were aggregated in the same way as the data from the design justice questions. We also compared the courses between Fall 2019 and Fall 2020 (61 courses) documenting changes in presence of design justice.

The syllabi ranged from course schedules and lists of topics covered in the year to in-depth descriptions of course policies and grading to slides in the presentation from the first class of the semester to pages on websites. We obtained syllabi through consulting the archives of MIT’s course management system and working with professors and departmental instructors and administrators. All syllabi that we gathered from the course management system were publicly available to the MIT community. We also reached out directly to professors and departmental administrators—an approach that posed its own challenges. We sent up to two emails requesting syllabi, but only 44% of emails yielded a syllabus of interest. We experienced several challenges and limitations with regards to gathering syllabi including the variety of dispersed locations that syllabi were stored (i.e., course management system, instructors, websites), low availability of syllabi if they were not posted online, only syllabi from one semester being available (often the most recent semester), and incorrect listing of instructors on the course website.

Another limitation of this work has to do with the descriptiveness and level of detail contained in course syllabi. Course syllabi are intended to provide an overview of the course; however, they may not capture all strategies that instructors use to incorporate design justice into their curriculum. For example, depending on the detail provided in the syllabi, it can be difficult to gauge if assignments engage with design justice material in the course in ways that may be student-directed and otherwise not captured in the course description or syllabus (e.g., projects could be creating a space for students to explore design justice principles that are not reflected in the syllabi). Our approaches for addressing these methodological limitations are described in the Future Work section.

4 Results

A total of 505 classes were logged for Fall 2020 across these six departments. Among these, 368 classes were identified as classes of interest (design or other ethics/justice/equity-focused critique) for syllabi gathering. Our analysis of the syllabi from these departments and courses, which forms a baseline against which future curriculum development can be assessed, reveals that design justice is grossly underemphasized in design pedagogy. This is despite increased discussion around diversity, equity, and inclusion in academic spaces, including calls from engineering leadership to center equity in undergraduate curricula (Gallimore, 2020; ABET, 2021), particularly in light of the recent social movements. Coursework continues to be more focused on the design process and design outcomes without detailed consideration of societal implications of technology development and use. Principles of equity, justice, and engagement with user populations and impacted communities, when present, are more commonly treated as one-off engagements instead of sustained community partnerships, which have been shown to be more impactful (Ostrowski et al., 2021). We observe some positive movement with classes discussing topics such as sustainability in engineering contexts. However, discussions around ethics, justice, and equity are more commonly found in classes that do not have design components or are outside of engineering disciplines, such as in DUSP or MAS. Though the COVID-19 pandemic and the social movements of 2020 served as catalysts for adapting courses for remote learning, there has not yet been a corresponding reform towards embedding design justice values in design courses, though it is possible that such changes are being planned. Though more time is necessary to determine a representative trend, we now have a critical first data point.
Figure 1. Design justice questions and their inclusion in course syllabi as compared across departments. The “Other” category in our analysis includes topics such as sustainability that were design-justice adjacent but did not fit one of the value categories.

4.1 Design Justice in Department Courses

We compared the courses from across departments to understand how various fields were integrating design justice into their courses. We compared the percentage of classes across each department that had any design justice component. As shown in Figure 1, DUSP courses had the highest prevalence of design justice (97.7%). NSE had the next highest (66.7%) followed by Architecture (54.3%), MAS (42.4%), and MechE (29.0%). EECS had by far the least prevalence of design justice themes, with only 4.3% of classes mentioning any design justice-related topic in the syllabus.

As shown in Figure 2, courses in non-engineering departments such as architecture, DUSP, and MAS consistently included design justice considerations at a much higher rate than courses in engineering departments. Courses in engineering departments performed especially poorly along the Equity, Sites, Values, and Discourse dimensions—categories that are no less applicable in an engineering context than a non-engineering one. Figure 3 provides an additional way to view the data along the dimensions of explicit/implicit and meaningful/superficial engagement with design justice. DUSP had the highest prevalence of design justice with most of the courses exhibiting some emphasis on design justice in the curriculum. MechE and EECS had the least presence of design justice and, correspondingly, on average, the principles were not included or not mentioned. MAS, Architecture, and NSE clustered together with having some design justice presence, but the overall average was a cursory one-liner in the syllabus without implicit or explicit mention of design justice, though the middle two quartiles demonstrate that there is a small range toward low implicit or explicit mentions in these departments.
4.2 Exemplar Courses

Despite the relatively low emphasis on design justice considerations across departments, our syllabus analysis did reveal a number of exemplary pedagogical practices. In this section, we explicitly identify these courses as exemplars that other instructors could emulate in the future. 

Design justice and related concepts as main learning objectives. Some courses had topics that were very aligned with design justice with an additional emphasis on technology. For instance, one way that design justice was incorporated into courses was having a focus and main objective of the course related to social justice and incorporating certain technologies into the course to facilitate discussions.
on how technologies can enable or prevent justice and perpetuate or help fix social inequalities. One course of this type in MAS began with an in-depth examination of racism and social injustice in the United States with readings and discussion focused on these and other justice-related topics. The course then introduced a technical foundation that merged technology applications with social justice. Students produced a proposal and/or research project that they worked on over the course of the semester that combined their interests and learning objectives of the course related to design justice.

*Design justice concepts incorporated into technical pedagogy.* One type of exemplar was a course that not only emphasized technical rigor, but also centered design justice considerations in the context of tool use and development. For example, a course on Geographic Information System (GIS) mapping offered in DUSP, in addition to emphasizing technical knowledge, also acknowledges the political significance of maps while critiquing associated historically oppressive practices. Specifically, it analyzes the use of maps and seeks to position map-making as a tool of empowerment for communities and activists that enables them to tell their own stories. The course achieves these learning objectives by interspersing technical readings on GIS with readings on power, colonialism, and the politics of maps such that students learn to critique GIS techniques and their potential uses even as they continue to acquire expertise in the area. This practice of foregrounding social context and interspersing ethics, equity, and justice considerations with technical expertise is a practice that could usefully be emulated in the context of any course similarly built around teaching the use or development of an analytical tool.

*Emphasis on community engagement.* Some courses incorporated external groups relevant to the design topic into their pedagogy, like clients, experts, and community members. Select courses in sustainability in Mechanical Engineering and DUSP took students on field trips and met with local experts to better understand the leading factors and first-hand insights related to a specific environmental issue. The hands-on engagements that centered around different aspects of the problem—from health (of humans and ecosystems) to economic security—promoted a more well-rounded problem-solving approach. Similarly, a design-for-the-developing-world social impact course in Mechanical Engineering had community partners evaluate the proposed technologies as part of the course’s evaluation process of whether or not the device would actually be useful to the community partners. Though these community members were not treated or identified as co-designers, they gave input throughout the design process in a formalized way. By collaborating with those who would be affected by design decisions, these classes in Mechanical Engineering and DUSP allowed students to better understand the social nuances of building technologies and/or designing urban infrastructures.

Just as the courses described above represent exemplary pedagogical practices, several other courses as depicted in syllabi we analyzed, offer opportunities for learning lessons from prior pedagogical practices that have incorporated ethics, equity, and justice content in design pedagogy with limited success. In general, these course fall into one of three categories:

1. One set of courses tends to over-intellectualize ethics, equity, and justice as conceptual categories through the use of theories and frameworks that are far removed from the lived experiences of communities and individuals who actually experience inequities. This approach to the treatment of ethics, equity, and justice content was especially apparent in departments that deal with the designs of large sociotechnical systems. Because of the size and scope of such systems and their architecture of systems made up of several systems, questions of equity, ethics, and justice are easily overlooked. Instead, they ought to be integrated into every level of scale and technology design (Turner et al., 2021).

2. A second set of courses that are a study in how not to teach ethics, equity, and justice are those that seek to develop products or systems for underserved communities, without directly engaging with those communities during any stage of the design process. Such approaches to design, if normalized
as part of the pedagogical practice at leading institutions of higher learning, are likely to be amplified and perpetuated in design practice when students enter the workforce.

(3) A third set of courses are those that treat ethics, equity, and justice in cursory and inconsistent ways across course offerings. Several course syllabi we reviewed included ethics, equity, and justice content but did not show students how to operationalize it in design or critique work. Overall, exemplar courses demonstrate a variety of ways to integrate design justice concepts into both engineering and non-engineering pedagogy, with several examples of exemplary pedagogical practices transcending specific departments. For example, both engineering and non-engineering departments could benefit from greater community engagement as part of teaching design or critique. Similarly, these departments could benefit equally from including reflections on, and critiques of, the analytical tools being developed in the course. Conversely, several courses whose syllabi we analyzed contain examples of how not to teach ethics, equity, and justice content. While our list of exemplary and non-exemplary pedagogical practices is not exhaustive, we recommend that instructors of design courses reference these examples, the exemplars in particular, to identify ways they might incorporate design justice into their own curricula. Instructors may also wish to consider and reflect on other novel pedagogical approaches that are not yet in practice.

4.3 Changes in Courses between Fall 2019 and Fall 2020

The majority of courses (80%) that were taught in both Fall 2019 and Fall 2020 had no change in their inclusion of design justice questions. Figure 4 reveals the positive and negative changes that occurred between semesters with respect to design justice areas. DUSP exhibited the most change between Fall 2019 and Fall 2020; DUSP increased design justice in its syllabi in all areas except Equity. MAS, MechE, EECS, and NSE saw some change, though to a lesser degree than DUSP. Architecture showed no change between semesters.

Figure 4. Changes in courses between Fall 2019 and Fall 2020 across the design justice areas. Bars above the zero axis indicate that courses in that department incorporated more design justice areas into their courses. Bars below the zero axis indicate that courses removed areas of design justice from the courses.
In addition to comparing the design justice areas between semesters, we also explored how design justice emphasis changed between semesters by analyzing how implicitly or explicitly the design justice questions and principles were addressed in the course and how meaningfully or superficially they were incorporated. Figure 5 depicts the results from 10 courses across the departments that exhibited change along these dimensions. There are three general trends that were identified from this subset of courses: (1) courses trend from being low implicit or no mention at all to explicitly incorporating design justice into the course with more meaningfulness; (2) courses move from having no mention at all to implicitly incorporating design injustice into the course with some curriculum emphasis; and (3) courses move from incorporating design justice explicitly to incorporating it implicitly. For example, courses that moved from low implicit or no mention to low or high explicit reshaped the course to include design justice or added design justice case studies to complement technical material. Courses that moved from having no mention to implicitly incorporating design justice added limited readings around the topic area without specifically categorizing them as “design justice focused” whereas, courses that moved the opposite direction from explicit to implicit, though few, often removed readings or focus on design justice to prioritize other materials.

![Figure 5. Plot demonstrating how classes shifted emphasis in design justice focus between Fall 2019 and Fall 2020. The open point represents Fall 2019 and the solid point following the arrow represents Fall 2020. The points are color coded by department. No changes were observed in Mechanical Engineering courses](image)

The changes we saw were incorporated into courses in a variety of ways. Some courses restructured lectures and curriculum materials to reframe the course more around social justice. Some courses completely redesigned the course to have a more even balance between technical material and case studies on design justice related areas. A few courses also removed course work, such as an inclusive design lecture, that decreased the emphasis of design justice in the course. Overall, the majority of courses held in both Fall 2019 and Fall 2020 did not change with regards to design justice areas or its emphasis. Those that did change generally changed positively, incorporating more design justice into the content and/or increasing emphasis on design justice through the methods described previously. One of the courses exhibiting positive changes was transformed into what we have called an “exemplar.” It is noteworthy that such a transformation occurred after a change of instructor. This
suggests that courses lacking design justice content might not falter from lack of potential or irrelevance to course content; it simply takes someone with an eye and intention for justice—a skill that can be learned by engineering and non-engineering course instructors—to redesign curricula. Ultimately, however, even the majority of courses with positive improvement could be considerably further improved through more explicit, meaningful, and intentional inclusion of design justice considerations.

5 Discussion

Overall, the results of this study indicate that design justice themes are, for the most part, not being prioritized in engineering courses. There is much room for improvement, especially in the engineering courses that are more focused on technology development for its own sake rather than viewing technology as a means to an end. Some courses are prioritizing this content through one-off lectures on ethics-related topics or short modules on relevant design justice-adjacent material, such as sustainability. However, most technology-design focused classes have little to no focus on ethics, equity, nor justice. This is a glaring gap in engineering design education that must be addressed. Non-engineering departments had a much more meaningful focus on design justice related topics. Although some non-engineering departments have a stronger focus on these topics, they are often not integrated throughout the entire curriculum and are not the main focus of the design process. Notably, the departments with the largest design justice focus tended to have the smallest number of students, so the overall reach of this content is very limited. At technology-focused institutions, these smaller departments often have less respect, power, and funding than engineering departments, which further limits their sphere of influence. Some possibilities for pedagogical reform may include engineering instructors learning from approaches adopted by colleagues, partnering with colleagues in other departments to develop novel cross-departmental course offerings, and urging their engineering students to take non-engineering courses as a way of improving their engineering practice through the development of intellectual breadth.

In addition to analyzing the department courses, we also examined changes between courses that were taught in both Fall 2019 and Fall 2020. In general, there were few changes in the inclusion of design justice questions addressed between Fall 2019 and Fall 2020. Though there were 17 examples of reform with respect to certain design justice paradigms, there were also five cases of courses reducing the presence of design justice related principles between the two years. While most courses did not change their overall explicit/implicit or meaningful/superficial engagement with design justice, those that did often incorporated more design justice aspects into their curricula, though this was done both implicitly and explicitly. Ideally, we would like to see courses consistently engage with design justice explicitly as demonstrated by the exemplars.

It is also important to note that the events of 2020, namely the COVID-19 pandemic and subsequent transition to virtual teaching, added stress and labor on educators that may have prevented them from embedding these values, as they focused more time on student wellbeing and acknowledging the emotional turmoil that students were facing in the context of the pandemic and the increasing visibility of police brutality and racism in the United States (Park et al., 2020). Virtual teaching and the added toll on educators may have limited instructors from experimenting with content: as such, we may expect to see more of the changes described added into 2021 syllabi when many courses reverted to the in-person format. Regardless, it is crucial that design justice paradigms be incorporated into design courses directly, so that students see them as fundamental components of the design process. Students who do not learn and practice these concepts will become design practitioners who do not have experience with considering the implications of their work and may become more disengaged
with these principles (Cech, 2013). Justice, ethics, and equity cannot be afterthoughts and must be foregrounded in design pedagogy.

We firmly believe that ethics, equity, and justice are fundamental components of engineering and must be incorporated into engineering education. Our results demonstrate that traditional engineering departments engaged much less with design justice than non-engineering departments. We are at a critical juncture to address the lack of design justice in engineering design pedagogy, and we are beginning to see commitments in the field to address this. Recently, the deans of multiple engineering departments nationwide jointly authored a letter to The Accreditation Board for Engineering and Technology, Inc. (ABET) emphasizing the need for implementing a Diversity, Equity, and Inclusion requirement in engineering curricula (ABET, 2021). Some universities have already embarked on significant programs of curricular reform. For example, the University of Michigan has begun incorporating these topics into their engineering education already to work towards “equity-centered engineering” (Gallimore, 2021). At MIT, the Social and Ethical Responsibilities of Computing (SERC), has been working towards centering on social, ethical, and policy considerations in computing pedagogy (MIT SERC 2021). In addition to these advancements, there are opportunities and methods for including design justice in future course offerings—as we’ve seen in our syllabus analysis—such as the inclusion of ethics and equity considerations in courses built around analysis tools and techniques. Courses can also include curriculum components that investigate and discuss the social implications of technology by questioning who has access to the technology, who benefits from it, and who designs it.

While our focus in this paper is on undergraduate and graduate courses, we believe that our work provides contributions and extensions to design practice as well. The training that designers and engineers receive in their coursework in undergraduate and graduate schooling is essential to shaping how these students will develop future technologies. Our work here also provides emphasis on Design Justice that can be translated to corporate and industrial design projects. The audit we’ve done in this work can be expanded to examining corporate and industrial design projects, encouraging professional designers and engineers to embed Design Justice principles in practice. It could also be used as a benchmark or assessment of corporate attention to Design Justice principles. This extension also provides future work directions for the interface and impact of Design Justice grounded coursework for design in practice.

5.1 Future Work

As previously acknowledged, syllabi are not a complete representation of the full pedagogical and learning experience imparted and experienced in a course. Future work will explore additional ways to understand how instructors include design justice considerations in their courses apart from the material listed on the syllabus. To this end, we have developed a survey that will allow course instructors to articulate how they incorporate design justice principles into their courses to build a more complete picture of how design justice is integrated into pedagogy. We also plan to interview instructors of the courses to understand why and when they incorporate design justice in pedagogy, in addition to any institutional incentives or barriers they encounter while doing so. We expect that this future research will be able to offer recommendations not only for curricular reform but also educational policy reform at institutions of higher learning as well as through accreditation organizations such as ABET.

In our ongoing work, we have already begun collecting syllabi from other departments and additional years to extend this investigation further. We also plan to conduct a comprehensive analysis of our recommendations that we noted when we were completing the syllabus coding. These recommendations will be used to inform how design justice could be incorporated into courses more
specifically (i.e., case studies, section of project, etc.). We have also developed a Python script that reads each syllabus and identifies the design justice related keywords within it. We plan to elaborate on this analysis in a future publication to show which terms appear in syllabi across various departments.

6 Conclusion

RQ1: How, if at all, are design classes engaging with equity, justice, and ethics considerations?
Most design courses are not engaging with equity, justice, and ethics considerations. In particular, there is a large gap in the level of engagement with these topics in engineering design courses compared to design courses outside of the engineering departments. This is a troubling finding and suggests that engineering design curricula could be reformed to meaningfully engage with equity, justice, and ethics considerations.

RQ2: Which design justice paradigms are implicitly or explicitly embedded in design pedagogy?
The design justice paradigms embedded in design pedagogy varied widely across departments. Urban Studies & Planning and Media Arts & Sciences tended to have a similarly high rate of all the design justice questions present in their courses and Electrical Engineering & Computer Science tended to have little to no design justice questions present in their courses. Mechanical Engineering and Nuclear Engineering courses both had a higher presence of Beneficiaries and Scope, but Nuclear Engineering also had a clearer focus on Histories, likely because of the presence of many critique courses that addressed past disasters. Architecture courses had a higher presence of Beneficiaries, Values, and Sites. We also found that some courses included topics adjacent to design justice that did not fit one of the explicit design justice paradigms. For instance, sustainability and climate change were focus areas for several engineering design courses.

RQ3: What impact, if any, have the BLM-led social movements of 2020 had on design pedagogy?
We found that the majority of courses had no significant changes between 2019 and 2020. It is possible that this is too short of a time frame to see any significant changes, so we plan to continue this research in the future to determine how long it takes to see meaningful changes in the curriculum.

Our paper highlights the notable absence of design justice principles in design and design critique courses, especially in engineering departments, at a technology institution, despite the BLM-led social movements of 2020. We call for a stronger emphasis of ethics, equity, and justice in design pedagogy. While these principles may be found in non-design courses and non-engineering departments, it is important for future developers and designers to responsibly engage with the social contexts and implications of their work, which is emphasized through incorporation of design justice principles in design education—both engineering and non-engineering. Several recommendations emerge from our work for how to include design justice principles. Our work develops a methodology for launching design justice audits as an ongoing process at technology institutions and identifying needs for institutional support for justice-, ethics-, and equity-minded work and education. Through these measures, we expand the epistemic scope of design education to holistically support a more socially minded design education centered on equity, justice, and ethics that empowers future designers to question and consider the societal impacts of technological designs from the earliest stages of ideation.

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References


The designer as cross-boundaries mediator: Merging machine learning, ethics, and design for the flourishing of humans

Martina Sciannamè
Politecnico di Milano, Design Department, martina.scianname@polimi.it

Abstract. Designers are elusive figures to define. As human beings, they have the ability to conceive and/or create something for a purpose, yet they are characterized by empathy, system-level thinking, and a transformative influence on the world: features that enable them to tackle significant challenges. To achieve high goals, though, they need to navigate across disciplinary boundaries, building on diverse disciplines theories and approaches to complement their education and to frame and address complex problems adequately. Among them, machine learning (ML) knowledge and ethical perspectives could be essential materials to face contemporary issues and design for the flourishing of humans and their ecosystems. In the following, a didactic experiment (i) to provide design students the tools to understand and exploit ML by translating technical knowledge in a designerly way, and (ii) to frame their education in a value-sensitive design perspective is described and discussed.

Keywords: expanding design education, introductory ML design game, machine learning (for) design, research-through-design, responsible design

1 Introduction
1.1 Everybody can design, but what defines a designer?

Prehistory is marked by the rise of technology: the first rudimental tools that men created. Indeed, if we consider design in its broadest sense, as the act of conceiving and/or creating something for a purpose, this capability – diffuse design in the words of Ezio Manzini (Manzini & Coad, 2015) – has characterized humankind since the beginning of time. Then, it might not surprise if different disciplines are now adopting and appropriating some design skills because, in the end, they belong to all of us.

In narrowing down today’s role of designers, it quickly becomes clear how much it is or should be expanding across boundaries but maintaining an undoubted specificity.

Throughout history, designers have been identified as the professionals who care about the beauty and the appearance of things, or as those focusing on their function, yet, going to the very roots of the practice of design in its multiple forms and embedding the viewpoint of activity theory (Kaptelinin & Nardi, 2009), we may say that what primarily define designers is their capability to mediate between humans and the world. Based on what they have available, they can envision things that have never existed before and create something valuable both in a concrete and an abstract sense, spacing between different scopes, which makes design a pervasive activity (Louridas, 1999). Especially from this point, the current figure of the designer needs to be reshaped in the eyes of the lay public as well as within the disciplinary educational institutions.

Designers’ main value lies in their ability to transform the world according to a predefined purpose (may this be for pleasure, better usability, or survival). Hence, they can easily adapt to different contexts, and it gives them the possibility to play critical roles in today’s pressing issues: either to
solve problems, no matter how ill-defined they are, but especially to frame them correctly thanks to their systemic reasoning.

In fact, more than ever before, we are becoming aware of the challenges we are facing, and that may increase in the near future. Friedman (2019) even listed a set of specific challenges for design that span throughout all levels of human condition: from performative issues to systemic, contextual, and even global challenges (M. W. Meyer & Norman, 2020). What emerges from the authors’ perspective is the necessity for designers to work across disciplinary boundaries to actually pervade and contribute to any sort of issue we are called to respond to, not only by being incrementally involved in multidisciplinary teams but also by taking on organizational and managerial positions.

1.2 Building the cross-boundaries mediator

In this historical moment, we are assisting to the revival of artificial intelligence (AI) and – more prominently – machine learning (ML) systems, which are wildly spreading into everyday life, due to the favorable technological development (i.e., improved computational power and availability of large amounts of data) and are expected to have significant impacts on human life as electricity did (Kelly, 2016). Dating back to the 1950s, AI is the field concerned with building machines “that can compute how to act effectively and safely in a wide variety of novel situations” (Russell & Norvig, 2020), and ML – its most popular subfield – is getting a lot of attention as it allows to create systems that address uncertain issues (i.e., for which writing step-by-step instructions would require a great effort or may not be possible) only by giving them a specific goal and huge amounts of examples to learn from, to finally let them derive how to reach the goal and improve their performance over time. In practical terms, it means that, among several other ML applications, it is now possible to easily automate burdensome and repetitive human tasks, personalize contents according to people’s preferences and behaviors, interact with devices by using natural language, and infer information from massive quantities of data. The main issue, though, is that the technology-driven diffusion of ML systems often is not in line with people’s needs, desires, or expectations. It does not comprehend the “wholeness of humanity” (Antonelli, 2018), while design has the potential to address this matter in a human-centered way. Therefore, this field may be a perfect playground for designers, who have the skills to anticipate the impacts of a technology and to provide it new meanings, but, unfortunately, they seem unprepared to effectively leverage ML capabilities and foresee opportunities as they lack understanding, experience, tools, and methodologies to deal with it (Dove et al., 2017; Yang et al., 2020).

Thus, besides a revised definition of their role (as suggested in 1.1), designers need to be given suitable means to amplify their field of action and have a role in this current hot topic. Specifically, as Meyer and Norman (2020) report, design education should “draw more extensively on knowledge developed in other established fields, translating that understanding into a form useful to practicing designers.”

To support the argumentation, the paper proposes an example of expanding the borders of design across disciplines by merging ML knowledge, ethical perspective, and traditional design skills (like empathy, system-level thinking, and a transformative influence on the world) to enable designers to impact human life. Indeed, ML could benefit people and their ecosystems in a revolutionary way as it unveils whole new possibilities to interact with the world, and, according to their defining traits presented above, designers have the potential to steer the spreading of this technology towards beneficial outcomes and trigger unexpected innovation if given the possibility.

The experimentation stems from a research project aimed at providing future designers the essential skills to navigate across disciplines in order to design responsible and meaningful systems integrating ML. Specifically, it is developing a methodological contribution for MSc design education and
designerly tools to enhance cross-fertilization and interdisciplinary communication between design and ML, with a research-through-design approach.

Two are the main features of the proposed activity: (i) providing design students the tools to understand and exploit ML by translating technical knowledge in a designerly way, and (ii) framing their education in a value-sensitive design perspective (van den Hoven, 2013).

As a matter of fact, it is in the light of awareness and responsibility – about technological potential and limitations as well as about ethical and sociological implications – that designers can play their mediating role to address the criticalities of human life.

2 An experimental method for expanding the frontiers of design

2.2 Setting up the didactic activity: aim, target, and modalities

Even though some attempts to bring AI/ML (Futurice, 2017; Piet, 2019) and ethics (Artefact, 2017; Gispen, 2017) to designers are emerging, to the best of the author’s knowledge, this represents a first empirical experiment on merging together the three disciplinary perspectives on ML systems development. Specifically, the study aims to assess the response of designers to this multifaceted topic. Configured as an introductory didactic activity to present the core ingredients of ML as design material, it targets doctoral students with some or no prior knowledge of the subject matter. They are relevant testers because they are close to the intended audience for the research, and they have more analytical skills, didactic experience, and consciousness about design research theories and methods to build an insightful discussion and peer-evaluation of the activity. Further iterations and applications may also involve MSc design and engineering or computer science students.

The expected impact of this activity is to build awareness on the ML topic and pave the way towards a value-sensitive approach to designing ML-infused solutions. For this, the set learning outcomes include that: (i) in terms of knowledge, students should gain familiarity with the basic capabilities, limitations, and implications of ML systems, as well as the main values and possibilities for a responsible and trustworthy design. (ii) In relation to skills, they should learn to pursue a value-driven design process, activate fruitful discussions in team collaboration, and identify ML as a design material. While (iii) concerning values, they should understand how to be responsible designers in the contemporary situation and that ML can be an asset to face big challenges.

Figure 1. In-presence playtest. Photo by the author
Due to its introductory character, the activity has been imagined as a brief (one to two hours) and engaging experience, possibly anticipating a more extensive didactic path. Thus, a cooperative board game format seemed the perfect fit to gently introduce the main topics, give procedural information, and stimulate reflection and discussion in a practical context. In fact, games create a parallel world, a safe place in between the physical and the game dimension itself (Huizinga, 1938), where players can freely express themselves, make mistakes, and learn with no concrete repercussions. The cooperative nature of the game, in this case, is essential as collaboration amplifies the team dimension that characterizes a design environment (to which the participants are used) and naturally encourages discussion and exchange.

As the pandemic period requires, the activity has been developed and tested with both physical and digital supports in two different sessions, each with two Ph.D. design students, for a total of four participants. For the qualitative purposes of the research, the limited number of testers left enough space for the involved people to actively interact with the game and freely express their reflections, and it allowed for an in-depth look at the experience of the activity itself, but of course, this presents some limitations in terms of representativeness.

The first in-presence session (Fig. 1) involved two students with no prior knowledge of the subject matter. For the second one, instead, the selected Ph.D. students’ research areas are somehow related to ML as a technology. For this session, the Miro platform (Fig. 2) has been chosen as digital support because it effectively enables most of the actions that they would have performed in live collaboration.

![Figure 2. Overview of the digital board supporting the online activity. Created by the author](image)

**2.3 An introductory board game: theory, tools, and procedures to structure the activity**

As the focus of the activity is to push designers to the edge of disciplinary boundaries to embrace and mediate between designerly approach, ML contents, and ethical perspectives, the design process represents the perfect space for the combination of the three ingredients. In a preliminary analysis (Fig. 3), the author explored how the three disciplines could contribute to each of the five stages of the
design thinking process, as illustrated by (Dam & Siang, 2021). The ideation phase resulted in being the one in which the mergence is most functional and significant. Therefore, the whole game explicitly refers to it.

**Figure 3.** Autor’s analysis of disciplinary contributions at each stage of the design thinking process

**SET-UP.** The initial situation presents the players with their role as designers at the service of a fictional World Association for Challenging and Strategic Issues (WACSI). They are called to join and lead a team with the aim of designing a system to accomplish a given mission. Before starting, an impact goal and a key outcome – as intended in (Design Kit, n.d.) – with available datasets are provided to synthesize the mission. The impact goals – long-term, significant impacts one is working to achieve – are identified as the Sustainable Development Goals (SDGs) of the United Nations (UN - Open Working Group, 2015) and declined with one of their more precise targets. While the key outcomes – near-term and observable change/behavior one wants to promote – are defined to narrow down the problem, including information about the context and target audience. Hence, this opening contains the basic assumptions upon which the research is built and intended for the participants to internalize: in the near future, designers striving for human flourishing should face increasingly dynamic and complex challenges (Weil & Mayfield, 2020). To this end, human needs will extend to a societal and eco-systemic dimension, and solutions will involve cutting-edge technology – an approach that influential academics called DesignX (Friedman et al., 2019).

After the initial setting, players are introduced to the core of their mission: to design a system, enhanced by ML, to beneficially impact the current situation according to their given purpose. The overall game structure aims at outlining the main steps one should follow to responsibly design a ML system, and it develops in three main phases: the kick-off, the system design, and the weighing up.
**KICK-OFF.** Preliminarily to any concept construction, few elements should be considered and openly defined to drive the ideation process. According to a value-sensitive design approach (van den Hoven, 2013), shared values should be expressed from the very early stages to be embedded in the technology and affect affordances and constraints of the system. Additionally, thinking explicitly about the values is morally significant and may lead to meaningful results. Hence, the players are invited to select one (i) value that will drive their system. Of course, it should not be the only one embedded but the most prominent one. The values proposed (Fig. 4) are an adaptation of the ethical principles behind the European Guidelines for Trustworthy AI (High-Level Expert Group on Artificial Intelligence, 2019b), which are highly comprehensive and founded on fundamental human rights. They are: respect for human autonomy, attention to fairness, increase of intelligibility, prevention of harm, and promotion of flourishing. The latter has been added in antithesis to the previous one to suggest a more proactive attitude towards life, well-being, growth, progress, and prosperity; while intelligibility replaces explicability because it implies that clarity can be achieved either by explanation or intuitively, expanding its sense to include UX issues as well.

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<td>RESPECT FOR HUMAN AUTONOMY</td>
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<td>INCREASE OF INTELLIGIBILITY</td>
<td>PREVENTION OF HARM</td>
<td>PROMOTION OF FLOURISHING</td>
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<td>People must be free to make their own decisions and to take control</td>
<td>People and their ecosystems need to receive just and impartial treatment, respecting a balanced proportionality between means and ends</td>
<td>Immediacy and understandability have to be guaranteed, whether with a proper explanation or intuitively</td>
<td>No material or mental damage has to be inflicted to people and their ecosystems, nor existing ones have to be worsen</td>
<td>Life, well-being, growth, progress and prosperity of ecosystems should be fostered and nurtured</td>
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Figure 4. Value cards provided in the game. Created by the author

Other essential components relate to the material at hand: ML systems. Their most common capabilities are introduced and synthesized in the form of (ii) **ML agents.** They represent the keystone of knowledge transfer. As in (M. Meyer, 2010) argumentation, they are conceived to be functional to move pieces of knowledge from one field to another by transforming it into a more familiar language for the recipients. Indeed, the characterization of ML systems as agents is actually borrowed by (Russell & Norvig, 2020), a worldwide reference textbook for AI – and, while maintaining technical correctness and clarity on their computer nature, an emphasis on the parallelism with human agents helps designers understand how to approach them as part of larger systems. Each ML agent embodies a ML task – or problem in the words of (Russell & Norvig, 2020) – and summarizes the question: what is the basic functioning principle of the system, generally speaking? The key tasks presented are classification, regression, sequence prediction, generation, clustering, and action selection – the explanation of which is beyond the scope of this argumentation. A previous workshop, organized in collaboration with a MSc student in Digital and Interaction Design at Politecnico di Milano (Arnone, 2020), proved this level of information, in-between the technical construction and the contextual capabilities of ML systems, to be essential and sufficient to enable design students to exploit this technology in concept elaborations effectively. The same experience revealed that a formal yet simplified definition of a ML system (summarizing its internal process in terms of input, procedure, and output) combined with case studies provide enough information for operational comprehension. Therefore, the ML agents sheets (Fig. 5) include a synthetic question expressing the core of the task, a brief definition, some system’s contextual capabilities to exemplify current applications, and two case studies (a positive one that complies with SDGs-level challenges and a questionable one, threatening ethical principles).
Finally, the players are supplied with (iii) five general intents to beneficially impact human life (Fig. 6) – automate, augment, empower, inspire, and specialize – among which they should choose the one responding to the question: “how would your system improve the current situation?”

Then, value, ML agent, and intent constitute the proposed founding material to orientate the design process and outline a meaningful and responsible solution. Their initial definition is aimed at stimulating reflections and at keeping the team aligned on the same principles. It does not need to be permanent; instead, variations are part of an iterative process.

A limitation of this approach is that players are forced to include one ML agent in their design for the didactic purpose of understanding them through a direct application in a concrete example. This does not imply that ML is the preferable solution to any problem and neither that a single ML agent is enough to tackle complex tasks nor cannot work in cooperation with others. Unfortunately, as the activity pursues immediacy, a short time frame, and a playful format, these issues are just briefly mentioned, and a proper explanation does not find place in the game. Nevertheless, it should complement the educational path.

**SYSTEM DESIGN.** Once the kick-off phase is concluded, and the consequent foundational elements have been selected – always with the mission goals in mind – the backbone and the boundaries of the system to design should be clear. Indeed, the discussion for the selection should embed the envisioning of possibilities. That being the case, the elaboration of a more defined concept should be relatively immediate by following the established guidelines. Thus, for this activity, a time limit of five minutes is provided to avoid redundant overthinking, and the completion of a system sheet is
required. The latter should support the participants in formalizing the system’s structure by pointing out its characterizing features. Specifically, it follows the configuration of the case studies attached to all the ML agents (as well as their definitions) and asks designers to describe: (i) the system task – how the ML agent should help to reach the goal; (ii) input – what information should the agent be supplied with to perform the task; (iii) output – what the agent is expected to give in return; (iv) stakeholders – who need to be involved in the team to set the right premises. Actually, (i), (ii), and (iii) are the basic constituents of any artificial intelligence (AI) system as outlined in the definition of the European Commission (High-Level Expert Group on Artificial Intelligence, 2019a). Instead, the identification and potential involvement of stakeholders in the design process is not only a widely suggested ethical practice but also a consolidated approach in the field of design (participatory design, or co-design). Ultimately, to anticipate possible difficulties in the systematization of the idea, examples have been prepared for the players to compare or adopt once the time is up. After the comparison, final adjustments can be made before moving on to the closing phase.

WEIGHING UP. Among morals, meaningfulness, and usability, the last part of the game encapsulates the human-centered soul of the approach. It introduces the criticalities that may emerge in a ML system, presenting them – in the form of cards – as the concerns raised by the fictional WACSI wise council. Each card (Fig. 7) includes a possible limitation of the system and the related implications, values, and options that designers have to avoid such hindrance. The concern cards are distinguished by disciplinary competence: some issues may be primarily identified or handled by ML developers, some by designers, and others by ethicists or social scientists. Still, they share the common goal of benefiting human beings and the world around them.

Concerns rooted in ethical discussions, which constitute the largest part of the deck, are the result of the analysis of the existing ethics guidelines comprehensively collected in the AI Ethics Guidelines Global Inventory (Algorithmic Watch, 2020). Currently, it includes 173 guidelines, among which only those in English, belonging to certain sectors, addressing AI in general (not specific applications such as AI in healthcare), and listing some principles AI systems should embody were considered to derive relevant values, implications, limitations, and options for the cards. As a result, 51 guidelines were selected: 7 from academia, 20 from civil society, one from intergovernmental organizations, one from international organizations, and 22 from the private sector. Further references include some consistent tools (Artefact, 2017; Calderon et al., 2019; Futurice, n.d.; IDEO, 2019) and the research work developed in the project Meet-AI for UX concerns (Spallazzo et al., 2021).

Moreover, time is another significant variable for facing concerns. Whether they occur during the design, development, or use of a ML system, a responsible approach requires that they be addressed early in the process, both to prevent risks and to avoid late and costly interventions. To highlight this point, the concern cards have been divided into three categories according to when the cause of concern is originated. In the before use deck, the cause of concern precedes the model creation (then the implications are patent also before the development of the system is complete); in the in-use deck, the cause of concern affects the use of the system; and in the long run deck, it develops over time.

With the purpose of stimulating discussions about possible unforeseen outcomes and reflections on responsible practices to be accounted for already in the ideation phase, the ultimate part of the game makes the players address up to nine different concern cards (three from each time category) randomly drawn. They can be read and solved in any order to underline that there is no preferable procedure as long as all kinds of issues are well pondered.
As anticipated, all the cards present the readers a possible action that they can handle to increase the beneficial impacts of their system or that they can disregard, exposing the system to be a potential threat. Of course, not all the concerns apply to the imagined system or are preferable to comply with. The focus here is on balancing the possible good or harm a system can cause, keeping into account the time factor (time will not be sufficient if all options are fulfilled, as tackling all concerns in a project would be an endless work), and acting accordingly. To do so, players can add some notes to their system sheet (if necessary), replace any of the value, ML agent, or intent cards (optional, this action that would cost time), and advance a marker on the benefits and time indicators if they decide to address the concern, just move the benefits marker if they considered the issue before reading the card, or advance on the threat indicator when they decide to ignore it. Instructions about the movements of the markers are provided on the cards and vary according to their potential impact. **MISSION END.** The end of the game is declared when players solve all the concern cards or reach the final space of any indicator (getting to use all the time at their disposal or attaining the maximum amount of benefits or threats). The level of positive or harmful impact achieved by the designed system determines the completion of the mission. Four different epilogues are available (Fig. 8), though they all converge in presenting the fundamental requirements for responsible innovation that students can guard for future reference: being (ethically) acceptable, sustainable, and socially desirable (von Schomberg, 2013). Ultimately, the game results in leaving open space for further considerations. In fact, whether a system satisfies these requisites – regardless of the outcome of the mission – is up to the players to understand and hopefully discuss.
3 From theory to practice: discussing the development of the game and the playtests

In the following, the results emerging from the observation of the playtests and the subsequent semi-structured interviews on the translation of ML and ethics concepts for designers are discussed. The aim is to highlight the issues that affect the didactic purpose of the activity, while insights about the game materials and mechanics are beyond the scope of this argumentation.

3.1 Limitations: Where the translation needs refinement

Since it was a first tentative experimentation of merging three disciplinary perspectives to pursue a common goal, the playtests have been a very informative occasion to spot some weaknesses in the instructional framework.

Above all, conveying ML’s value as a design material that can help facing important societal issues seemed feeble. In the first session, the impact goal was not made explicit as one of the SDGs, although clarifying that in the second playtest did not change the participants’ perception. In fact, being Ph.D. students in the Department of Design at Politecnico di Milano, they are quite used to deal with such high goals. Certainly, ML agents were embraced in both sessions as manageable tools to address the mission, regardless of the scale of the problem.

Their communication, however, highlighted some difficulties. Even if the combination of a definition and case studies effectively delivered the core principles and the level was appropriate, the first impact with a technical presentation was a little disorienting for the players with no prior knowledge. At the same time, a more visual language could enhance assimilation and memory. The most problematic point, though, is the length of ML agents sheets. Although containing just essential information, they require some effort from players. If introduced in the kick-off phase, they break the rhythm of the activity, but also making them anticipate the game (as tested in the second version), it remains a burdensome task. A collective introduction, aided by visual supports, may facilitate the knowledge transfer, leaving ML agents sheets the role of reminders.

Similarly, the tone of the concern cards needs simplification for greater accessibility by master students (the ultimate target of the activity). Additionally, marking the differentiation of the cards’ contents (limitations, implications values, options) may increase the intelligibility of the translation.

Overall, the game experience appeared balanced with respect to the capabilities of the testers and the provided knowledge. Some uncertainty emerged only in the system design phase of the second playtest when prior (non-expert) familiarity with the topic brought up issues that went beyond the
intended task. This was a further indicator that expert assistance is essential at this stage of the game development. Of course, some minor graphic adjustments might smooth out the fruition. Indeed, the order of the contents on the board has been modified for the second digital playtest to limit external intervention, increase the focus on each phase of the game, and the visibility of important definitions that the participants should acquire for a precise understanding of the elements in play. Though some confirmations by the facilitator were always sought, and the two-pages rules booklet predominantly guided the players, who quite ignored the additional contents on the board.

3.2 Challenges: among unexpected outcomes and space for improvement

The premises of this experimentation reveal its ambitious nature. Merging ML, ethics, and design in a single brief activity to start expanding the borders of current design education necessarily required simplification. After having identified the key information to be transferred within the didactic introduction, the risk of trivializing or omitting some fundamental pieces of knowledge was high because this translation represents quite an unexplored territory.

The problem is exemplified by the fact that ML systems are rarely linear and often necessitate integrating multiple systems to achieve seemingly simple goals. More ML agents may be combined to get to a solution, yet the players are asked to select only one and describe the system accordingly. Although this helps limit the time and complexity of the activity by encouraging novices to focus on one agent at a time, it lacks completeness. In fact, some confusion arose during the second session system design phase. In this case, the participants aimed at building a recommendation system to orient potential criminals towards positive activities instead of perpetrating in noxious environments. To do so, they identified the Sequence Prediction (SP) Agent – able to predict values or outcomes in a sequence based on historical information (data in which it is possible to detect patterns of activities or behaviors over time) – as means to reach their goal. As visible in Fig. 9, they wanted to feed the system with twofold sequential data: sentiment analysis of posts on social media (like Facebook) and videos and ads of constructive activities capable of capturing users in a virtuous circle. Though, to produce both kinds of information, other ML agents are necessary: specifically, a classification system able to determine whether hate or violence emerge from written posts (to detect which people to target with positive contents), and another one to identify contents that instill positive addiction towards constructive subjects (to decide which suggestions the SP Agent might propose). At this point, the recognized overlapping of sequence prediction and classification tasks induced a short circuit and required the facilitator’s intervention. Yet, to understand the basic principles of ML, is it necessary for the ideated systems to be totally correct, or are some mistakes allowed in favor of immediacy?

The example highlights how the gradual expansion of the frontiers of design has to be reasoned thoughtfully: the completion of the system design sheet leverages consolidated design skills, but the modalities of knowledge transfer may challenge the process.

Figure 9. System design sheet developed in the second playtest

Another central issue is enabling the participants to elaborate on a system concept by integrating the multidisciplinary perspectives acquired. It affects both the framing of the ML problem for the set-up
and the system design phase. In the set-up, defining the key outcomes that players need to reach with their systems means finding a balance between specificity and freedom. In the first case, the key outcome should be very detailed and imply only one ML solution; in the latter, it would be broader, leaving space for several possibilities (maybe not straightforward or not involving ML). Another concern that can be raised is that forcing a ML-infused solution could suggest a technology-driven approach. For the system design phase, the focus is on the guidelines for an actionable system design sheet: they need to be easy to understand and follow, and, ultimately, they should empower players to depict a system in both a sufficient but not too detailed way.

![Figure 10. Key outcome and impact goal cards on the board. Created by the author](image)

Since the activity entails the total inexperience of the students in designing with ML, it was challenging to understand which level of guidance they might need with the few tools provided. In the end, to measure the capabilities of the testers, the key outcome cards (Fig. 10) contained only quite general briefs and suggested datasets (as possible inputs for the system to design), while sample sheets were prepared and included in the game as a backup plan. The system design sheets, instead, were supported by the structure of ML agents ones. Surprisingly, during both experiences, the participants had no trouble in quickly delivering a system idea. The suggested datasets in the settings and the examples after the system design activity were not even necessary (in fact, the latter were not included in the second playtest, which caused no problem). Instead, the case studies from the ML agents sheets were important references to comprehend the requirements properly. However, what needs to be clarified is whether the systemic vision of Ph.D. students may have affected these results or if it also applies to master-level students.

Eventually, the playtests revealed some challenges also in the weighing-up phase. Although they had the chance to modify the elements defined in the kick-off (value, ML agent, intent), this was never considered. On the contrary, deciding to address a concern was so easy to comply with, while ignoring it caused negative feelings. Especially in the first session, the cards were perceived as prescriptive and triggered reactions like: “How to say no?” In this light, the purpose of the weighing-up phase could be reinforced towards a more conscious and thorough questioning of the idea. Then, instead of having students acknowledge some possible concerns about ML systems, the concern cards could be reframed to go deeper into project matters, stimulating a more realistic iterative process.
Overall, the main challenges for enabling designers to work across disciplinary boundaries lie in the interstitial points between them, more precisely in knowledge transfer and operationalization. Especially in the introductory phases of a disciplinary expansion, trade-offs are required: it is necessary to understand what the most appropriate levels of completeness, depth, guidance, and active involvement with the contents for designers to deal with are.

3.3 Strengths: Rudiments for a hybrid designer

The enthusiast exclamation “I learned something today!”, pronounced by one of the participants at the end of the game, perfectly synthesizes the most valuable outcome of the didactic experience. Indeed, testers in both sessions proved and confirmed that they had finely assimilated the pieces of knowledge that the activity aimed to instill, despite the substantial cognitive load to which they have been exposed. Moreover, the connection of the three disciplinary perspectives was discerned, and the participants demonstrated no problems in handling them, proving their openness towards expanding the frontiers of design.

In fact, despite the aforementioned issues with the dense contents of ML agents sheets, all the Ph.D. students involved in the experiment appeared at ease with the given materials and tasks, and these were effective in providing the basic equipment to face the system design. For instance, in this sense, the custom additions to the values and intents usually encountered in the literature received very positive feedback and have been incorporated into the system’s foundations (Fig. 11). In fact, towards the key outcome of preventing deadly attacks orchestrated by organized crime in public spaces, both groups embarked on a proactive approach. The first one elected promotion of flourishing as driving value because it was considered more comprehensive than prevention of harm: they stated it could help people appropriate their territory and avoid crimes. The second chose inspire as system intent to encourage potential criminals to pursue constructive interests.

Already during the kick-off phase, several ideas were brainstormed, triggered by an effective combination of ML agents’ capabilities, intents, and values, so that the design of the system flowed smoothly. Also, to define the trickier elements (i.e., input and stakeholders), the players needed no assistance and identified coherent and original ones.

Additionally, from the very beginning, ethical concerns were explicitly discussed, as value-driven design may already be embedded in the mindset of designers. Indeed, this was the case for both the Ph.D. students with no prior knowledge of ML and for those who might have been exposed to this subject. The former imagined a detector of the conditions that nurture crime (given context and municipality investments), insisting on including different stakeholders for a plural perspective. The latter proposed a recommendation system to deter criminals from malicious activities and drive them towards more constructive ones. In this case, the players were perfectly aware of their system’s insidious and manipulative nature, though they considered this solution more ethically acceptable compared to capillary and undifferentiated surveillance. Therefore, even without a formal ethics education, the Ph.D. students manifested a responsible approach to design. Being early-stage researchers, their sensitivity may be increased; still, these kinds of considerations are at the basis of human-centered reasoning.
Albeit the expected outcome of enabling students to activate fruitful discussion should be verified in less guided contexts, the cooperative game turned out to be a fertile ground for debate and represented a successful example for opening the frontiers of design and enriching its tools. Throughout the entire activity, in both the physical and digital environments, communication is effectively fostered by the materials and the assignments players are faced with. The selection of foundational elements, the outlining of the system, and the final weighing are all collaborative activities and entail making decisions together by exchanging personal perspectives. As intended, also the mission end cards successfully accomplished this result, encouraging a retrospective discussion on the designed system and the whole experience.

4 Conclusions and future work

As Manzini stated in (Frascara, 2020), designers can operate in a variety of fields, and they can contribute to conceive and realize varied artifacts. A reason for this may be that “designers bring multiple talents to the solutions of complex issues, but first and foremost […] empathy” (Friedman et al., 2014).

Empathy allows designers to understand the needs of all the people involved in a project, which implies absorbing their perspective. This is why, if properly equipped, they can comfortably navigate among disciplines and build upon their knowledge and methods, as corroborated by the empirical experiment above depicted. If the translation of technical knowledge (the primary objective of the activity) can be a delicate practice as it requires finding the correct language to efficaciously engage and empower designers to comprehend and make use of the transferred contents, instilling a value-sensitive perspective (secondary goal) appeared a far more natural outcome.

Indeed, going back to Alain Findeli’s study on Ethics, Aesthetics, and Design (1994), he already stated that ethics is an expansion of the currently accepted design definition. He sustained that “ethical deliberation is not very different from any other decision-making process,” suggesting that designers not only have the means and the capabilities to handle ethical questions, but they also inevitably act in the field of ethics when they design an artifact. In fact, like any human activity, design is not neutral:
choosing a technological mediation (in the broadest sense of creating instruments for people to interact with the world) is itself a matter of ethics, not of technology. Further assonances can be reported in that designers’ criteria of choice do not arise from the truth (as in science), but from more qualitative evaluations of appropriateness, acceptability, correctness or desirability, and the now common practice of involving different stakeholders in the design process, that the author defines a “multicriteria approach,” is already a moral action. What distinguishes a design decision from an ethical one is, in the words of Findeli (1994), a “total moral engagement on the actor’s part,” which, in line with the opening of this paragraph, can be reframed as the empathy representing a major strength of designers. To support once again the innate capability of designers to include ethical principles in their reasoning, Findeli (1994) underlines that “the systemic apprehension of a complex reality comes from intuition,” a skill that designers have to train with appropriate methods but that is rooted in their previous education and practice. After all, just as design pervades every aspect of human life, any field can be embraced and shaped by design, reinforcing the idea of a transdisciplinary design (Blevis et al., 2015) that transcends disciplinary boundaries. Expanding the frontiers of design, then, could contribute to the creation of a new kind of skill: that of mediating among approaches and value systems of a variety of disciplines (Kirschener & Norman, 2021). As self-conscious bricoleurs (Louridas, 1999), designers will not just merge the materials at hand; they could also identify and bring together different kinds of professionals to foster collaboration across multiple disciplines. In the end, extending the breadth of design borders will not threaten a loss of identity. As demonstrated by the portrayed didactic experience, what characterizes designers is their attitude, their approach, and the processes they are used to apply to frame and solve problems. From its origins, design was outlined through the distinctive traits of other disciplines combined – namely, art, science, and technology. Today, this disciplinary distinction should be blurred and enclosed within a more general model to define a designer, whose essential skills would be perception (including visual intelligence) and (moral) action (Findeli, 2001). With such foundational equipment, the designer could easily merge into different disciplinary realms to deal with the most pressing problems and act as a bonding agent. To support this vision, it would be interesting to expand the proposed introductory activity. It may be the building block for a more comprehensive educational project or include more vertical topics and become modular and flexible. Likewise, its finality could also be broadened, and further relevant insights could be gained from the submission of the game to students with different but inherent backgrounds. In the current state, if ethicists may not find cues to operationalize their knowledge, ML students could be interesting testers. Could a different perspective on ML agents enrich them? Can they get to design a system with the provided materials? How would they react to ethical concerns? Responding to this sort of questions may convey a deeper understanding of computer scientists or engineers’ approach to the same problem, eventually suggesting how to facilitate communication with designers and make this game a basic tool for interdisciplinary problem-based teams (Friedman et al., 2019).

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References


4 Design Thinking in professional training
Design process of live-action video instructions

Yvonne Eriksson\textsuperscript{a}, Katrin Skagert\textsuperscript{b} and Per-Erik Ekwall\textsuperscript{c}

\textsuperscript{a} School of Innovation, Design and Engineering, Mälardalen University, Sweden, yvonne.eriksson@mdu.se
\textsuperscript{b} Division Material and Production, Department Method for Product Realization, RISE Research Institute of Sweden, Gothenburg, Sweden, katrin.skagert@ri.se
\textsuperscript{c} Faculty of Media Studies, Dalarna university, Falun, Sweden, pek@du.se

Abstract. The aim of this design project is to explore ways of co-designing instructional videos, together with representatives from the elderly care sector, that show how to use Personal Protective Equipment (PPE) and how to follow basic hygiene routines. We have used a Design Thinking (DT) and Research through design (RtD). The results show that the main improvements derived from using a co-design process were input on the details needed to make the video more realistic and more reflective of real-world scenarios.

Keywords: co-design, research through design, live-action video, visual instruction, live-action video

1 Introduction

Today’s Sweden may be described as a “risk society” (Giddens, 1998, p. 27), where communication about safety and risk prevention commonly takes the form of warnings and instructions. In this paper, we present an innovative way of designing video instructions, namely co-designing them with their presumed users. In a professional safety control context, the creation of visual instructions is normally the affair of specialists that design the instructions in accordance with warning design standards such as, for example, the ANSI Z535 for safety signs and colors (Woghalter & Mayhorn, 2017). However, the description of design element properties that can alert workers to hazards are of questionable use if the actual hazards are partly unknown and exists in a new type of hazardous condition. A case in point is the covid-19 pandemic. Therefore, new types of hazards in the workplace require innovative, designerly approaches with regard to the communication of hazard control and disease prevention procedures (Ekwall, Adel & Nyström-Höög, 2021). Our particular instructional approach involves live-action videos, since this particular format allows for a quick-turnaround between design iterations, and functions very well when instructions rely heavily on human speech and human movement (Eriksson and Eriksson, 2018; Ganiër & Vries, 2016).

We have used a Design Thinking (DT) process (Cross, 2010; Badke-Schaub, 2022) and Research through design (RtD) (Giaccardi, 2019). DT was helpful in the problem framing process, and for gaining an understanding of the user and empathising with them; namely, personnel working in homecare for elderly people. In the iterative ideation phase, we used photography and videos. The aim of the project was not the end-product but to gain a deeper understanding of what is required for the creation of instructional videos; in this case, instructional live-action videos. Therefore, the project could also be defined as research through design-process, an artefact-centred design approach, where two researchers (specialised respectively in design, and occupational safety and health management) involved stakeholders working with homecare in a municipality in the southern region of Sweden. The stakeholders involved held different occupations such as manager, nurse, homecare workers (with and without formal training), occupational therapist, and union representative. The project started in
July 2020 and lasted for one (1) year. It was financed by Afa Insurance, and the municipality contributed the participating personnel.

1.1 Background
Elderly care services in Sweden have certain problems related to a shortage of educated workforce, which is also the case in many other countries (WHO, 2016). The pandemic seems to have only made these problems more acute (Swedish Association of Local Authorities and Regions, 2021). Employees in the elderly care sector are often part-time employees, have Swedish as their second language, and have attended zero or less than one year of nursing school (Strandell, 2020). To support these workers, and to prevent the spread of Covid-19, various how-to videos have been developed which show them how to use protective equipment and follow guidelines for basic hygiene in care environments. However, the videos in question do not adhere to the segmenting and contiguity design principles (Mayer and Clark, 2016). They are too lengthy, and, above all, they are inconsistent, e.g., what is said and what is done in the videos is not synchronised. In addition, they were recorded in a hospital environment and did not relate to people working with homecare. It is important to keep in mind that this category of employees did not have a tradition of using personal protection equipment since they mainly assist with daily hygiene routines (where they use gloves), preparing food and cleaning up. Therefore, our instructional support was developed with this particular kind of personnel in mind.

1.2 Aim and research question
The aim of this design project is to explore ways of co-designing instructional videos, together with representatives from the elderly care sector, that show how to use Personal Protective Equipment (PPE) and how to follow basic hygiene routines. To do this, we ask this primary and basic research question: How can a co-design process improve understanding of the challenges involved in the design of instructional live-action videos?

1.3 Research Through Design
By co-designing videos in accordance with a Research Through Design (RtD) framework, the focal point of this design project is not the end product, per se, but a mutual knowledge creation which, hopefully, will be beneficial for both home healthcare workers, designers of the instructional videos, as well as the patients and elderly in nursing care facilities. This approach essentially means that we regard the end-product, i.e., the final video instruction, as a good enough, albeit improved, design solution that is based on realistic expectations, as oppose to (lofty) ideas of design perfection. The means by which to achieve such a good enough design solution is the RtD framework, since RtD offer ways for the stakeholders to engage in deeper dialogic interaction with regards to how to communicate the proper use of personal protective equipment and basic hygiene routines. Similar to RtD-researcher Giaccardi (2019), we consider digital communication objects as connected things capable of illuminating both hidden and obvious knowledge that are the result of dialogical interaction between stakeholders. In doing so, the communication object (the video instruction) reflects the role of the RtD artifact in participatory processes of co-design and co-reflection. At the heart of any RtD-project, lies the activity of prototyping. The RtD prototype, indirectly helps forming a sort of consensus among non-designers and designers (cf. Sanders & Stappers, 2014). This is what Giaccardi calls a “stabilizing character” of the RtD-artifact (2019, p. 141). Oftentimes, RtD-researchers use prototypes to support processes of reflection, in terms of what did not work and what did work in the design process. If used like this, the artifact is used primarily in its evaluative
capacity. In the study presented in this paper, the video instruction is used in this way. But more importantly, it is also a vehicle for theory building (i.e. generate generalizable knowledge) as well enabling stakeholders to simulate and ‘see’ procedures and practices in a new light thereby being able to identify what might be regarded best-practice routines.

2 Visual communication

Visuals are perceptually tangible to various degrees and can portray objects and spaces and demonstrate spatial relations. A visual can be an object by itself, or a representation of an object based on the similarity of what is represented, or it can be based on abstract conventional signs. Visual communication is part of every culture, even though we may sometimes use it in different ways. Interestingly, even a very simple symbol can carry a complex meaning, something which needs to be learned. Visual communication can be defined as the use of one or several pictures to visually represent and illustrate a concept for the explicit purpose of communication. We use visual communication to express ourselves with the aim of sharing thoughts, ideas, emotions, or information. Regardless of whether the content is complex or not, all communication is an externalisation of our ‘inner voice’, our thoughts; and the purpose is to make these thoughts accessible and understandable by someone else. Whether we want to explain a concept or call attention to something, or entertain, it’s all about sharing with others. It is not only socio-cultural aspects that matter in visual studies. We also need to take cognitive aspects into consideration. Our ability to imagine things influences the way we see and perceive the world, which ties into Mitchell’s (2015) suggestion to distinguish images from pictures; where images are to be regarded as mental images or metaphors, and pictures as actual representations. This definition indirectly highlights the difference between two distinct modes, or types, of visual instructions. There are visual instructions that are meant to aid users in creating ‘mental images’, i.e. by being mentally engaging (Mayer and Clark, 2016) such as, for example, abstract, static, instructional drawings, as well as visual instructions that are more ‘naturalistic’, such as live-action videos that display people who function in more direct ways since they offer humans a kind of mirror neuron advantage, being imitable (Eriksson and Eriksson, 2019). It is necessary that those who are learning a task or approach understand why something should be done in a specific way (Endsley, 2016). Visual instructions need to be motivational. In addition, in a useful visual instruction, the user should be able to easily identify what the displayed image or video really shows or represents (Eriksson and Eriksson, 2019). The videos we have designed are the live-action video format type, i.e., recorded videos. The videos feature care workers working at an elderly person’s homes.

2.1 Live-action video

In contrast to computer generated animations, live-action videos are recorded with video cameras, showing events and procedures as they occur over time in real-life situations. The rapid adoption and development of new communication technologies such as powerful video-capable smartphones have revolutionized the face of instructional communication, in essence making it a lot easier and affordable to create and co-create various types of video instructions using human instructors, as well as offer simple ways to very quickly distributed content to the right type of audience/user. Hence, in recent years, studies investigating the usability and design implications of live-action how-to videos have increased. For example, Eriksson and Eriksson explore how direct affordances inform users’ abilities to imitate construction procedures (2018); Cheung et al. test the effects of video instructions on procedural skills transfer in clinical practice (2020); Biard, Cojean and Jamet, (2018) investigate the role of pacing and segmenting in procedural video instructions demonstrating how to make hand orthoses; Ganier and Vries (2016) investigate the relationship between users’ performance and static
or live-action instructional design in suture workshops; and Yi et al. (2019) study what role the live-action video-mediated presence of an instructor plays in students’ learning when decoding instructions. The underlying reasons behind this research development has to do with ease of use editing and recording technologies (such as iPhones and various kinds of web cameras) which have now become commonplace, and online distribution venues (such as YouTube) that allow for a quick turnaround of recorded videos. However, at the heart of research efforts, such as these, there is the issue, and research problem, of the role design plays and how designerly ways of producing instructional content relate to learning outcomes.

2.2 The cognitive load aspect

Defining and measuring learning outcomes associated with online video instructions are specialised interests in the field of cognition and learning, as most notably exemplified by Mayer (cf. 2019) and Sweller et al. (cf. 2019). According to Mayer’s Cognitive Theory of Multimedia Learning (CTML), as well as Sweller’s Cognitive Load Theory (CLT), learning outcomes are intrinsically linked to the interplay between the capacities of the limited working memory and the unlimited long-term memory. Over the years, this insight has indirectly warranted the employment of design guidelines (also known as ‘design principles’) for visual instructions, which are meant to lessen the cognitive load of the working memory. Such guidelines are also applicable to the live-action video format (Eriksson and Eriksson, 2018). In spite of the growing number of so-called DIY-videos (do-it-yourself videos), explainer-videos and how-to videos on the internet and in social media, in the field of information design, research on live-action visual instructions has been rare. Still, information design scholars Spinillo & Perozza (2015) recommend that animated procedural instructions, which may or not be live action, should be based on Mayer and Moreno’s design guidelines for animations (2002) in order to support communication effectiveness:

1. Video content should include both pictorial elements and narration (text or voice)
2. On-screen text that refers to pictorial content should be presented near the pictorial content
3. The video content and the narration must be presented simultaneously
4. Only relevant and coherent elements of an animation should be included in the video to avoid extraneous elements (including sounds)
5. Video content should be associated with audio narration rather than with on-screen narration
6. If audio narration is employed with pictorial content, do not add on-screen text
7. Verbal content (on-screen text or voice narration) should be presented in a conversational and informal manner

Video is a time-based, or transient, medium. The transient effect refers to the negative effects associated with the constant flow of new information in videos that cause cognitive load. Unsurprisingly, according to some online education scholars, presentations that are too lengthy are the main problem with instructional videos in general and may possibly explain why the implementation of Mayer’s multimedia design guidelines in lecture style videos, which are partly live action, have failed to generate positive learning outcomes (Lamb, 2015). None of Mayer and Moreno’s design guidelines will aid in making instructional videos more useful for users, in the sense that they will make the videos in question shorter. In other words, none of Mayer and Moreno’s design guidelines include the so-called segmentation guideline, which is specially geared towards combatting cognitive load via the means of breaking down multimedia lessons and, hence, decreasing the negative effects of the transient effect (Biard, Cojean & Jamet, 2018). However, with respect to the live-action video format, segmentation can, nowadays, be easily achieved via user interaction whereby the user uses control buttons integrated with the viewing interface, thereby essentially achieving self-paced lessons (Biard, Cojean & Jamet, 2018). This also allows for some level of user-interactivity.
In summary, then, the design guidelines proposed by Mayer and Moreno (2002) seem to overlook the interactivity-factor that has been proven to promote comprehension and learning (Koć-Januchta et al., 2020). The issue of interactivity, and the lack thereof, not only concerns the ability to control the pace of the instructional video content but is also connected to the type of modality (written explanatory text versus spoken narration). Empirically based studies have shown that spoken narration is dependent on the type of interactivity/pacing (cf. Koć-Januchta et al., 2020). If the pacing of the video is largely system-paced, an auditory narration leads to a better learning outcome than written text; but if the learner completely controls the pacing by themself, written text is better (Koć-Januchta et al., 2020).

2.3 The live-action advantage

Curiously, the transient effect, which is normally considered to be something extremely negative in instructional situations, may be advantageous in the live-action video context because ‘transience’, simply put, is the normal state of affairs in the natural world. If one acknowledges that mediated communication may be understood as a kind of exchange in a natural environment, and that this environment is the basic and essential ingredient in the formation of messages, then we might have to accept that ‘natural communication’ also involves things that are known without being overtly communicated and/or taught (Geary, 2008; Paas & Sweller, 2012). In other words, gestures, facial expressions, and aspects of human speech do not require overt teaching methods since some communication exchanges take place, and become ‘meaningful’, between bodies and in bodies, thereby bypassing the working memory altogether. According to Paas and Sweller (2012), there is actually no evidence that basic problem-solving skills, planning skills and decision-making (i.e., means-end analyses) can be taught at all, since these skills are part of our predetermined repertoire of biologically primary knowledge which we are pre-programmed to know and be able to automatically relate to. Thus, biological primary knowledge cannot be taught, and therefore requires no explicit tuition (Geary, 2008). This approach to natural information processing systems provides the rationale behind labelling live-action videos as the perfect medial vehicle for exploiting humans’ bodily architecture. Essentially, the rationale is that biologically primary knowledge is integral to live-action videos, as they often feature people who make actual human movements, are involved in basic problem solving, use human speech (often in our mother tongue) and exhibit naturally occurring cues and signals (cf. Eriksson and Eriksson, 2018). Therefore, the explicit teaching part in some Live-action-video instructions can be omitted. Immersion can be a good enough approach (Paas & Sweller, 2012).

This presents the key advantage for designers using the live-action format. If some aspects of the overall instructional goal can be left without overtly attending to them, more effort can be placed in instructing about what is normally the primary goal of any instruction: to drive the acquisition of biologically secondary knowledge. Biologically secondary knowledge is culturally and socially acquired knowledge that is not preprogramed in humans, and that ‘resides’ in the mind (Sweller, Ayres & Kalyuga, 2011). In other words, biologically primary knowledge may leverage instructional attempts to promote acquiring biologically secondary skills (Paas & Sweller, 2012). The reason for this is that when we convey information belonging to the biologically primary knowledge realm, very few cognitive recourses are required (cf. Eriksson and Eriksson, 2018). This frees up cognitive space for other, more demanding, mental activities which are the real important ones and the focal point of the instruction in quest Standard operational procedures to prevent the spread of Covid-19.

Covid-19 is classified as an epidemic disease in Risk Class 3, which means that employers are responsible for ensuring staff members have access to personal protective equipment, and that the equipment meets safety standards (WHO, 2021; Swedish Work Environment Authority, 2020). Safety
standards and regulations for basic hygiene routines are often translated into written standard operational procedures (SOP) in terms of instructions, norms, and rules to manage and prevent the spread of disease. Those SOPs can be described as a dimension of work as imagined (WAI), while work as done (WAD) is how it is performed in practice. WAI, in terms of SOPs, cannot fully reflect actual events and the performance of work but is needed to create a framework for WAD. Yet, a continuous reconciliation is required through reflection and learning to adjust and harmonise between WAI and WAD (Calvharo et al., 2018). In this sense, the design process worked as a continuous reconciliation.

3 Method

This study is a RtD study. The overall RtD process can be divided into four fundamental phases, akin to Herriott (2019). The background research Phase 1 includes a general risk analysis of how, when, and why protective clothing should be used or not. The method used in Phase 1 was a semi-structured interview where one interview was with a mixed group in the collaborative municipality, and the other was with a group of four homecare workers in another municipality. Participants in the municipality we collaborated with were union representatives for different professions working in elderly care (i.e., assistant nurses, registered nurses, physiotherapists and administrative staff), as well as healthcare managers and medical responsible nurses (MRN). In relation to the written Hygiene routines and the result from the interviews regarding in what order the PPE is put on and taking off we made a story board. In Phase 2, the visual prototypes were designed and produced based on the results of Phase 1. A slideshow was created with photos and accompanying text in plain language, explaining what PPE to put on or take off, and how to do it. The slideshow was analysed together with the mixed group with focus placed on the order of instructions on how to dress and undress. The result from the analyses of the slideshow created a base for Phase 2. The design of the live-action video prototypes started. The live-action video was recorded using an iPhone on a tripod in the hall entrance of one of the researchers’ homes. This researcher also performed the role of the main actor/instructor in the video. An objective camera angle was used, and the tone of the verbal instruction was instructive with plain language. It was an iterative process that generated seven (7) versions of the live-action video. The analyses of the videos were completed using visual methodology (Rose, 2016) and content analyses (Krippendorf, 2004) with focus on the hygiene routines. In this second step of the design process, when we started to videotape prototypes, we mainly met with two nurses who are responsible for hygiene routines. This was partly due to restrictions related to physical meetings, and also because of the second wave of the pandemic which made the homecare workers very busy. The nurses were involved in the co-design of the prototypes by taking part in the analysis of all seven steps (the 7 versions of the prototypes).

In Phase 3, video production and process analysis, the final video was produced based on dialogues related to the video prototypes. Digital workshops were held with homecare staff to capture how the visual instructions are perceived and understood. Ten focus group interviews were conducted online over two days, with a total of forty-two (42) homecare workers from two units in the municipality. On the first day, technical administration/support was undertaken by a staff member from the administration department. On the second day, the manager of the group took care of administering the meeting and participated in all the interviews. The two final versions of the videos about how to put on and take off PPE were shown. The participants watched the videos for the first time. The videos were shown on a computer screen in the room where the participants met, while two members of the research team participated online from two different places. The discussions were recorded with the participants’ permission, and the researcher wrote field notes during the process. We asked the following questions:
Before Covid-19, when was protective equipment used?
How did you learn how to put on and take off the protective equipment?

Then, we showed them the videos with the instructions. First, the one that shows how-to put-on PPE, and then the one showing how to take off PPE.

We asked for spontaneous thoughts:
What do you recognise and what is different compared to how you usually do this?
What are the advantages or disadvantages of visual instructions like this one that we have made?

We also asked about the value of the video in relation to work to be done.
In Phase 4, the comments and reflections were sorted after those questions, and a manifest content analysis was conducted (Graneheim & Lundman, 2004; Krippendorf, 2004).

4 Results of the research through design process

Here, we describe the first three (3) phases of the research through design process, and end up in a discussion in Phase 4, where new information and theory is modified.

4.1 Phase 1 - risk analysis

The whole process and Phase 1 started with an initial meeting with the strategic and operative management group for the care giver staff in the local municipality. Ten people (10) attended, including union representatives for different professions (i.e., registered nurses, assistant nurses, physiotherapists, and administrative staff) and MRN for care homes and homecare. This first meeting we held was our only physical meeting. We met the group in their regular monthly, one hour meeting, between August and December 2020. We started by presenting the project and our aim of designing visual instructions for home homecare workers related to how to use PPE. Initially, we talked about whether it was only elderly care or whether care for disabled (personal assistants and supported housing) would be included. We started discussing specific work situations where protective equipment is used. Here, the representative from the union was careful to distinguish between ‘personal protective equipment’ and ‘protective equipment’. Protective equipment, such as a plastic apron, is used to prevent the contamination of the ordinary workwear and the spread of infection between patients or the elderly person receiving care. PPE is used for the safety of the employee, and can include medical masks, goggles or face shields, and can differ depending on the situation.

They pointed out that the accessibility of PPE it can differ locally, for example, if there is space in a nursing home to have the PPE standing in the corridor or inside the user’s door. For homecare, the user may be required to change into their PPE in the stairwell. The MRN made it very clear that all the instructions and local risk assessments were in place and the staff had received clear written instructions (we interpreted the sub-meaning that, if they do not do it right, it is because of them—not because they did not receive good enough instructions).

During our dialogue about how it works in practice, it became clear that the dressing situation varies depending on how the care recipient lives—in an apartment or in a house—and how the home is designed, especially the entrance. The most critical moment, we learned, is during undressing and determining when and where the discarded PPE are to be thrown away. We also noted that it was unclear when, where and how employees clean their face shields between care recipients’ homes. The meeting led to a mutual decision to focus on how to put on and remove PPE. In our dialogue with the meeting participants, the group help defined what part of the instructions for PPE could benefit from visual instruction.

After the meeting with the management group, we took part of and read the municipality’s basic written hygiene routines. We conducted a semi structured interview online with four home homecare
workers in another municipality to gain a broader understanding of how the basic hygiene routines are used in practice by different organisations and parts of the country. We asked them to describe, step by step, in what order they put on and take off the PPE. Two out of the four interviewees worked in a nursing home, while two of them worked in homecare services as homecare workers in people’s homes.

4.2 Phase 2 - visual prototypes

Based on the information gathered in Phase 1, we designed a prototype of the visualisation in the form of a slide show with still photography, including a short text on every slide explaining what to do—which means the slideshow had a high degree of redundancy. The photos were taken by a student, with another student acting as a homecare worker, and they were instructed by the research team. The slideshow consisted of 25 slides. Many of them contained several pictures demonstrating every single step, aiming to visualise, step by step, how to, e.g., put on PPE in line with how we have understood the basic hygiene care instructions. The first challenge we faced in the early stage of the design process was how to put on different elements of PPE (Figure 1). We only received information in this order:
1. Start by sanitizing your hands.
2. Put on shoe covers without touching your shoes.
3. Put on the gloves.
4. Then put on the apron, mouth guard and face shield.

![Figure 1. Example from the slideshow](image)

When starting the design process by just following these steps, we faced a lot of practical challenges and not only when it came to how to put on the different elements. There were no instructions regarding where to put the jacket and bag when entering the door of the pretend care recipient's home. These details were under discussion during the whole process, from the making of the slideshow to the final video. However, the staff commented on the fact that she was not wearing working clothes. The basic hygiene routines are not adapted to the private sphere and are not concretized either. They are written on an abstract level and learned during nursing education. Then it is up to every co-worker to interpret the basic hygiene routines and apply them to the best of their ability. Before the pandemic, this was not a big issue. But because of the pandemic, it became a big problem, especially in the beginning of the virus’ spread. The existing instructional videos were based on a hospital context and did not offer any guidance.

The second part of the slideshow contains instructions about how to take off the PPE in a correct way, without causing contamination, and where to put the used PPE. The instructions on the slides accompanying the pictures advised that the PPE be taken off in the hallway before leaving the care recipient's home and thrown in the trash can in the hallway, within a garbage bag. The homecare worker should start by removing the shoe covers and throwing them in the trash. Then remove the gloves (we asked how) by pulling them inside out so you do not touch the outside of the gloves. Throw them in the trash and sanitizes your hands. Remove, the face shield without touching the outside of it (what do you do with it then?) Place it on the floor while you take off your apron (our solution).
Remove the mouthguard by holding only the loops and then sanities your hands again. Remove the apron. Start by unloose the apron at the back (our solution). Fold the apron inwards with the outside of the apron (our solution). Pull it up over your head. Roll up the apron with the outside inwards (our solution). Throw the apron in the trash. Finally, put the face shield in the backpack, or carry it in your hand (our solution). Sanities your hands. The last thing to do is throw the garbage bag outside in the dustbin.

The design team and the management team met for a dialogue regarding the content of the slideshow. The discussion was mainly about the advice that home homcare workers should start by sanitizing all the way up to their elbows, before putting on the shoe covers. Most comments were related to the undressing part. Such as: Do not lay the face shield on the floor! Wear gloves while removing the face shield. The gloves should be taken off after the face shield. Throw away gloves in bucket/bag at the door. Sanities the face shield (with spray bottle or plastic wrap for face shield cleaning). Sanities the hands.

Lay the face shield down in a backpack (all homcare workers wear a backpack with the PPE in it). Even though we asked them to focus on how to put on and take off the PPE, several of the staff commented on the clothing since they were not work clothes but her own—as well as the fact that she was wearing jewellery. We were told that hom homcare workers in general leave the garbage in the care recipient's hallway, and never brings it with them. The garbage has been an issue throughout the whole project, and we will discuss it later in the paper.

Based on the comments on the slideshow, we started to make video prototypes using an iPhone. Since the video instructions were intended for hom homcare workers visiting people’s homes, we chose an entrance hall to an apartment to frame the situation authentically. The camera was stationary, and the actor (a member of the design team) entered the entrance hall and put the bag on the floor before beginning the process by using hand sanitiser and putting on the PPE. The actor talked to the camera during the whole process. Every single step was commented upon, using a straightforward language, with clear instructions and no motivations given for how to act, only for what to do; for example, ‘Sanitise your hands, wrists, and underarms’.

In the first prototype, our team member acting as staff started with a mistake: she put on the shoe covers before sanitising her hands. That was probably an effect of the slide show, for which she was involved in the design of the pictures. The rest of the prototype video took into consideration the comments that we’d gathered in the meeting with the management group. In the prototype video’s the representative from the design team that act as a care worker wore private clothing, but in a neutral colour in order to avoid creating distracting information related to the clothing related to the clothing, and no jewellery. However, the staff commented on the fact that she was not wearing working clothes (Figure 2).

![Figure 2. From the prototype video showing how-to put-on mouth guard and face shield](image-url)
After finishing the first prototypes, one showing how to put on the PPE and one showing how to take it off, we showed them to the nurses. In a dialogue with the nurses, we gained new comments and suggestions on how to improve the video instructions. They were mainly about details but, from the perspective of basic hygiene care, they were important. For example, the backpack should not be put on the floor, they said, but needs to be placed on a stool, chair, or table to avoid contamination. They also commented that the actor put the face shield on the table in the hallway before sanitising it. They suggested that the face shield, instead, be carried in a separate plastic bag which should be hung on the door handle when entering the care recipient’s home. In a later prototype, we received the comment that the handle needs to be sanitised before hanging the plastic bag on it.

The undressing part was also a challenge since it has to do with details such as the quality of the apron plastic which affects the ability to tear away the apron, how to sanitise the face shield and where to put it when leaving the care recipient. The instructions from the nurses were that the apron should be wrapped up and, at the same time, the gloves should be taken off inside out with the apron inside the glove, together with the other glove. We were told that the face shield could be sanitised with spray and left to dry in a clean plastic bag.

With every version of the prototype, new details that were not noticed in the previous video were commented on. All the meetings took place online. However, all seven of the prototypes were made in the same entrance hall with the same actor and video recorder. The design team interpreted this as the development of the instructions—the closer the video got to an acceptable result; the more details became visible.

From our dialogues, it seemed to us that the nurses had limited experience from homecare in practice. They did not support the design team regarding how to handle the basic hygiene routines in practice. Instead, they referred to the text document. One of them gave comments on the last prototype regarding hand sanitation, arguing that three pumps from the bottle is necessary and at least 6 ml should be used. We later used the advice of three pumps but ignored the instructions of how many millilitres should preferably be used, since it is not possible to use that information in practice.

Once we had agreed upon the last version of the prototypes for putting on and taking off the PPE, with some small modifications, the final manuscript for the live-action video was produced.

4.2.1 Result from the Phase 2: Video prototypes. Using videos in the co-design process generated good insights among the involved partners, the designers, and the nurses. This is because live-action videos are associated with visual realism, partly due to the fixed camera position (the iPhone) while recording. For viewers, the video content is directly recognisable, in terms of what is performed and how. The actor in the videos explains what to do using a plain and straightforward language, without giving any explanations of why (i.e., without verbal contextual information). This was a conscious decision since we wanted to keep the videos short; and during the prototype process, there were no comments on the verbal presentations from the nurses, only on the visual parts. The tangible nature of the video—it is imitable—made it possible for the nurses to reflect on how to put the hygiene routines into practice. This gave the nurses the opportunity to reflect on the relationship between general roles for routines and the very concrete situation that occurs when a homecare worker enters a person’s home. The gap between the written bullet points and the visualised situation became highly apparent.

As we learned, the video format offers an advantage in one way, and a disadvantage in another. The advantage was the ability to discuss practical issues regarding how to put on parts of the equipment and in what order to put on the bag and the jacket. The disadvantage was the discussion about details such as what clothing the actor was wearing in the prototype. Details that were not relevant to the focus of the prototypes, since the aim was to understand how to put on and how to take off PPE and in what order to do so. Every single one of the seven (7) video prototypes were rectified from the meeting discussion with the nurses. To conclude, the prototype phase provided insights into the
complexity of the design process of live-action videos; but also highlighted the necessity of involving the users of instructions in order to gain a full understanding of how such instructions can be perceived.

4.3 Phase 3 - Video production and process analysis

In the last design step, we involved a professional filmmaker and a professional actress, which requires a specific order skill. Since the professionals were not involved in the design process, they were not familiar with the project, aside from the brief they received. The video was made in the same entrance hall as in the prototypes, with a static camera. The manuscript was based on what was agreed upon during the last meeting with the management group and the representative from the staff group. The recording took place for one day, and several versions were made. In one version, for how to put on and take off PPE, the actor talks simultaneously to the camera, in the same way as in the prototypes, explaining what she was doing. In an additional version, she acted without narrating her steps and, afterwards, the talking was taped in a closeup camera angle. Besides filming the full PPE routine, several versions were filmed showing how to use parts of the PPE. One with gloves, apron, and face shield; another with gloves, apron, and face mask; and a third with only gloves and apron. The aim was to create visual instructions that could be used even after the pandemic, and in more ordinary situations where basic hygiene routines are necessary.

The design of the final versions was completed together with the professional film maker who edited the films in relation to how much time one can expect a homecare worker to spend watching the video. This led to a mixture of full picture views and close ups. The length of the video on how-to put-on PPE is 3.32 minutes, and the video for how to take it off is 1.42 minutes, and the actors describe what to do and demonstrate it simultaneously. There are no explanations in the video, only instructions. The instructions are segmented by the actor’s gestures, and is easy to follow even for staff that are not fluent in Swedish (https://play.mdh.se/media/t/0_vm6olg6n; https://play.mdh.se/media/t/0_2d3gbhev). In the final version of the live-action video, we had access to working clothing which the actor wore, but they were borrowed from a different region of Sweden than the one we were collaborating with. Some of the staff did not recognise the clothes as working clothes and commented on that (Figure 3).

The final videos were shown to the management group. This was followed by a discussion about the content and details in the videos. The meetings took place online, due to the pandemic and related restrictions.

Figure 3. From the final live-action-video showing how-to put-on mouth guard and face shield. Photography: Magnus Göthlund

4.3.1 Input from the target group. To gain information and input directly from the target group for the visual instruction, digital workshops where conducted. We learned from the staff that, prior to Covid-19, PPE was seldomly used, only in cases of calicivirus, where they used gloves, aprons, and mouth guards. In cases of calicivirus, they always put on the PPE before entering the home of the care recipient. Other situations in which they used protective equipment such as gloves and aprons were
close-contact care situations, such as helping with shower or bathroom visits. In these situations, they put the equipment on in the care recipient's bedroom or bathroom. They said that, prior to Covid-19, they had never used a visor before.

We asked the staff how and where they had learned about the regulations for how to put on and take off the PPE. The one who had a formal education said that they had learned basic hygiene care in school. The others said they had learned from short instructions when they started working in elderly care. We found that there was great variety in the ways they handle basic hygiene care in practice. Much is dependent on the actual situation, and some of the staff mentioned that elderly people stand waiting for them just inside the front door in the entranceway, and it is difficult to put on the PPE before they get too close. Others mentioned that the living conditions and how the home is designed influences where you can put the jacket and/or backpack. Sometimes, the floor is the only place. One of the comments was about the entrance hall in the video. They commented that it was too organised, with an empty chest of drawers and only a bottle of hand alcohol for sanitation, and a chair where the backpack could be placed. It is more common, they said, that the entrance hall is very narrow and full of things which makes it impossible to place the backpack any other place besides the floor. Even the jacket needs to be placed on the floor in some homes. Most of the groups also mentioned that it is not possible to leave hand sanitiser or gloves in the care recipient's home since it gets stolen by friends and relatives (See table 1).

Table 1. Highlight video comments

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Highlighted comments</th>
<th>Day 2</th>
<th>Highlighted comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1: 7 persons</td>
<td>- We use double gloves, it’s not necessary to sanitise that often. - Sanitise hands and put on mouth guard outside the apartment/house. - The visor must be sanitised and dried.</td>
<td>Group 1: 5 persons + manager</td>
<td>- The bag does not look like our backpacks. - She forgot the garbage.</td>
</tr>
<tr>
<td>Group 2: 7 persons</td>
<td>- She is not wearing same kind of apron as the one we use. - We use double gloves, it’s not necessary to sanitise that often. - Sanitise hands and put on mouth guard outside the apartment/house. - The visor must be sanitised and dried. -The video shows the same order as we follow to put on and take off PPE.</td>
<td>Group 2: 4 persons + manager</td>
<td>-You always put the backpack/bag on the floor. -We don’t sanitise the handle. -It is not always possible to take off the apron as suggested. -We dry the visor after sanitising it.</td>
</tr>
<tr>
<td>Group 3: 3 persons</td>
<td>Group 3: 4 persons + manager</td>
<td>Group 4- 5: 4 persons + manager</td>
<td></td>
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<td>-------------------</td>
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<td></td>
</tr>
</tbody>
</table>
| - She is not wearing the same kind of apron as the one we use.  
- We have never sanitised the handle.  
- The visor must be sanitised and dried.  
- ‘I don’t sanitise my hands that frequently.’  
- We use double gloves. | -We take the garbage with us when we leave.  
-We don’t put on gloves when sanitising the face shield.  
-We sanitise our hands between every ‘task’.  
-We dry the face shield after sanitising and put it in the backpack. | -We have never sanitised the handle.  
-We wash our hands between every task.  
-We put on shoe covers before gloves.  
We un-dress in the following order: Apron, gloves, shoe covers, mouth guard and face shield. |
| Group 4: 3 persons | Group 4: 5 persons + manager |
| - We have never sanitised the handle.  
- The video is fine. It covers the most important parts. | -We have never sanitised the handle.  
-We wash our hands between every task.  
-We put on shoe covers before gloves.  
We un-dress in the following order: Apron, gloves, shoe covers, mouth guard and face shield. |
| Group 5: 4 persons | | |
| We use double gloves, it’s not necessary to sanitise that often.  
- Sanitise hands and put on mouth guard outside the apartment/house.  
- Visor must be sanitised and dried. | | |

After we had already conducted the prototyping sessions, and before we met with the ten staff groups, we realised that new directives and instructions for handling PPE before and after use had been rolled out by the municipality. Now, they have bags that contain aprons, gloves, and mouth guards, and before they leave the care recipient, they put it all back in the bag as garbage. We did not know this when we met the staff and, therefore, it is not included in their comments above. Most of the spontaneous comments concerned the gloves and details on sanitising hands and face shields (see Table 1). Yet, the groups commented and described how they managed details differently, even though they would follow the same instructions. That underscored our reflection during the earlier Phase 2, that the MRNs seemed to lack experience on how the work and basic hygiene routines are performed, and that implied the WAI in the written instructions is as easy to follow in the WAD. The interview participants from the first day had extensive working experience and had developed their own routines for how to handle PPE. When we mentioned the use of double gloves to the second day staff group, they immediately referred to rules that state the use of double gloves is not allowed. The presence of the manager of the group that we interviewed on the second day was unmistakable. She was very ambitious and commented on what was written in the basic hygiene routines and what she had taught the staff. However, the groups still commented on details that did not match the way they performed their job when visiting care recipients.

4.3.2 Challenges and benefits of the visual instructions. The actual possibilities of following SOPs to use PPE and prevent the spread of Covid-19 seemed to be influenced by homecare workers’ earlier knowledge and experiences, the spatial design in the care recipient’s home and their approach, and
local routines and the praxis developed within the team. The results indicate that the live-action video format has both challenges and benefits when it comes to the visual instructions that are connected to these themes as well. The main advantage with instructional live-action videos is, simply put, ‘transience’, which reflects the normal situation in the natural world. The staff could therefore easily recognise the situation and follow the instructions, the length of the videos was significant, and all participants found it appropriate regarding the required information. As expected, the live-action videos left a lot of cognitive capacities and working memory powers to decode and process the overall meaning and message of the instructions for the users. In other words, this format functions very well as a point of departure for deep-probing and constructive discussions that concern the real issue here: what elderly homecare workers actually do in the given situation, and what they can do to improve their disease prevention work methods.

All ten of the groups found the videos to be very useful, and easy to follow, regardless earlier knowledge and experience. The overall reactions from the ten groups were that they found the videos to be instructive, with a good balance between information and performance. They thought that the length of the videos was adequate and that the spoken instructions fit well with the actors' performance. One comment from Group 2, from the first day, was that they wished that they had seen the video when the pandemic started. Another comment from Group 3, from the same day, was that ‘all new staff should see it’. On the second day, we received comments from Group 1, mentioning that the video works well for people with limited skills in Swedish.

We asked if they would have preferred an animated video, but all groups preferred the life-action video, since it makes the instructions more realistic and easier to follow. The live-action video was experienced as ‘natural communication’ (Geary, 2008; Paas & Sweller, 2012), even though the interviewed staff found the hallway entrance to be ‘too perfect’ and clean. The main disadvantage of the live-action video format is another side of its advantage, namely, that it is ‘naturalistic’, and displays a wide range of specific, and distracting, visual details, such as the displayed entrance hallway in the videos. That invite comparisons to other known entrance hallways and what a ‘standard entrance hallway should look like. In this context, this kind of discussion would not be very fruitful. Visuals have other conditions for statements than verbal language. Language can be imperative, while visuals are always compulsory since they are tangible and show what something looks like. Therefore, the challenge of designing visual instructions is to create generalisable instructions that work for various users in different situations and are still instructive for a specific purpose. The discussion regarding the aprons indicates how easy it is to build in visual noise in an instruction. Visual communication of this kind becomes perceptually concrete since all the communication that is performed is visible in the form of gestures, facial expressions, and actions of various kinds. In the videos, the staff could follow what to do by observing in which order the different parts of the PPE was put on and how. It also became clear, when the actor deviated from their local routines and praxis of how the staff usually performs the tasks, that these deviations would become a basis of discussion. A discussion that elucidates that the staff could not follow the basic hygiene routines to the letter because of certain contexts and situations.

The ambition with this project was to conduct a continuous dialogue with employees working in elderly care. But, because of the second wave of Covid-19 in the actual region, it was not possible. Instead, the dialogue was conducted with nurses responsible for basic hygiene routines. From the dialogues in the meetings with the ten groups, we learned that the project would have included to many ad hoc solutions and suffered from too many deviations from the basic hygiene routines. That sparks a discussion about when and how to use participatory design as an approach, and when to use an interactive design approach as we have done in this project.
4.4 Phase 4 - New information and modified theory

The RtD process is about learning and gaining knowledge, both with respect to the process itself, and the learning exchange between the participants in the co-design process (Castro & Lima, 2017). Thus, in this RtD context it is more relevant to talk about the creation of new knowledge, than to only point out that stakeholders, over the course of the project, gain new information about the problem area (i.e., new data on disease prevention in Swedish elderly care services). From the perspective of the researcher and prototype designer, one important type of knowledge is relatable to insights on how photographs and moving image sequences function as visual, instructional, prototypes. First and foremost, their ‘naturalism’, invite the onlooker to look for anomalies that stand out in an assumed natural context. For example, in the first RtD phase, when looking at the slideshow made up of photographs presented in a sequential manner, the stakeholders noticed details that we as designers had not noticed, such as jewellery and odd (private) clothing choices. Abstract images, such as line drawings in the form of, for example, action diagrams, on the other hand, would not have been associated with such comments since they are highly abstract and altogether ‘fantasies’ devoid of a natural context in which things may be noticed as anomalies. In hindsight, perhaps it would have been relevant to use instructional line drawings early on in the RtD process in order to get the routines right (how to put on the PPE and how to take it off) instead of getting into more complex discussions about both the process and details, such as what to wear and what not to wear at a certain instance, in a certain situation. On the other hand, if more abstract instructional imagery had been used as the primary RtD medial object at this point, perhaps we would not have gained important knowledge regarding how, for example, used hygiene articles should be disposed of at an elderly person’s home (in a waste bucket, close to the exit door, with plastic a bag that is immediately discarded elsewhere after use).

All in all, the design of the live-action video prototypes, including the still photograph sequences, taught us that they are useful when it comes to concretising what should be done and how, step by step. However, the prototyping also taught us that it is extremely difficult to provide the final, exact, and correct video instruction on how to follow specific hygiene routines in a homecare setting since, simply put, as noticed by several nurses, there is no ‘real’ and fixed nursing home setting, they all vary.

Since the home homecare workers’ working conditions differ in relation to spatial design in the care recipient’s home and influence their ability to strictly follow SOPs, the videos do not function so much as instructions, but more like education. They create the opportunity to reflect on what it looks like in different homes, in various situations, and how one may adapt basic hygiene routines and the use of PPE to the surrounding conditions. During the research project, the researchers noticed that risk assessments, national and local guidelines and instructions regarding what, when and how to use different types of PPE have changed several times since the first wave of Covid-19 in spring 2020. This also affected the development of visual instructions and the risk that they would quickly become obsolete. This type of video instructions, however, obviously revealed details that are difficult to obtain in written instructions.

Consequently, we learned from the workshops with the homecare workers for homecare that the final versions of the live-action videos work as a starting point for a very constructive discussion about what to do, and what not to do. However, they do not show what homecare workers define as ‘a real situation’. In other words, the videos show mere ideal situations; not the familiar, but unique ‘messes’ that homecare workers often meet in peoples’ entrance halls. Furthermore, according to the hygiene specialist (a nurse), the videos failed to correctly communicate how much rubbing alcohol is to be used when disinfecting hands and arms. We therefore conclude that visual instructions that are based on specific regulations appear to be unsuitable for the live-action format. It is a kind of paradox. 
specificity of the live-action format, on one hand, is useful since it invites critical perspectives and discussions on anomalies. On the other hand, it does not easily offer information that is concrete enough to be useful, and which can be generally applied to diverse situations and contexts. In summary, then, the live-action video format functions very well as an ease-of-use medial object and catalyst for a valuable and constructive discussion about procedures and routines. However, the live-action video format is, probably, less valuable as an actual instructional tool when a user is performing a routine. This is to infer that, while the live-action format normally relieves pressure on the working memory (Eriksson and Eriksson 2018), it is also not mentally engaging enough to foster focus, selection and the re-organisation of information that forms ‘mental images’ which, in turn, are critical to being able to perform a certain task (cf. Arnheim, 2004; Tversky, Morisson & Betrancourt, 2002). This insight partly modifies the theory about the live-action video as an instructional tool since it highlights the value of the live-action format’s indirect effects in a pre-production phase of instructional content; namely, its capacity to generate more knowledge out of a certain instructional situation than the designer puts in (cf. Schön 1983). By visualising instructions and reflecting on what employees do in practice, the gap between written instructions on WHAT to do (WAI) and HOW it is performed in reality (WAD) became obvious. Especially in the discussion with the responsible nurses who seemed to have experience from practical homecare. Carvhalo et al. (2018) used simulation exercises and observations made by researchers to explore the gap between WAI and WAD, they emphasised that the participatory method in the analysis seemed to contribute to reflection and learning. Our results show that live-action videos can be a useful tool for adjusting and harmonising between WAI and WAD and can be easier to use for educational purposes when introducing work routines to newly recruited staff. It may also be a time and cost-effective complement to training exercises. This is also to point out that the employment of live-action video instructions is an enabling media technology that may support development work, in which the objective and goal of the instructional project are identified.

5 Conclusion

The aim of this design project was to explore ways of co-designing video instructions, to answer the question: How can a co-design process improve the understanding of challenges in the design of instructional live-action videos? We used a case study to answer the question where we, together with representatives from elderly care sectors, show how to use Personal Protective Equipment (PPE) and how to follow basic hygiene routines, with regard to the implications of Covid-19 in an elderly care context. To use Schön’s terminologies (1987), we consider the knowledge type in question to be ‘knowledge-in-action’. The video instructions become visual, mediated manifestations of this type of knowledge, what Schön refers to as a passive form of ‘knowledge-in-action’ (1987). Consequently, the video prototypes, when viewed and listened to by a user, are meant to support ‘reflection-in-action’, i.e., the capacity of homecare workers to consciously think about what they are doing while they are doing it.

Live-action videos may be useful for educational purposes and when introducing work routines to new staff. In particular, the results show that the main improvements derived from using a co-design process were input on the details needed to make the video more realistic and more reflective of real-world scenarios. In part, we think this is due to the fact that the live-action format allows users to use more cognitive capacities to discover and gain insights into key details (i.e., image and sound elements). These details sometimes convey just the correct kind of activity, while other times they distract or seem contrived. Thus, over the course of the project, the video prototypes became more and more nuanced and pedagogically straight to the point. Yet, at-home elderly care is complex work, with various conditions in every home and far from ‘Standard Operational Procedures’. Hence, we
think that the live-action instructional format of this kind can function very well as a basis for reflection on how to actually perform work tasks, even for experienced staff. However, the best fit for the proper use of PPE and basic hygiene routines is probably a combination of visual instructions and practical training. No instruction alone, without actual ‘reflection in action’, will result in better and more sound practises and routines.

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References


Design Thinking workshops for social workers

Joana Alves dos Santos\textsuperscript{a}, Joana Moreira\textsuperscript{a} and Katja Tschimmel\textsuperscript{b}.

\textsuperscript{a} Mindshake, jas@mindshake.pt, jm@mindshake.pt
\textsuperscript{b} Mindshake / University of Porto / ID+, ktschimmel@gmail.com

Abstract. Design Thinking has been gaining significant attention as a potential approach to addressing organisational problems, including those of social institutions. This paper provides a theoretical and practical approach to Design Thinking as a method for social workers. The starting point of this research is based on the hypothesis that Design Thinking can make a significant contribution to social workers' mindset and skills for developing innovative projects, by providing a design methodology set of tools. To answer the main research question, if and how social workers can become Design Thinking practitioners, we conducted a qualitative study through the realisation of 3 training workshops supported by questionnaires and interviews. The results indicate that social workers are motivated to learn DT skills and to work more creatively in teams, but that a 5-day workshop is not enough to give them the basic competences to apply the DT process by themselves.

Keywords: Design Thinking, Real Context Workshops, Social Innovation, Social Worker.

1 Introduction

Design was always a catalyst for innovation, chiefly in the industrial, architectural and graphic fields. Over the last decade, with numerous publications about Design Thinking (Brown, 2009; Martin, 2009; Tschimmel, 2012; Mootee, 2013, & Uebernickel et al., 2020) and several case studies (Liedtka & Ogilvie, 2011; Kimbell, 2014; This is Design Thinking website), the term has gained popularity in business and management media and became a label for the awareness that any kind of organisation can benefit from the designers’ way of thinking and working, including within social institutions and initiatives (Brown & Wyatt, 2010; IDEO, 2015; Docherty, 2017).

Before becoming a popular concept for innovation, design thinking (at that time written in lowercase) had been defined and studied by the international research community, solely as the cognitive process of designers (Cross, Dorst & Roozenburg, 1992; Eastman, McCracken & Newstetter, 2001). In the last 15 years, the concept of design thinking has been stretched, and has broken free from its domain limits. Today, Design Thinking (now written in uppercase) is understood as a human-centred, collaborative and transdisciplinary innovation method, expressing the introduction of design culture and its tools into fields such as service innovation and organisational or social innovation. This move from design thinking as the way in which designers think, to Design Thinking as an innovation method embraced by the business world offers many new challenges and opportunities to the design community. As many Design Thinking projects are lacking professional designers in their multidisciplinary teams, one of the questions the 13th DTR Symposium aims to discuss is how useful the expansion of Design’s boundaries is for the evolution of the design field and for society in general, and where the limits are.

This paper provides a theoretical and a practical approach to Design Thinking (DT) as a method for Social Innovation. The starting point of this research is based on the hypothesis that Design Thinking as a method for innovation can make a significant contribution to social workers’ mindset and skills for developing innovative projects, while benefiting from a set of tools that design methodology offers. The goal of this paper is to demonstrate the potential the Design Thinking process and mindset have to change the way social workers collaborate creatively.
2 Contextual background

Since the beginning of the 21st century, social innovation has been high on the European agenda (Simon et al., 2014; Manzini, 2015). Social innovation and transformation is generally seen as one way of contributing to economic growth, while at the same time promoting sustainability and addressing social challenges. Across Europe’s member states, there is a range of funds, foundations, labs, research centres and networks, dedicated to supporting social transformation through Design and Knowledge, such as the DESIS network (Design for Social Innovation and Sustainability), SIKE (Social Innovation through Knowledge Exchange) or Social Innovation Academy. The role of designers in this scenario of fundamental social change towards sustainability, includes supporting social organisations and their agents in collective projects where the culture of design and the methods designers use can be an important contribution to transformational processes. Besides their possible role as design activists, or triggers that initiate social projects, designers can act as facilitators, supporting ongoing processes and initiatives through their design-specific process knowledge. Projects such as the Human Centred Design model and the respective toolkit developed by IDEO (2015), in response to a request from the Bill & Melinda Gates Foundation, show that Design Thinking is an emerging method capable of responding to Social Innovation challenges.

Although Design Thinking for Social Innovation is proven to contribute to addressing user needs and to finding innovative and useful solutions for social projects, there is a lack of understanding about the usefulness of Design Thinking for social workers in supporting them over the process of finding innovative solutions for their communities. Most research in the domain of social innovation is focused on the contribution of Design Thinking to sustaining social innovation within the field of social organisations. Kummitha (2019), for example, studied how users persuade social organisations to adopt design thinking. But the focus of this research was the designers’ roles in social organisations when adopting Design Thinking. We couldn’t find any research project which addressed the Design Thinking training of social workers, with the goal of equipping them with supportive tools for their collaborative creative processes.

As professionals, we perceive the use of Design Thinking for social workers as adding value to the creation of knowledge within the innovation process by 1) being inclusive, 2) allowing collaborative workflow, 3) being motivating and empowering, and 4) having the potential for co-creation (Moreira, Santos, Palma & Tschimmel, 2020). According to Docherty (2017), the application of Design Thinking within social projects provides a ‘safe’ space for different perspectives to be shared openly, for new insights to emerge and to empower participants in cooperating and creating shared visions.

This investigation emerged as an opportunity for us, as our team was refining a Design Thinking model for Social Innovation (which will be described in more depth below). In August 2018, the National Commission for the Promotion of Children and Youth Rights and Protection (CNPDPCJ) was looking for a partner to carry out a set of activities to support a project called “Adélia”. This project intends to build Local Plans for the Promotion and Protection of the Rights of Children and Youth based on a local diagnosis and develop a set of activities that are part of this plan. However, the CNPDPCJ felt that these activities could benefit from being designed using a set of tools different from those that have so far been used by social worker teams. This partnership therefore enabled a line of research using the new DT Social Innovation Model. The research opportunity was particularly attractive, as the participants were mainly social workers who intervene with children at risk, and with their families. But perhaps above all, within the context of the Adélia project, in the area of risk prevention and parental skills improvement involving the broader context of the community, and not only families already on the radar of social services. In order to take this research further, we designed a Design Thinking workshop, directed at social workers (and other professionals), with our main research question being: Can Social Workers be Design Thinking Practitioners?
3 Methodological approach

3.1 Research method

The methodological approach in this study integrates the Social-critical paradigm of Research through Design, which according to Pedgley & Wormald (2007, pp. 72-73) means “research with a practical design element” or “research incorporating a design project”. In our case, the design project was carried out by the three of us as Design Thinking researchers and trainers with more than a decade of experience and backgrounds in product design, research and education. That means, in the words of Pedgley & Wormald, that the integration of the design activity was a means to an end, and not an end in itself. The principal aim of this research project was to verify through practical experimentation if social workers would get the necessary motivation and skills to become Design Thinking practitioners, as a result of our intervention. However, supplementary questions then arose:

- How can we make the Design Thinking process for social workers more comprehensible?
- Which are the DT tools from our Social Evolution 6 model that social workers perceive as the most useful for their work environment?
- How motivated to innovate do social workers become, after going through Design Thinking training?
- Which elements of design culture and which kind of DT tools, will it be easy for social workers to integrate into their daily life?
- What is the impact of the workshop on social workers' mindset regarding awareness, motivation and self-appraisal of their ability to apply DT?

Based on research by Chesson (2017) and by Schweitzer, Groeger and Sobel (2016), we conceived a framework for a questionnaire to help us to understand and measure social workers' Design Thinking knowledge and mindset. Our framework has 4 different levels:

- **Practices**: Work approaches, such as Observation, Questioning, Identification of patterns, Experimentation, Visualisation of knowledge and ideas, etc.
- **Techniques**: Methods and tools supporting practices such as Mind Maps, Stakeholder Maps, Insight Maps, Brainstorming, etc.
- **Mindset**: attitudes and ways of thinking (being empathetic, being divergent, not choosing the obvious, being playful, embracing failure, etc.).

In our research approach, we used the following techniques:

- Pre and post questionnaire to all the participants of the workshops;
- Field observation during the training;
- In depth interviews with one random participant from each region at least 6 months after the training.

The pre and post questionnaire considered the 6 principles from our framework and included a total of 27 questions divided into three sections (in the first section the participants had to indicate the level of agreement with a sentence, on a scale from totally disagree to totally agree; the second section participants had to choose what most closely reflected their positions, from opposing concepts; the third section had 3 open questions for feedback). With these questionnaires we evaluated their awareness, motivation and capability to apply these principles. During the workshop training the facilitators took occasional notes of the most relevant insights. The in-depth interviews took place in June 2021 via zoom, using a semi structured guide with 5 open questions.
3.2 The Design Thinking model “Social Evolution 6”

In 2019, we developed a Design Thinking model for Social Innovation, called “Social Evolution 6” (Moreira et al., 2020), designed with the goal of helping companies to work on corporate social responsibility, and potentially, to collaborate with public services for their own modernisation. Regarding the workshop’s context, the model was the relevant DT model to use as a base for social workers’ training.

The Social Evolution 6 model (SE6), is a natural evolution of the Portuguese Design Thinking model Evolution 6², developed between 2012 and 2015 (Tschimmel, 2018), and registered under Creative Commons, combined with the Social Innovation Spiral from NESTA.

Taking into account these two “mother” models on which Social Evolution 6 is based, it also comprises 6 phases, and maintains the rationale of the letter 'E,' existing in the E6, both for Portuguese and English. There are many other DT process models developed in academic or business context, which consider 3, 4 or 5 phases, depending on the organizations’ approach. The major difference between all these models does not lie in the number of phases (which are frequently related to the ease of memorizing the model’s name), but in the visual representation of the process and the integration of several DT tools.

Our Social Evolution 6 model consists of the following 6 phases (Moreira et al., 2020):
- **Empathy** - Emerging challenges and social needs: explores challenges and needs that emerge directly from people and their circumstances, and the goal is to identify a problem to solve.
- **Exploration** - Generation of ideas: this phase is about exploring wild ideas and thinking in analogies in order to find ideas that will possibly be an answer to the challenge.
- **Elaboration** - Prototyping, testing and development: materialising ideas and testing helps develop an idea further, transforming an idea into a concept.
- **Exhibition** - Presentation of the project: it is necessary to present the idea properly in order to garner the support on which it depends for its successful development. This presentation is at the level of content and form, which means that not only are the necessary tools developed for the idea to receive economic support, but also that the narrative develops to support the idea.
- **Execution** - Implementation and impact assessment: associated with the implementation and impact assessment, are sets of theories and tools that emerge exclusively from the social context, and which are used in practice.

- **Expansion** - Systemic change: the final phase corresponds to the ultimate desirable impact, which is Systemic Change and it requires a complex interaction of culture, consumer behaviour, business practice, legislation and public policy.

For each phase of SE6, we also propose a set of tools as a way to support the development of a project. The workshop programme was designed according to each phase and respective proposed tools. The Expansion phase was the only phase that wasn't considered, due to the research purpose and the training context.

### 4 Workshop

In March 2020, the authors were ready to start a programme of Design Thinking for Social Workers to be replicated in three regions of Portugal: the North, the Centre and the South. The promoter of this initiative as mentioned above, was the **National Commission for the Promotion of Children and Youth Rights and Protection** - CNPDPCJ - in the context of a project dedicated to Positive Parenting. This initiative was aimed at practitioners in the field of childhood and youth, integrated into several entities, both public and private.

The designed programme comprised a 5 day-workshop for Social Workers (7 hour/day) and a public presentation to relevant stakeholders (Government representatives, Social Entrepreneurs, Managers of Social Innovation Hubs) in each region with the aim of developing local projects addressing children's rights and positive parenting.

The first group (25 social workers) from the Northern region was scheduled for March 2020. Unfortunately, given the pandemic outbreak that occurred in the meantime, the last two days of training as well as the Pitch Day were postponed to September of the same year. This interruption led to the withdrawal of two of the participating teams. The remaining sessions were realised online, using Zoom and the collaborative platform Miro. This hybrid format was unexpected and made it difficult to familiarise all the participants with collaborative digital tools. All participants were unanimous in considering that these tools allowed a better visualisation of the contents than a mere Zoom call, even though it was not possible to use the Miro tool to its full potential.

The training sessions for the Central region were also scheduled for March and were rescheduled for October 2020, when it was possible to carry out the entire programme in person, as well as the Pitch Day. The total number of social workers was 22.

The Southern region sessions, initially planned for November 2020, took place in an exclusively online format in April 2021. A total of 15 social workers were involved. The Presentation Event - Pitch Day - took place in a webinar format.

The design of the programme was determined by the Social Evolution 6 model’s phases and consisted of the following activities:
At the beginning of the training, participants, who applied in teams, were posed with the challenge of building an initiative or social business that would fit the Local Plan for the Promotion and Protection of the Rights of Children and Youth of their city. Accordingly, in each session, after a more theoretical contextualisation, we urged the participants to use several tools and templates, following the phases defined in the model. In the 1st phase the teams designed an Opportunity Mind Map to explore the knowledge about positive parenting and all information gathered by local diagnosis of their region/city, so that they could identify a problem or opportunity to explore. From there, the participants resorted to several techniques, mainly using templates designed or adapted specifically for this model, that guided them through the 5 initial stages of social transformation. In this journey, we highlight the use of Stakeholder Maps, Interviews, ‘How Might We’ questions and a Social Business Model Canvas that supported a Pitch presentation on the final day.

5 Findings

The findings of our Research through Design come from two different perspectives: the social workers' perception (Questionnaires, Feedback tool I like / I wish and Deep Interviews) and the authors' analysis of their observations made during the workshops combined with the results from the questionnaires, informal feedback and interviews. The findings resulting from the several research techniques are complementary and added value to our final conclusions.

Our observations were focused on the collaborative dynamics and engagement of the participants in the DT process, as well as the way participants applied the proposed tools. We perceived the social workers initially as very passive and expecting a traditional teaching format. As these social workers were not used to practical training, they had problems getting out of their comfort zone and adopting a more hands-on approach. Furthermore, we observed the participants had various difficulties in understanding and using the tools according to our instructions, and also understanding the context in which they could apply them. However, the tools presented were perceived by the participants as beneficial in helping them solve complex and challenging societal problems.
The initial questionnaire was answered by 40 social workers, but the final questionnaire was only answered by 21. The main reason was clearly the difficulties thrown up by the pandemic situation. In the following text, we describe the findings from these sources:

At the beginning of the training, 27.5% of the participants were not familiar with the DT process, 40% claimed that they had heard about it but didn’t really know what it was about, and 10% stated that they already used some of its tools. The remaining 9 people (22.5%) said they were familiar with the method.

From the initial questionnaire it is possible to infer that the participants' expectations about this 5-day training were learning “new work methodologies” and tools, having contact with new perspectives, and applying the method in projects with children and their families in the future. They also believed this was a method “to look for innovative solutions to common/old problems” and, as well, one that supplied much needed support for generating ideas and finding solutions for social problems. Some participants also mentioned the need to “think outside the box”, to be more creative and that new tools could also be a way of motivating teams and beneficiaries of their organisations. In summary “to be able to draw my ideas, in order to make them happen!”

The findings from the questionnaires applied both in the beginning and at the end of the training are divided into the 6 DT principles (1. Human Centred Approach, 2. Collaboration, 3. Openness to Risk/Permission to fail, 4. Holistic Approach, 5. Register of ideas, knowledge and process, and 6. Iteration), identified in the framework built for the questionnaire as mentioned above, and sub-divided into awareness, motivation and capability. There were also synthesis questions for each one of the principles.

5.1 Human centred

Awareness: Although discreetly, the results show an inclination towards the understanding that knowing how a problem affects people is one of the fundamental elements for solving it. At the end of the training more than 50% of the respondents totally agreed with the statement “The most important step in solving a problem is to understand how it affects people”.

Motivation: The results show no particular improvement in terms of motivation for empathising with people affected by a given problem, and most of the answers “agreed” or “totally agreed” with the claim “When I’m solving an issue, I’m curious to understand how people are affected by this situation”.

Capability: At the end of the five Design Thinking sessions, while answering the question “When someone tells me how they are affected by a given problem, I can readily look at the situation from their point of view”, trainees seem to be more moderate in self appraisal of their capacity to put themselves in someone else's shoes, since some answers shifted from “totally agree” to “agree” or “partially agree”. Although not particularly positive, we understand, also according to our observation during the training, that this type of evolution in answers may be due to a greater awareness of how their preconceptions about how a problem affected people may not be real. There is a realisation that it is necessary to go through a process of empathy to observe and question specific people affected by specific problems.

However, trainees conclude overwhelmingly, in this part of the questionnaire dedicated to the Human Centred principle, that understanding how people are impacted by a problem is important or very important, and there has been a great evolution in terms of responses (Fig. 3).
5.2 Collaboration

Awareness: From the question “Collaborating with others is essential to create the best solutions”, we conclude that trainees are more aware of the importance of collaborating with others, and the percentage that “totally agrees” that only in this way it is possible to create the best solutions, rises visibly, to more than 75%. Beside the Questionnaire, this perception is reinforced in the Deep Interviews. All interviewees underlined their higher awareness of the importance of collaborative work in innovation processes.

Motivation: Likewise, the motivation to collaborate has significantly improved. In the question “When solving problems, I actively seek other people's involvement”, people that “partially disagreed” disappeared and those who “partially agree” diminished. The percentage of people that “totally agreed” rose to more than 45%.

Capability: When answering the question “My abilities to create new solutions stand out more as a team than when working individually”, as in the case of the theme related to Human-Centred, there seems to have arisen a more acute awareness, self-analysis and moderation regarding the ability to put collaboration into practice and obtain better results. The number of people that “totally agreed” to the statement diminished and was replaced with people that “agree” or “partially agree”.

Trainees learnt from this formative process that working with others has more value than the opposite, placing all answers in the range from 6 to 8 (Fig. 4).
5.3 Openness to risk taking/permission to fail (creative thinking)

**Awareness:** To the question “Failure is part of the problem-solving process” the results are slightly better in terms of the awareness, but they are not so expressive of change that definitive conclusions can be drawn. At the end of the formative process, the majority of people agree (38%) or totally agree (43%) with the statement.

**Motivation:** The group reveals greater motivation for experimentation in the question “I always want to try new things”. Those who “disagreed” and “partially disagreed” prior to the training disappeared, and the percentage of trainees at the end of the training that “agreed” or “totally agreed” rose to 90%.

**Capability:** Similarly, to previous themes, with regards to the ability to accept risk, there is a decrease in the number of people who say that they “totally agree” with the statement, but there is also a decrease in the number of people who “partially disagree”. The results look more judicious and realistic to the question “I’m very comfortable with the risk inherent in trying something completely new” and more that 70% of the answers fell in the “agree” or “partially agree” area.

In the summary question, there is a clear indication that most trainees understand that failure is a form of learning (Fig. 5).
5.4 Holistic approach

Awareness: Included in the Holistic Approach principle, the statement “I think it's important to look at an issue from different perspectives” demonstrates that the group grasped the concept that different perspectives are advantageous when analysing an issue. All disagreement with the statement disappeared at the end of the training, 39% of the people agreed and 61% totally agreed.

Motivation: The answer to the question “When I work on a given problem, I look for complementary or contradictory information” does not show significant improvements regarding tolerance and/or the search for ambiguity. Most of the answers are similar to those at the beginning of the training and are in the partially to totally agree areas.

Capability: The largest shift in responses was among those who “fully agreed” with the statement to “partially agree” (Fig. 6). The insight we have, from our observation, is that the work practices of this particular group of people is not very inclusive of divergent opinions and that these 5 full days of training are not enough to change that attitude and perhaps other groups got a better understanding of this situation.
Figure 6. Graphic result of the opinions before and after the training on the statement “I get frustrated when I have to make commitments that integrate conflicting interests”

5.5 Register of ideas, knowledge and the process (Making things tangible)

Awareness: The graphic (Fig. 7) shows clearly that people became more aware of the power of images and drawings to communicate.

Figure 7. Graphic result of the opinions before and after the training on the statement “Images and drawings are a great way to explain ideas and solutions to others”

Motivation: At the end of the training there are more people (38%) who disagree with the statement that “Images and drawings distract me when I’m trying to find a solution to a problem”.

Capability: There doesn’t seem to be a particularly positive evolution in the ability to think through design/sketches and prototypes, which obviously reveals that nobody can develop visualisation skills
in a 5-day workshop. The principle of registering ideas and knowledge (making things tangible) is probably one of the most difficult skills to develop in non-designers (Fig. 8).

**Figure 8.** Graphic result of the opinions before and after the training on the statement “I think about ideas and solutions and prototyping”

**5.6 Iteration**

**Awareness:** In this statement “Reflecting on the opinion of others only delays the search for a solution”, trainees evolved in their position. At the end of the training, 85% of the group “disagrees” or “totally disagrees” with the idea that considering others’ opinion delays solutions versus 60% prior to training.

**Motivation:** Likewise, the number of people who “totally agree” with the statement “In a creative process, I believe in taking two steps backward to take three steps forward” has increased from 30% to 48%.

**Capability:** The percentage of people who fully agree with this statement after training has increased from less than 10% to almost 40% (Fig. 9). In fact, we believe, based on our observation, that people were able to verify that the DT process, having reached the goal of building a new project, often involved iterating between ideation and idea selection.
5.7 Findings from open questions

Regarding the open question, posed in the end Questionnaire (Q), “What advantages do you see in a process that uses Design Thinking in the work you develop in the area of intervention/participation/social work?”, and also including some insights from the Deep Interviews (DI), the most interesting answers can be clustered as follows:

5.7.1 Human-Centred
Q: “The advantage is that this process focuses on the human, from the perspective of who is the user, in social work it is important to know the problem that afflicts the context/individual and intervene directly in the problem in order to improve the individual's quality of life and consequently society.”
Q: “Ability to give ‘voice’ to all stakeholders and create negotiated and shared solutions.”

5.7.2 Collaboration
Q: “Teamwork is very beneficial and all the steps to be taken to reach a solution are very important.”
Q: “It is very creative, an igniter of new ideas, actively involves a team, stimulating.”
DI: “Now I tell people that DT is a ‘glue’ that helps to gather contributions from different people and perspectives.”

5.7.3 Openness to Risk Taking/Permission to fail (Creative Thinking)
Q: “It is a creative methodology that helps to think outside the box which is very necessary for social work that is too standardised for a certain way of working.”
Q: “Creativity and new solutions.”
Q: “It helps to ‘get ideas’, to look at the problem in a different way and in the process realise that it is possible to intervene using more creative approaches.”
DI: “I enjoyed the challenge of looking at the same things I've been looking at for a long time, but in a different way, shaking them. Like grabbing the same thing but grabbing it in an innovative way. It's fun, and very difficult.”

5.7.4 Holistic approach
Q: “We were able to see a given problem from different perspectives and then find more than one solution.”
DI: “The Stakeholder Map is very important for us as we work with many different partners, and it is valuable to quantify and qualify relationships.”
5.7.5 Register of ideas, knowledge and the process (Making things tangible)
Q: “A more realistic and promising process.”
Q: “Helps to structure ideas, understand problems and create solutions.”
Q: “I think it is important, as it makes us reflect, to have a concrete idea of the whole process and it is easier to find solutions.”
Q: “Helps gather ideas to prepare a project, evaluating all the issues, not dispersing us, and focusing on the essential.”
Q: “Assertiveness, better time and resource management.”
DI: “You, for me, have become an equation: this structure works and causes change in the community or wherever we want to apply it.”

5.7.6 Iteration
There was no relevant answer that would have led us to a meaningful conclusion.
Regarding the question about obstacles in using Design Thinking tools to develop ideas or solve problems in the area of intervention/participation/social work, we can summarise most of the comments with these testimonies:
Q: “The lack of knowledge of the existence of these tools by the vast majority of workers in the social area and families, prejudice towards the use of this method, and resistance to change, in my opinion, are the biggest obstacles.”
DI: “In normal work processes, most social workers believe they already have a deep understanding of the problems, and thus act on preconceived ideas.”
In short, since most of their peers did now have access to this training, many people saw ingrained work habits, and also lack of financing, as the biggest obstacles for implementing DT tools in their daily work routine.

Figure 10. Picture of the I like / I wish tool at the end of the first 3 days of training with the Northern region group

Regarding the tool I like / I wish (Fig. 10), used to gather feedback from the trainees, it was clear that the most common denominator in terms of the things that people appreciated were the “dynamics” of the training itself. Also mentioned were sharing among participants and the discussion moments, creating prototypes and getting to a final presentation for the Pitch Day. Citing one of the social
workers “I liked better understanding the importance of having a model that guides our intervention; to follow the steps and not rush to the solution; to work in a team; to prototype; …”.

As for what people would like to have had in this training, most answers referred to the lack of time to explore the support materials and tools, to incubate ideas, to iterate more using the prototypes and also more time to discuss with the project team with the dedicated attention of the DT facilitator. Nonetheless, one of the participants wrote: “I would like to have more time, but I also understand that this way forces us to focus on the goal”.

6 Research limitations

This research was conducted during the Covid-19 pandemic and obviously it had an impact on various aspects of the scheduled programme. These series of workshops, initially designed to take place in person, at three different times of the year and in three different locations, had to be adjusted several times in order to follow the safety measures against the virus. What happened was that the first workshop was 3 days in face-to-face format and 2 days adapted for online, the second workshop was fully face-to-face and the third fully online.

Due to the uncertainty and the short time to adjust to the preventive measures imposed by the Portuguese Government, the number of participants was lower than expected, as was their availability to fully participate, due to remote work and the adjustments that each institution also suffered. It is important to take into account that many of the participants work in institutions where there are several risk groups such as the elderly and children. Many of them also had to be in preventative mode because abuse and risk situations for children and youth rose significantly during lockdown. This situation, unfortunately, also affected the quantitative participation in our questionnaires (from 40 before the training to 21 after the training).

7 Conclusions

This paper provided a theoretical and practical approach to Design Thinking as a method to change the mindset of Social Workers, improving their way of collaboration and developing innovative projects through design culture.

Based on the Questionnaire answers, our conclusion to the main research question “Can Social Workers be Design Thinking practitioners?” is that there isn’t a huge positive evolution in trainees as Design Thinkers. However, through our observation and informal dialogue with the participants, the feedback received in the I like / I wish template and the in-depth interviews demonstrate in some aspects (awareness, motivation and learning) many benefits for the social workers mindset, regarding collaboration, empathy and creative thinking (divergence, playfulness, experimentation, etc.).

Regarding the supplementary question “What is the impact of the workshop on the social workers’ mindset regarding awareness, motivation and self-appraisal of their ability to apply DT?” our conclusions are as follows: Concerning the “Human-Centred” principle, the trainees seem not to have gained much more motivation or ability to put themselves in the shoes of others, however they clearly recognise that this is a fundamental step towards building social innovation solutions. There seems to be a better self-perception of each trainee's real competence in empathetic thinking. With regard to “Collaboration” there was a clear improvement in awareness and motivation of the advantages of working together and a moderation in the self-perception of competence. We believe that most of these professionals had never faced this kind of creative working environment and realized that their usual practices were not really collaborative (even when developed in a team) and that their perspectives about social problems do not correspond to the beneficiaries' perspectives (the
people they work for). Nonetheless, we are convinced, giving the participants’ motivation, that if institutional obstacles are overcome, these practices can become integrated and part of social workers’ mindset.

On the subject of “Experimenting and accepting risk and failure”, there seems to be a slight improvement in awareness, an improvement in motivation and a greater moderation in response as far as ability is concerned. However, the participants seem to have “learned” this concept. There doesn't seem to have been much learning about a holistic approach to problems that integrates different views or even conflict. The participants recognise that it is necessary to look at different perspectives but do not understand the need for uncertainty and opposing views. There seems to be more awareness and motivation for using visual tools to register ideas and knowledge during the creative process. However, there was no improvement in competence and learning of how to visualise ideas (drawing and prototyping).

It was unexpected for us that the evolution of self-appraisal of participants’ capabilities in some skills related to the main principles of DT was negative. Nevertheless, upon critical reflection on the results, we concluded that somehow these results reflect a more judicious evaluation of their own capabilities. Often, in the learning process, trainees become aware of what they do not know and realise, in the process, the skills that they lack to work on.

Regarding the question of how motivated social workers are to innovate, after going through a Design Thinking training, the questionnaires and interviews let us conclude that the social workers are very motivated to learn more about the Design Thinking process (by expressing high enthusiasm and belief in the power of DT), but that they still do not see a context for the practical application in real projects. The obstacles they identified are related to the resistance to change of the social institutions, the lack of finance and the lack of DT knowledge/training of their peers. The motivation and desire to learn more from the DT method was demonstrated by 3 requests we received after the workshops from different social institutions to facilitate DT workshops in other contexts. We have already answered two of these requests by the realisation of a workshop for the Red Cross and another for ASAS - Santo Tirso’s Solidarity and Social Action Association.

Concluding with which elements of the design culture and which kind of DT tools, social workers will be able to integrate easily in their daily life, our findings have shown that the social workers evaluated very highly the dynamic and systematisation of the DT process, the collaboration, human centeredness and the divergent thinking. The participants recognised clearly that Design Thinking focuses on establishing an innovation-friendly climate in their organisations, for the long-term, and they are willing to advocate for it. Concerning the DT tools, the in-depth interviews revealed that in general the social workers don’t remember the name of techniques they applied in the workshop, with exception of the Opportunity Mind Map, Stakeholder Map and the Cause Diagram, probably because these tools are in a way connected with their common ways of working and most pressing concerns.

This research was essentially conducted to give us an understanding of how to improve social projects through our Design Thinking knowledge. Thus, as a creativity and design consultancy we, of course, asked ourselves how we could make the Design Thinking process more comprehensible for social workers. By the end of this study phase, we conclude that our Social Evolution 6 model needs to be improved, above all in relation to the specific language and to the templates used in the training sessions. At the moment, one of the authors of this paper is involved in a series of follow-up events and is aware of the work some of the participants are developing. There are some promising signs, however it is still too soon to evaluate the long-term impact.

In future workshop programmes, in order to make the process more comprehensible, we will concentrate more on a learning by doing approach and leave theoretical explanations of DT principles, models and tools behind. As a next step in our research, after improving some templates and the
workshop programme, we will run a workshop with the social and private sector in order to test the improvements and develop tools to follow up and measure impact of the 1) learnings from the workshops, 2) projects created during the workshops, and 3) future projects developed by the participants.

Regarding the topic of the DTRS13 conference, the usefulness of the expansion of Design’s boundaries, based on our training experience with the social workers, we consider the expanding of design frontiers to clearly be a blessing for social institutions and also for all kind of other organisations, as the DT process and tools helps them to think more empathetically, collaboratively and creatively. For designers, the extended perception of Design and the recent Design Thinking boom, which goes beyond Social Innovation, is a great opportunity to export their process knowledge to other domains. Not only can and should the designer be a member of social innovation teams, but often he/she could take on the role of a facilitator in the development of innovative projects, guiding ‘social innovation agents’ or providing training on Design Thinking procedures and techniques for social environments.

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How do older adults engage as robot co-designers?
Rapid prototyping supported by lived experiences with technology

Anastasia K. Ostrowski, Cynthia Breazeal and Hae Won Park
Massachusetts Institute of Technology, MediaLab, {akostrow, cynthiab, haewon}@media.mit.edu

Abstract. Co-design is a powerful methodology to incorporate older adults into the design of new technologies. It has been less commonly used in robot design processes, especially with older adults. Embedded in our work of a year-long co-design process with older adults, 28 participants between the ages of 70 and 94 engaged in a rapid-prototyping session to design social robot interactions using a flow-based programming interface. In this paper, we explore the rapid-prototyping session investigating how older adults design robot interactions supported by lived experiences with technologies, and how older adults relate to being robot interaction designers after the rapid-prototyping session. Results demonstrate the impact and value of incorporating co-design rapid-prototyping methods that empower users to design and program social robots. Our results strongly advocate for co-design methodologies that empower users, such as older adults, and expand the boundaries of technology design.

Keywords: co-design, older adults, rapid-prototyping, social robots, technology design

1 Introduction
Design research has become embodied in many fields including engineering, human-computer interaction (HCI), and human-robot interaction (HRI) to address wicked problems (Rittel & Webber, 1973; Zimmerman et al., 2007). Through this process, the technology design boundaries are expanding, creating bridges with and enhancing design (Dorst, 2019). With this approach, it is critical to remain mindful of the design space and stakeholders and how these vary between social context and culture (Bucciarelli, 1996; Wallach & Allen, 2008). By empowering users and creating spaces for them to work within design teams (Ostrowski et al., 2020), we can engage with users in a more meaningful way during the design process than has historically been done in user-centered design (UCD). Recognizing the need for researchers to understand how people will engage with robots and how they wish for them to be designed (Jung & Hinds 2018), approaches, such as UCD and human-centered design (HCD), are increasingly being applied to HRI. While both involve users, UCD often limits users’ role to informants and HCD upholds them as main contributors in the design process and integrated members of design teams (Buchanan 2001; Lee et al. 2017). Related to HCD, co-design and participatory design uphold these values by incorporating users into the design process, amplifying their voices, and empowering users as purposeful contributors (Braa, 1996; Ertner et al., 2010). Co-design frameworks such as experience-based co-design demonstrate the value of leveraging people’s lived experiences in the generation and design of new devices (Harrington et al., 2018; Sanders & Stappers, 2008).

Older adults have been incorporated into co-design of new technologies (Harrington et al., 2018; Lee et al., 2017; Lee & Coughlin, 2015), but this methodology is less common in robot design processes (Björling & Rose, 2019). Within a year-long co-design process with older adults (Ostrowski et al., 2021a), we engaged older adults in rapid-prototyping of social robot interactions. Social robots are physically embodied, emerging relational AI technology that leverage verbal and nonverbal social
modalities to engage with users (Breazeal, 2002). Our previous work on the year-long co-design process focused on the development of the process promoting co-design within HRI and providing co-design guidelines for future HRI research (Ostrowski et al., 2021a) and exploring how participants incorporate stories in co-design processes (Ostrowski et al., 2021b). With this work, we deeply explore the rapid-prototyping session embedded in the year-long co-design process. The overall contribution of our work is to discuss how older adults as co-designers can expand the boundaries of design for technologies such as social robots. Our work was guided by the following research questions around older adults as co-designers:

- R1: In a rapid-prototyping session, how do older adults design robot interactions supported by lived experiences with the technology?
- R2: How do older adults relate to being robot interaction designers after engaging in rapid-prototyping of robot interactions?

2 Background

2.1 Understanding Who Designs and Who Gets to Design

Design researchers have studied design through various lens, such as framing problems and solution spaces (Patton & Dorst, 2011; Dorst & Cross, 2001), prototyping (Cross, 1999a; Ullman et al., 1990; Houde & Hill, 1997), and building capacity (Cross, 1972; Coyne, 2005). Users have also been studied in design research and are perceived, conceptualized, and included differently in varying design methodologies. Perhaps the most common design approaches that are highlighted in HCI and HRI include UCD, user experience (UX) design, service design, and participatory design, which will be covered in turn.

UCD emphasizes that users are included in the design process focusing solely on usability (Buchanan, 2001). Criticism of UCD has highlighted that UCD promotes a “narrower focus on people’s roles as users”, rather than a focus or “concern for people” which is what HCD promotes (Steen, 2011). UX is similar to UCD as they both focus “almost exclusively on the ‘user’s needs and desires”, often focus “on the design of a single computational system” and take “a product design perspective” (Forlizzi & Zimmerman, 2013), rather than the perspective of a sociotechnical system in which the product will operate within. Jordan (2002, p.12) outlines limitations of user-centered approaches like UCD and UX highlighting that “the problem with usability-based approaches is that they encourage a limited view of the person using the product. This is – by implication if not by intention – dehumanizing.”

In contrast, HCD approaches incorporate participants as main contributors to the design process (Buchanan, 2001) – examples are service design and participatory design approaches. Service design examines a problem space and context holistically analyzing the underlying relationships, roles, and agendas of stakeholders involved in the design process (Forlizzi & Zimmerman, 2013). A key focus of service design is the co-production of value for both service providers and customers. The output of service design is a meta-design: “a set of interactions across stakeholders, service agents, customers, and many computational systems” that prompts designers to consider more than just technology design but societal level challenges as well (Forlizzi & Zimmerman, 2013). Participatory design (discussed further in Section 2.2) supports involvement in the design process as a two-way collaboration process between researchers/designers and participants and recent conversations have emphasized the importance of revitalizing participation in participatory design with a focus on “participatory design…[as] a tool to help people influence important matters in their lives” (Bødker & Kyng, 2018). This calls for the partners, or participants in a design project, being the major drivers of
the process and researchers taking on a role of both an investigator and an activist (Bødker & Kyng, 2018).

The perspective of users in participatory design, service design, UX, and UCD demonstrate how users are valued and perceived in various ways that can impact how designers engage in the design process. In addition to focusing on who designs and how people are incorporated and perceived in the process, it is also critical to consider how people who participate in technology development are valued. For example, Loyotard (1986, p.9) asks, “who decides what knowledge is, and who knows what needs to be decided?” Questions like this open the door to consider how co-designers are incorporated into design processes and how does their knowledge contribute to design research.

2.2 Co-Design and Participatory Design Values

Participatory design and co-design are often used interchangeably but “the practice of collective creativity in design” is rooted in the participatory design that emerged 40 years ago in Scandinavia (Sanders & Stappers, 2008). The first research projects in the 1970s were focused on engaging workers in workplace design and development, specifically engaging both “the expertise of the systems designers/researchers and the situated expertise of the people whose work was to be impacted by the change” (Björgvinsson et al., 2010). Participatory design has been centered around this tenet of empowering or emancipating workers or users in other contexts, highlighting the value for democratic ideals (Ertner et al., 2010). Cross (1972, p.11 at the Design Research Society Conference) also espoused the responsibility that designers have to include users in design processes to better address “wicked problems” (Rittel & Webber, 1973) in society: “Professional designers in every field have failed in their assumed responsibility to predict and to design-out the adverse effects of their projects. These harmful side effects can no longer be tolerated and regarded as inevitable if we are to survive the future…There is certainly a need for new approaches to design if we are to arrest the escalating problems of the man-made world and citizen participation in decision making could possibly provide a necessary reorientation. Hence this conference theme of ‘user participation in design.’” When bringing users into the design process, it is critical to consider how users will be supported in the design process and how their contributions and innate knowledge is valued by researchers and within the design process and output.

Participatory design approaches, such as experience-based co-design, build upon prior technology or lived experiences and environmental knowledge of participants and co-designers to support idea generation and development of new devices (Harrington et al., 2018). Empowerment is a critical component of participatory design aligning with its democratic ideals (Ertner et al., 2010). Ertner et al. (2010) outlines five enunciations of empowerment in today’s discourse of participatory design: enunciation as (1) “concrete improvement of the life conditions of a specific demographic group”, (2) “an enablement of citizens to participate democratically and gain direct influence on political and social matters”, (3) “a strengthening of the user’s position on behalf of other dominating factors in the participatory design framework”, (4) “reinforcement of the researcher’s ability to negotiate access in the practice of participatory design”, and (5) “dependent on the practitioners’ ability to expose the design practice to a reflexive analysis of how discursive conditions for knowledge production shape the process and the achieved results.” Our work focuses on this third enunciation of empowerment, working to address power imbalances between researchers and co-designers, or experts and novices in the lens of robot interaction design. It also supports and advocates for older adults to be included in HRI robot interaction design, ensuring that they are empowered and respected in design processes with a voice in the design of technology as these technologies will influence their world (Knowles et al. 2021) The robot rapid-prototyping sessions expand beyond users “simply uttering wishes” (Ertner et al., 2010). Situating this session within a year-long co-design process also promotes sustained user
engagement in the process (versus sporadic engagement) to better support user empowerment and users directly influencing designs and the design process (Ertner et al., 2010; Ostrowski et al., 2021a). Shifting power dynamics and supporting participant empowerment can promote joint inquiry and joint imagination in the design process for improved idea generation and increased user satisfaction in the final design product (Steen, 2013).

2.3 Participatory Design & Prototyping in HRI

Participatory design methods are not yet commonly used in HRI (Björling & Rose, 2019). Studies in HRI have utilized participatory methods such as workshops and/or design sessions (Ostrowski et al. 2019; Lee et al., 2017; Björling & Rose, 2019), card sorting (Ostrowski et al., 2019), sketching (Lee et al., 2017), storyboarding (Björling & Rose, 2019), role-playing (Björling & Rose, 2019), and low-fidelity prototyping (Björling & Rose 2019; Lee et al., 2017). Ostrowski et al. (2019) and Lee et al. (2017) have specifically engaged with older adults in participatory design workshops including an experience with a social robot (Ostrowski et al. (2019) was a 3 week-long experience; Lee et al. (2017) dedicated a workshop to learning about social robots), card-sorting, and sketching. These participatory design workshops did not engage older adults in prototyping interactions on a social robot and/or did not provide an opportunity for older adults to interact “live” with their designed interactions on a social robot. Our work sought to explore how to more deeply engage with older adults in the co-design process with older adults living with a social robot in their homes long-term and engaging in a hands-on rapid-prototyping experience. While participatory design and co-design can shift power dynamics and empower participants resulting in successful design outcomes, it can be challenging to keep participants engaged in the process and/or feel valued in the design process. An additional challenge for HRI is that there is a lack of methodologies and robot platforms that allow for prototyping and programming of the robot by non-experts that can often limit robot design that supports experience-based co-design. Our work incorporates a rapid prototyping experience to help support older adults’ experience in the co-design process and promote older adults feeling valued in the design process.

3 Methodology

Over the course of a year, twenty-eight older adults, ages between 70 and 94 (mean: 79.5, std: 7.8; female N=15, male N=13), participated in the co-design process (Ostrowski et al., 2021a). The co-design process had 7 stages including interviews, artmaking, hosting a social robot in participants’ homes, prototyping interactions on the robot, and creating design guidelines for future robot designs (for more details see Ostrowski et al., 2021a). The robot rapid-prototyping session occurred after the robot hosting experience where participants lived with a robot in their homes for at least a month, gaining an understanding of what it would mean to live with a social robot and allowing participants to create a mental model and knowledge of social robots and their desired functions. Participants lived with a conversational social robot, Jibo (shown in Figure 1), in their homes for at least a month. The robot has a lively persona with touchscreen and a three degree-of-freedom expressive body and has interaction functions such as chit-chat, physical and mental activities, information retrieval, entertainment, daily check ins, etc. The goal of the rapid-prototyping session was to build upon the mental model and knowledge of the robot gained during the robot hosting session to allow participants to independently prototype interactions on the robot in real-time, embodying participants’ desired functions for the robot.
In the session, participants learned how to program the robot, designed interactions for the robot, played the interactions live on the robot, and iterated upon the interactions until they represented their ideal interaction. The session included multiple components to allow for iteration and tactile prototyping through programming the robot. The structure of the session included two components. Before the session, participants reviewed a script of 14 proposed interactions that could happen with a robot throughout a day. The script covered potential robot application areas including assistant-like and companion-like functions, medication adherence, emotional wellness, exercise, memory support, and mediating social connection with others. Participants edited the scripts and shared their thoughts with researchers on the interactions. These revised interactions served as a foundation for the activity. Researchers incorporated the participants’ interaction drafts into the robot to provide a baseline for participants to work from in the session. This provided one round of iteration. The second round of iteration occurred during the rapid prototyping session using the Interaction Flow Editor (Huggins et al., 2021). The interaction flow editor is a graphical rapid-prototyping tool for robot interaction developed by the Personal Robots Group at the MIT Media Lab to empower more people to program social robots. Participants saw their first iteration of the interactions on the robot in real-time and then could iterate them by programming the robot’s interaction as many times as they would like to reach a desired interaction design (Figure 1). To support participants in programming their own interactions, the researchers led participants through a demo of the flow editor and participants completed a tutorial to familiarize themselves with the tool. After the demo and tutorial, participants began to program their interactions. After each interaction, participants were asked what they thought about the interaction and what they would like to change about the interaction. Researchers also asked participants questions about the overall process and experience after all the interactions were completed. Questions included what participants thought about having the designed interactions portrayed on the robot, what changes participants decided to make and why, what they thought about their final set of interactions designed on the robot, what participants thought was the next stage of development for the interactions, and what did they think about the process of programming the robot. Lastly, participants reflected on the session discussing what they liked about the robot rapid-prototyping session and what they would change about the session.

This session lasted on average 79.37 minutes and was audio and video recorded. Of the 28 participants in the co-design process, two were unable to participate in the robot prototyping session.
and two couples decided they would like to design the interactions together. Therefore, there was a total of 24 rapid-prototyping sessions. The dataset includes screen recordings of the prototyping session, transcripts, and the designed interactions. The interactions were annotated by two researchers and analyzed for changes made across each iteration (such as adding, modifying, or deleting flows) and the overall design concept. Participants’ discussions on questions they had as they learned to program the robot, what it meant to be a robot programmer, and design interactions were also analyzed. The two researchers discussed the results and resolved any disagreements, similar to Daly et al.’s (2012) coding approaches.

4 Results

Participants’ lived experiences with the social robot provided them with references and ideas to design, create, and build their ideal interactions for the social robot. Analysis revealed several key areas of focus including participants’ question asking behavior, core design actions, and reflections on the co-design process.

4.1 Questions

Throughout the activity, participants asked questions as they learned to program the robot, including about the process of programming a robot and how to conceptualize a design idea. A thematic qualitative analysis approach was used to extract themes (Braun & Clarke, 2006) in the questions asked by the participants. Older adults asked a total of 47 questions across 6 different areas (Table 1). Questions throughout the sessions demonstrated how participants further deepened their knowledge about programming social robots and how best to embody their design in the robot interactions.

Table 1. Types of questions older adults asked while designing the robot interactions

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot Behavior Clarification</td>
<td>Questions regarding the robot playing out the interaction.</td>
<td>“Can I ask you a question? When he starts talking is that in response to something I've done or he just, has like motion detectors?” (P01)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“The light ring…are we talking about the blue light [on the robot]?” (P29 &amp; P31)</td>
</tr>
<tr>
<td>Editor Tool Clarification</td>
<td>Questions regarding the flow editor on the screen and its usage such as about restarting the flow, saving the flow, moving blocks, block meanings, connecting blocks, typing in the flow editor, and volume adjustment. This theme also related to questions about how the user locates themselves in the system and how the interaction editor flow translates to the embodied robot.</td>
<td>“Where do you save?” (P13) “Can I move that up further?” (P08)</td>
</tr>
<tr>
<td>Instruction Clarification</td>
<td>Questions asking for clarification on the process or steps the participant should be doing in the session.</td>
<td>“So what you want me to do is come over here and add a box?” (P05)</td>
</tr>
<tr>
<td>Interaction Design Clarification</td>
<td>Questions that are asking how to achieve a specific feature or action in the robot or the context the flow would occur in. These tend to be more future focused then what can currently be</td>
<td>“Will that be connected to my schedule?” (P14 &amp; P15)</td>
</tr>
</tbody>
</table>
done in the prototyping phase.

<table>
<thead>
<tr>
<th>Expertise</th>
<th>Questions about the researcher’s programming background.</th>
<th>“So what's your training for this?” (P07)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>Questions for what happens if the participant makes an error</td>
<td>“What if I make a mistake?” (P01)</td>
</tr>
<tr>
<td>Programming</td>
<td>Questions strictly related to the robot's programming.</td>
<td>“So does he, is he programmed the same way [as the flow editor]?” (P25)</td>
</tr>
</tbody>
</table>

4.2 Core design actions

Between iterations and during the session, participants refined their interaction flows (Figure 2) and iterated upon them (Figure 3, 4, and 5), using a multitude of design changes to best create their intended interaction for the social robot. Researchers analyzed the flows to identify how participants were refining their interactions, revealing 6 core design actions that participants used: (1) adding/deleting comments that provided notes or added context to the interaction scenario; (2) adding/deleting action/speech boxes (therefore, adding or removing actions for the robot to complete); (3) deleting an interaction; (4) adding/removing back and forth conversation between user and robot; (5) adding/deleting branching allowing/disabling for multiple types of responses; and (6) rewording speech boxes (therefore, rewording the robot’s speech in the interaction). Examples of some of these core design actions can be seen in Figures 3, 4, and 5.

**Figure 2.** Examples of programmed interactions created by participants. The programmed interaction on the left is a robot interaction that has the social robot provide a dinner recipe to the user. The programmed interaction on the right has the robot describe the day’s events and provides a reminder and any necessary help with medication.
Table 2. Older adults’ core actions during rapid prototyping interactions on the robot

<table>
<thead>
<tr>
<th>Action</th>
<th>Percentage of Older Adults</th>
<th>Corresponding Action</th>
<th>Percentage of Older Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding comments</td>
<td>50%</td>
<td>Deleting comments</td>
<td>41.7%</td>
</tr>
<tr>
<td>Adding action/speech boxes</td>
<td>62.5%</td>
<td>Deleting action/speech boxes</td>
<td>50%</td>
</tr>
<tr>
<td>Adding back-and-forth conversation</td>
<td>41.7%</td>
<td>Removing back-and-forth conversation</td>
<td>20.8%</td>
</tr>
<tr>
<td>Adding branching</td>
<td>20.8%</td>
<td>Deleting branching</td>
<td>41.7%</td>
</tr>
<tr>
<td>Deleted interaction</td>
<td>45.8%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Reworded speech boxes</td>
<td>91.7%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

In addition to these smaller iterations to the flows, participants combined core actions together to (1) significantly change the interactions’ intent or the focus after seeing it “live” on the robot by moving boxes or rewriting the text and/or (2) remove robot proactivity, i.e., robot initiation, of the interaction. Participants would also change the connotation of the interaction utilizing the 6 core actions such as making the interaction more or less conversational and social, or incorporating in assistant-like tasks. Overall, participants made 267 core actions to their flows (average of 11 (standard deviation: 5.2) core actions per person). A detailed breakdown of the 6 core action presence in older adults’ prototyping is in Table 2.

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Figure 3. P09’s flow iterations that depict an interaction where the robot reviews the user’s schedule for the day and reminds them about their medication. In the first iteration, P09 personalized the medication to be taken and included options for getting information on the medication dosage and the user confirming with the robot that the user took the medication. In the second iteration, P09 modified the interaction to only have a reminder for the medication (no dosage information) and kept the user confirming with the robot that they took the medication. The user can also inquire later about medication information as desired.
Figure 4. P22’s flow iterations for a robot interaction at the start of the day. In the original interaction, the robot wakes up the user and asks how they sleep with additional responses based on the user’s response. P22 did not iterate the interaction in the first iteration. In the second iteration, they deleted parts of the flow to simplify the interaction with the robot asking if the user was awake and then leaving the user for a user-defined period of time, instead of inquiring about the user’s night of sleep.

Figure 5. P11 and P12’s flow iterations for an interaction where a friend sends the user a message and the robot reads the message aloud to the user. P11 and P12 modified the interaction in their first iteration to be more direct through text rewording in the “Jibo-Speak” block. In the second iteration, P11 and P12 expanded the interaction to include the robot asking if the user wants to reply to their friend, transcribing the reply that the user desires to send, and, then, sending the reply to the friend.
4.3 Reflections on programming robots

After programming the robot, participants reflected on the difficulties and concreteness of the design process and how the experience empowered them and increased their knowledge of social robots. A grounded theory qualitative analysis approach was used to reveal salient themes (Charmaz, 2014) in 18 participants’ reflections (4 participants did not answer these questions). Analysis revealed five key theme areas that older adults reflected upon including (1) reflections on the flow editor rapid prototyping system, (2) the impact of seeing programmed interactions live on the robot, (3) how the session empowered them in the design process, (4) feeling like a non-expert, and (5) how the experience translates to the future. Forty-four percent of participants’ reflection described aspects of the flow editor system such as the ease-of-use of the editor, how the system provided the ability to change or adapt the robot interactions, what was difficult to operate in the system, and sometimes doubting if they used the system “right” (P02). Participants also mentioned how the robot’s embodiment or ability to play out interactions or program live with the robot impacted their experience of the design process (50%). P02 commented, “when they heard [the interaction from the robot], it’s more realistic. When you heard it, you could really feel how it's going.” and P18 and P19 mentioned, “it helps to have the written word translated into Jibo. And then seeing Jibo and how it would work.” Most participants commented on the helpfulness of seeing the interactions embodied on the robot and how that feature played a key role in their design iterations. Seventeen percent of participants also commented about how the rapid prototyping experience could translate into the future. P05 commented, “[the prototyping] lays out a pathway to the future [in the robot design]” and P08 mentioned how they could interact with prototyping in the future saying “…maybe if I went over it again three more times and I’d make a correction on her [the robot]” while acknowledging that “I think basically [the rapid prototyping] worked well.”

In addition, participants interwove their experiences living with the robot prior to the rapid prototyping session to further describe their designs on the robot. These often took the form of stories that participants used to convey a point relevant to the programming of the robot (see also Ostrowski et al. 2021b). P07 described how “in some ways Jibo was very realistic.” They proceed with a story: “He [the robot] likes to play [dice]. The first time I said yes, let’s play [dice], it was so realistic. I thought the dice were going to fall on the floor. It was so loud. And when I showed my friends that, they can’t believe this.” P07 followed up with this to reflect on the programming and co-design experience: “I think I’m contributing something. When my friends asked me what have you been doing? I say, well, I go to [MIT]…and we discuss these things…Well, I used to say this, I don’t think Jibo was very intellectual. If he was able to do [these programmed things], sure. But I don’t think he has the brain power to do any of these things [these programmed things].” P25 also highlighted a story around living with the robot: “It’s kind of nice to have some interaction and he’s made us laugh a bunch of times …Every once in a while you’re just sitting there and you’re ignoring it, it’ll draw a picture…” They then discussed the value of personalization: “This [the robot] is much cuter and much more personal and if you can program it and design it for what you need…I don’t know what I can do with that cause I haven’t really explored it…” Later on in the conversation, P25 revisits talking about programming, “Even though [programming’s] simple…it’s a lot of work to program each…because there are so many branches that you can go off on and…these choices…There’s just way too many layers…It’s like so many subtle things. That would be hard. That would be difficult.” These depict examples of how participants weaved stories of living with the robot into designing and discussing new features of the robot, what needs to be programmed, and how they are contributing to the design process.

Throughout the activity, participants referred to themselves as “non-experts” in programming, doubting their ability to program the robot or perceiving the experience as an educational opportunity.
P07 commented to the researcher in the session, “I don't know exactly what you're doing because you're the designer.”; and P29 and P31 commented, “Well, I had no prior experience programming, and it's very fascinating for me and extremely educational and fun. Very impressed with the insight, the ability to navigate and understand what's going on here.” Participants varied from referring to the researcher as an expert or underlining they hadn’t programmed previously. Regardless of viewing themselves as non-experts, the interaction flow editor and prototyping session allowed participants to learn how to program the robot and independently prototype interactions. Fifty percent of participants commented on how the session empowered them in the co-design process. Participants described that the hands-on programming activity increased their knowledge of social robots that they could leverage in the design process. P23 commented on how they “lik[ed] to learn…the programming process, because it’s something [they] didn’t know anything about…It took some of the mystery out of it…It gave me a little insight into the whole…area of programming.” Similarly, P12 mentioned that learning about programming is “useful and it gives us a little sort of insight into what goes into making a social robot and a little more opportunity to think what a social robot might be able to do”, citing how learning about programming expanded their design space. P20 expanded upon this idea explaining how programming allowed them to build a foundation for moving forward with the project: “I think [learning about programming is] a necessary step. You can’t go into all the miracle stuff and how it will flow in and out without understanding some of it.” Participants also expressed how the programming and prototyping component made them feel empowered and valued in the co-design process: “…this really makes me feel part of this whole study and I appreciate that…our opinions matter and…that…even though we’re not programmers or…electrical engineers like our son, that we were still about to do some simple programming and I think that’s fun” (P31). Further examples can be found in Ostrowski et al. (2021). Participants also mentioned that they wanted to continue building on their new programming skills with future programming. P05 commented that they “would be willing to play with some of these things [prototyping interactions]…I even have a laptop that I can use for that.” Overall, participants were very proud of the interaction designs they developed and felt valued and empowered in the co-design activity.

5 Discussion

In this work, we sought to answer in a rapid-prototyping session how do older adults design robot interactions supported by lived experiences with the technology (R1) and how do older adults relate to being robot interaction designers after engaging in rapid-prototyping of robot interactions (R2). The following discussion sections are structured around these questions and explore how co-designers engage in design similarly to traditionally defined designers, how lived experiences supported participants in the interaction design process, and how co-design activities can be structured to promote older adults and others as robot co-designers.

5.1 Co-designers & designers

Participants in the rapid-prototyping activity created interactions on the robot by engaging in six core design actions (Section 4.2) and combining the core design actions together to achieve their design goals. They also engaged in behaviors and design activities similarly to designers as has been reported in design research literature. Researchers have studied how designers engage with tools or design strategies. Prototyping specifically has been explored as a design language (Cross, 1999a; Ullman et al., 1990) and as a source of knowledge for furthering the design process (Houde & Hill 1997). Our work reveals how older adults used prototyping interactions as a way to express their desires and envisioned functions for the social robot. By using the flow editor, older adults could craft their own
experience of what a robot should be, resulting in an implementation and role prototype (Houde & Hill, 1997) that both reveal the functions desired in the robot and how the design would fit into context with their lives. It also captured if the design would not fit into their lives as was seen when participants deleted flows completely or changed the meaning significantly from the first design iteration. Some of participants’ core design actions, such as adding comments and significantly changing the meaning of the interaction, espoused the co-designer’s designerly ways of knowing (Cross, 1999a) as they justified their iterations made to the flows leveraging features such as comments and rewording speech boxes in the flow editor. In this way, participants found ways to express their desired intentions for their flow diagram, even if they were unable to embody the new design iteration using the flow editor. They worked with the system to ensure their design ideas could be communicated to others for future iterations and prototyping of the design.

Another design behavior that participants engaged in was problem framing as evidenced by the questions that were asked during the co-design process by the participants (Section 4.1). Participants used questions as a way of clarification when working with the system but also as a way to frame and scope the problem they were addressing with the design iterations. For example, P14 and P15 asked “Will that be connected with my schedule?” reshaping the problem space to include integration of multiple devices as a requirement. P25 redeveloped the problem space considering the type of conversation they would have with the robot asking, “If I tell Jibo I have a headache, then what should it do?”, and considering how the robot would respond to such question. They then began to adjust their designs (solution space) to ensure that the interactions were designed with respect to the robot’s ideal capabilities in a conversation with a user. In the sessions and through the design iterations, questions were used as a way to take a current problem and design solution scope, gain information on the process or purpose of an interaction, and then reshape the problem and design solution scope. This was also evidenced when participants engaged in design actions like changing the meaning of an interaction flow, deleting an interaction flow, and redesigning interaction flows. These behaviors reshaped the problem and solution space across the session and within each individual interaction that was designed, evidencing Maher’s model of co-evolution of problem and solution spaces in the design process (Dorst & Cross, 2001). There can be barriers when engaging in problem reframing such as fixation on an idea or a problem-solving mental model of design (as seen between clients and designers in Patton & Dorst (2011)). These barriers can be mitigated by “contextual engagement through research”, “co-exploring the abstract conjectured view of the situation”, and “language co-creation” (Patton & Dorst, 2011). In our co-design process with older adults, we mitigated these barriers with older adults by having a lived experience with the social robot before the rapid-prototyping session to develop their mental model of the system and provide contextual engagement of what it would mean to have a social robot in their home. This lived experience also supported a language of co-creation that researchers and older adults used in the rapid-prototyping session to communicate and embody ideas in the interaction flows. Within the sessions, the interaction flows acted as a method for researchers and older adults to explore the abstract design space of what a social robot could be designed to do in future designs. Older adults exhibited several methods and activities that are common with designers, expanding who can be called a technology designer in the field of HRI.

5.2 Rapid-prototyping connected to Research Through Design

The participants embedded their desires and embodiments of robot interactions through the rapid-prototyping process and embedded design knowledge into their final designed interactions (Cross, 1999b), supporting Zimmerman et al.’s (2007) model of design research with a focus on the production of artifacts. Zimmerman et al.’s (2007) research through design model allows for
researchers to identify new opportunities for technology that will impact the world, provide inspiration and direction to engineers in the design of technologies, and understand unanticipated effects of these technologies incorporating aspects such as social context and target users. In the rapid-prototyping session, participants designed robot interactions, working “more as a collaborative equal” (Zimmerman et al., 2007) with researchers. P25 vocalized the value of learning about how robots are programmed, saying “[the flow editor] put it into a format that is concrete so I kind of can understand what it’s doing…It’s a whole breadth of knowledge that I’ve never tapped, so it’ll be interesting to see what [the robot] knows.” P29 also expressed this mentioning they were “very impressed with the insight, the ability to navigate and understand what’s going on here.” P29 built upon this highlighting that the design process and the knowledge developed “makes [them] feel part of this whole study and [they] appreciate that…[their] opinions matter…even though [they’re] not programmers…” Sentiments such as these demonstrate how in designing interactions on the social robot, older adults began to view themselves as “collaborative equals” of the research team. Overall, the rapid-prototyping session aligns with research through design in two ways: (1) the intent of the rapid-prototyping session was to produce insights for research communities on the older adults’ desired interaction design for social robots and the assumptions embedded within them; and (2) the lived experience with the robot allowed participants to study a social robot in their world and make changes and design upon that to affect change in their life (Zimmerman et al., 2007). The outputs of the robot prototyping session also allow researchers to identify new opportunities for social robots that will affect how social robots impact social contexts and provide future direction for engineers to develop social robots, aligning with research through design’s objectives (Zimmerman et al., 2007). Zimmerman et al. (2007) outlines four criteria to evaluate design research contributions such as our work with rapid-prototyping: process, invention, relevance, and extensibility. For process, the main objective for the rapid-prototyping was to understand how older adults design interactions for social robots. The process included two design iteration points and opportunities for building capacity including demos and tutorials. For invention, this work revealed how older adults design interactions for social robots and how older adults desire social robots to be designed for a range of interaction types. The programmed interactions represent the ideal interaction design for a robot interacting with them over the course of the day. For relevance, it is rooted in the need for more voices to be heard in the technology development process of social robots. Co-design has been recognized as a beneficial design process for engaging older adults in the design process of technologies (Harrington et al., 2018; Harrington et al., 2019). Previous technology experiences and lived experiences can inform the design of technology and provide a foundation for older adults engaging in and contributing to co-design technology processes (Harrington et al., 2018), as demonstrated in how the social robot lived experience was leveraged in the rapid-prototyping process in their interaction designs. For extensibility, the output of interaction prototypes and designs support the extensibility of this work. The rapid-prototyping session amplified older adults’ voices, ideas, opinions, and designs of social robots and shifted perspectives of who can be considered a robot interaction designer in HRI.

5.3 Supporting co-designing prototyping experiences

Designers, in addition to prototyping and problem framing, build capacity and develop expertise for how to design solutions for complex problems (Coyne, 2005) such as designing robot interactions for a social context. To fully support older adults in the co-design process, the robot lived experience served as a method for building capacity (Dombrowski et al., 2016) to inform their design process in the rapid-prototyping session. For almost all of the participants, this was their first time programming a robot and designing “live” interactions for the social robot. Many of them expressed the value of learning how the system works and how it influenced their design iterations, evidencing that they built
capacity during the rapid-prototyping session as well. This was also evidenced by participants’ questions during the sessions that inquired about the interaction flow editor, how the flow editor “relayed” the interaction to the robot, and how to accomplish desired interaction designs in the system. The overall structure of the rapid-prototyping session and engagement with older adults through the session suggest that the session took the format of a hands-on project-based learning experience for the co-designers, further developing their abilities to “solve real-world, ill-defined problems” and “offering opportunities for development of a wide range of abilities in nonverbal thought and communication” (Cross, 1972). We have identified social robot lived experiences as a method to support older adults in the co-design process and provide diverse sets of activities for older adults to engage in design in multiple ways (Ostrowski et al., 2021a). While participants mentioned the value of the learning experience and ability to design interactions on the robot, some participants also referred to themselves as non-experts, or those that cannot or should not program robot interactions because only experts such as computer sciences are able to program. It is critical for us to consider how we can structure co-design processes to make co-designers feel valued for their lived expertise and tacit knowledge they bring to the design process and consider how feeling like a non-expert or someone who can’t be a designer or programmer may affect co-designers’ design process. Additionally, it is important to note how hands-on design processes in participatory design and co-design can not only result in design artifacts that inform future design iterations but these design processes also serve as a design education experience that supports capacity building, creates a sense of ownership in the design of the technologies, and helps balance power dynamics between researchers and participants (Coyne, 2005; Steen, 2013; Harrington et al., 2019; Dombrowski et al., 2016).

Overall, in the rapid-prototyping experience and larger co-design process, a core tenet (as with most participatory design and co-design) was empowering co-designers, specifically addressing power balances between researchers and co-designers and strengthening the co-designers’ position (Ertner et al., 2010). The tutorial at the beginning of the session allowed co-designers to build capacity for how to design the robot interactions using the flow editor. While the participant was the robot programmer and directed the designs and iterations for the session, the researcher was available as a resource that was often used as evidenced by the question behavior of participants. The rapid-prototyping session served as a source of empowerment in the larger co-design process as expressed by participants when they reflected on the session and what it meant to be a robot programmer. Several participants cited that the session provided insight for their designs and the programming of the robot, demystifying the technology overall. It also allowed them to feel a part of the study, signifying a greater feeling of empowerment in contributing to the design of the social robot. This shifting of power dynamics promoted joint inquiry and joint imagination in the design process strengthening the design generation process and hopefully leading to social robot designs that will increase user satisfaction in the final design product (Steen, 2013).

5.4 Future work

This paper focused on how older adults as co-designers designed interactions in a rapid-prototyping session and how they relate to being robot interaction designers. Future work could explore interactions across application areas of focus (i.e., medication adherence, social connection, etc.) and themes relating to specific application areas. The core actions could be further explored to understand if there are patterns for how older adults were designing their interactions such as some people leveraging comments more than others or some people using rewording more than others. Building upon research through design objectives (Zimmerman et al., 2007), future work could further investigate how the co-designers’ interaction designs may help researchers further understand
unchallenged effects of social robots. Reflecting on the value of the rapid-prototyping session in empowering older adults as co-designers and making them feel valued in the co-design process, we would recommend that in future social robot co-design processes, rapid-prototyping or similar design activities that involve programming robots are incorporated multiple times into long-term partnership with co-designers. Researchers can also explore various structures for rapid-prototyping sessions, having a mixture of structured design activities such as tutorials and more open-ended and specific application area focused design prompts. Future research could also explore the impact of the robot’s tangibility on the co-design experience and how varying robot embodiments may affect and differ between different application areas of robots. Overall, the rapid-prototyping activity was embedded within a year-long co-design process and, as of writing this paper, the researchers and co-designers are still working together. We support future co-design engagements that support sustained engagement with communities (Ostrowski et al., 2021a) and that focus on enablement, or “facilitating and developing opportunities for people to fulfill their potential and to develop their own capacity” (Dombrowski et al., 2016). For HRI, this can be realized as “fostering human capacity or helping people take advantage of opportunities by creating platforms for participation and self-determination” (Dombrowski et al., 2016). Through promoting sustained engagement with communities and democratizing how people design, we can reshape the notion of who can, should, and is a robot interaction designer. We hope that with our work, we have amplified this conversation.

6 Conclusion

This paper provides an in-depth exploration of older adults as co-designers of robots, revealing how older adults wish social robots to be designed and how older adults can be supported as designers, valuing their built technology experiences. Our dataset and results demonstrate the value of incorporating methods that allow users to design and program social robots and the value of co-designing long-term with users to guide technology design. Overall, we advocate for sustained engagement with communities and users through co-design, participatory design, and human-centered design, empowering users, such as older adults, to be designers of robot interactions, expanding who can be called a technology designer.

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References


5 Design teams of diverse backgrounds
Exploring the effect of team composition on creativity in design idea generation

Xifan Ou\textsuperscript{a}, Gabriela Goldschmidt\textsuperscript{b} and Miriam Erez\textsuperscript{b}

\textsuperscript{a} University of Shanghai for Science and Technology, eileen0002@163.com
\textsuperscript{b} Technion – Israel Institute of Technology, gabig@Technion.ac.il, merez@technion.ac.il

Abstract. Team composition affects the performance, including creativity, of teams in design tasks as in other tasks. Existing research presents mixed results on the impact of team composition on creativity. In this paper, we conduct an empirical study to investigate the impact of three different team categories on creativity: teams composed of designers only, teams composed of designers and non-designers, and teams of non-designers only. 18 volunteer dyads completed a short design ideation task by generating solution ideas, expressed through quick freehand sketches and/or texts. Three expert judges scored the ideas in terms of originality, usefulness, compliance with requirements, and in addition assigned an independent subjective creativity score to each team. Fluency and rareness of ideas were also calculated. Findings indicate that mixed teams got the highest scores in almost all variables, thereby adding to the literature that favors mixed teams for increased creativity.

Keywords: Creativity, Design idea generation, Team composition

1 Introduction

Design is increasingly dealt with by teams that are often composed of additional actors beside designers. A variety of professionals step into the domain of design, resulting in larger access to knowledge and information, and wider insights into the design area (Liedtka, 2018; Yilmaz & Daly, 2016). The diversity of team composition has an impact on the team’s performance, notably on creativity. This issue has been amply researched in many domains that experience a similar expansion, but not so in design. In this study we investigate the impact of multidisciplinary backgrounds on the creativity of design teams.

Many students of problem-solving view diverse expertise in teams as a contributing factor to creativity, under the hypothesis that integrating knowledge, skills and experience from different domains and perspectives increases the quality and creativity of problem-solving (De Dreu & West, 2001; Menold & Jablokow, 2019; Shin, Kim, Lee & Bian, 2012). Though studies have suggested that multidisciplinary background may indeed contribute to creative performance (Aggarwal & Woolley, 2019; Chen, Liu, Zhang, & Kwan, 2019), diversity in general has also been shown to cause significant difficulties in communication and team cohesion (Aggarwal & Woolley, 2013; Ancona & Caldwell, 1992; Lovelace, Shapiro, & Weingart, 2001; Miron-Spektor, Erez, & Naveh, 2011; Miron-Spektor & Naveh, 2017; Srikanth, Harvey, & Peterson, 2016). The positive or negative effects caused by diversity may prevail or be counteracted, but which of these effects is predominant is uncertain and depends on a host of factors.

Design is associated with a specific way of thinking that distinguishes it from science and art and makes it difficult to predict how diverse and multidisciplinary backgrounds may affect design performance. Research on this topic is still scarce in design. Design problems are almost always ill-defined and ill-structured, which means that they can have many possible solutions and that the way
to solve these problems is not known ahead of time (Cross, 2018; Kokotovich & Dorst, 2016). Unlike traditional problem solving wherein the problem is defined and problem solving favors the application of tested methods to reach a solution, design problem-solving often starts with exploration, experimentation and framing in order to reach a problem definition, which is tentative and flexible, and may change in the course of the search for a solution (Cross, 2018; Lawson & Dorst, 2009). Moreover, designers utilize rapid sketching to explore the ambiguous and uncertain nature of design problems, which gives them an edge over non-designers who are not necessarily skilled sketchers (Brun, Le Masson, & Weil, 2016; Cross, 2018; Menold & Jablokow, 2019). Therefore, it is not surprising that we find a tendency among designers to prefer all-designers teams over multidisciplinary (or other collaborative design by designers and non-designers) teams. A study by Ertmer et al. (2008) has shown that professional skilled designers and well-organized inventories of domain-specific knowledge have an advantage in achieving a high level of creativity when facing design problems. However, there is some evidence that having experienced work in mixed teams, designers (and non-designers) tend to favor them over uni-disciplinary teams (Santandreu Calonge & Safiullin, 2015).

In this study we focus on idea-generation in design, resembling informal brainstorming, and not on a full design process. Therefore, we conduct an experiment using a simple and short exercise, requiring no specific prior design knowledge, that allows us to test the preliminary reactions of teams and their intuitive design responses (ideas) to a design challenge. We investigate the impact of multidisciplinary backgrounds on the creativity of design teams in a lab exercise, based on judges’ scores of originality, usefulness, and compliances with task requirements, as well as on calculated scores of fluency and rareness of the teams’ ideas. By multidisciplinary teams we mean teams wherein members with a design background work with members with no such background, but who are skilled in a different domain (Harrison & Klein, 2007; Boon, Van Baalen, & Groenier, 2019). Because the exercise was very short, we cannot talk of interdisciplinary or trans-disciplinary teams; ‘teams composed of diverse backgrounds’ would have been a better definition but since diversity can mean many things, we revert to multidisciplinary (as opposed to uni-disciplinary) teams. We refer only to disciplinary diversity, not to other differences such as cultural, ethnic, personality or other differences.

Our research question is thus:
What would be the team composition that yields the highest level of team creativity in design idea generation, and in what order do the other two teams follow?

2 Literature review

Team creativity can be referred to as the development of diverse kinds of team thinking that generate useful and novel ideas within a complex context (Kurtzberg, 2005). Team creativity emphasizes the importance of pooled resources and divergent thinking that each team member brings to the table. Recent studies on creativity have called for attention to factors affecting team creativity (Shalley, Zhou, & Oldham, 2004), stressing the influence of team composition on its creativity (Hansen & Levine, 2009; Hülsheger et al., 2009).

In general, team composition impacts team output since it affects the amount and diversity of members’ knowledge and skills applied to the task the team is handling (Mello & Ruckes, 2006). Previous research differentiated surface-level composition variables like overt demographic characteristics, from deep-level composition variables that are underlying psychological characteristics such as personality factors or values (Bell, 2007). These composition variables were regarded as critical to the ability to adopt diverse perspectives, knowledge, and experience, as well as to the potential to promote unusual ideas, thus promoting team creativity. Some scholars suggested
that homogeneity facilitates creativity because team members can easily communicate and interact with each other (Bell, Brown, Colaneri, & Outland, 2018). Others argued that heterogeneous teams with members from different backgrounds are more likely to expand the boundaries of problem-solving, which may eventually generate more creative ideas, albeit at the cost of possible conflict (Somech & Drach-Zahavy, 2013). The effect of team composition on team creativity is inconclusive. Because the variables in teams may pertain to many different causes, it is practically impossible to flatly compare multidisciplinary and uni-disciplinary teams in terms of creativity and particular variables must be defined for a comparison.

Alves, Marques, Saur and Marques (2007) stated that with dissimilar points of view, expertise and relevant information, multidisciplinary knowledge would increase novelty and creativity in mixed teams and would be crucial to consider in problem-solving. Reiter-Palmon and Leone (2018) argued that owing to their domains of expertise, multidisciplinary team members think critically and analyze ideas from a variety of perspectives available to them, thus providing a more precise evaluation of concepts, leading to better choices of solutions. Aggarwal and Woolley (2019) reported that cognitive diversity enhances team creativity by facilitating the detection of cognitive resources. De Dreu and West (2001) suggested that multidisciplinary knowledge is more likely to integrate the probably conflicting points of view of team members, through sharing information and task-relevant knowledge, helping to avoid fixation, thus enhancing creativity.

However, other scholars were suspicious of this positive viewpoint and reminded readers that many case studies revealed that knowledge of diverse disciplinary origins among team members may cause conflicts and misunderstanding, which mitigate creativity. Hawlina, Gillespie and Zittoun (2019) argued that diversity may decrease cohesion, information sharing and motivation for discussion, and increase coordination problems and communication conflicts, leading to a negative effect on team creativity. Aggarwal and Woolley (2013) suggested that even though multidisciplinary knowledge was predicted to enlarge the available knowledge and improve problem-solving performance in a team, this same multidisciplinary knowledge can adversely affect group processes.

Designers solve problems in a different manner than scientists, artists, and many other professionals (Cross, 2006; Dorst, 2011; Dreyfus, 2004; Lawson & Dorst, 2009). Cross (1982, 2006) stated that the “designerly ways of knowing”, a term he coined, are a typical characteristic and main facet of the practice-based methods that distinguish designers from non-designers. They also have a specialized exploration tool: sketching. Sketching, as a basic professional skill of designers plays a vital role in the early idea generation phase. Sketching provides visual representations that support iterative efforts to develop ideas, facilitates the oscillation between different modes of reasoning, and helps designers discover unintended consequences of their acts in a reflexive dialogue with the situation (Cross, 2018; Goldschmidt, 1991; Schön & Wiggins, 1992; Härkki, Seitamaa-Hakkarainen, & Hakkarainen, 2018). That is, sketching acts as both a thinking tool and a communication tool that designers use to converse with themselves and others, thus greatly aiding the process of idea generation and reasoning about them (Ainsworth, Prain, & Tytler, 2011; Mao, Galil, Parrish, & Sen, 2020; van der Lugt, 2005). The nature of problem-solving in other disciplines does not often require visual representations and therefore most non-designers are not experienced in using sketching in their problem-solving routines.

In the field of design not much research has been conducted on the creativity-team composition issue. One related study by Badke-Schaub, Goldschmidt, and Meijer (2010) found that cognitive conflicts in teams were responsible for more creative design solutions. This finding supports the view that diversity in team composition can create a positive environment of debate and controversy, in which ideas synergistically resolve into more creative outcomes than would emerge in more homogeneous teams. Brown and Katz (2011), who come from the domain of design, explained that creativity is fostered by interdisciplinary teams at work; such teams’ creativity exceed that of multidisciplinary teams because of the disposition for collaboration of its members, who experience collective
ownership of, and responsibility for, their ideas. It is very difficult to find empirical studies on mixed
teams vs. other team compositions in design. One study that did undertake the challenge is by
Christensen and Ball (2016), who found that unique knowledge backgrounds fuel analogy-based
creativity in design contexts. Santandreu Calonge and Safiullin (2015), who sought the opinions of
students from diverse backgrounds on a “creativity, innovation and design thinking” on-line course
they participated in. The students came from various cultures, disciplines, and educational standings,
and answered a pre-course and post course questionnaire regarding their expectations and experiences
in the teamwork they engaged in. They found that while the pre-course questionnaire expressed a high
level of suspicion and disbelief in the potential success of the collaboration in mixed teams, the post-
course replies were very positive and indicated a high level of satisfaction.
The current research focuses on idea-generation in design by different-type dyads (in terms of
discipline only). We inspect whether, in a very short exercise, differences can be found between these
dyad types in terms of the creativity of their design ideas while tackling a very simple design task.

3 Method
An experiment was designed to investigate the research question, in which participants were asked to
generate ideas for the solution of a simple design problem in a limited period of time. The variability
in this experiment is in team composition: designer teams, mixed teams, and non-designer teams.
Team creativity was assessed in terms of originality, usefulness, and compliance with the
requirements, in each concept idea. These variables were assessed by expert designers who served as
judges. As a supplement, we also assessed the fluency and rareness levels of ideas in each team
category (see Hsu, Wang, Lin, & Chang, 2018; Nouri et al., 2015). In addition, both judges and teams
assigned each team a subjective creativity score.

3.1 Participants
36 volunteer participants were allocated into 18 dyads (teams of two participants). Half of them were
designers or had an ample design background; most of them were professional designers or graduate
students in industrial design or architecture. Only a handful were undergraduate students who were at
least in their third year of studies. All other participants, who were for the most part graduate or post-
doc students in scientific or engineering (non-design) disciplines, had no design experience at all.
Designer participants (N=18, mean age=36.39% female) and non-designer participants (N=18, mean
age=28, 39% female) were randomly assigned to one of three different team categories: designer
teams (six dyads of two designers, N=12); mixed teams (six dyads, each composed of a designer and a
non-designer, N=12); and non-designer teams (six dyads of two non-designers each, N=12).

3.2 Task
All teams were asked to design a table lamp for an exhibition of bamboo products. The allowable
materials for the lamp consisted of natural bamboo canes with a diameter of up to 100 mm and a wall
thickness of 6-10 mm, metal wire of 1mm diameter, glue, electric circuitry, and a light bulb. Bamboo
could be cut crosswise or lengthwise and could be drilled and bent. A design brief including the task
description, the timetable and bamboo-bending illustrations was provided in printed form. The task
was chosen because although it is very simple it also affords innovation opportunities. No knowledge
beyond everyday common knowledge is required, thus it is accessible to designers and non-designers
alike.
3.3 Experimental settings

Each team tested separately by an experimenter who handed out the design brief to each team and explained the procedure but did not intervene in what the participants did. Team members were asked to engage in conversation with each other during the whole session, which was videotaped with a single camera pointed at the desk surface on which the participants worked. In phase one, teams were instructed to spend 8 minutes generating as many creative ideas as possible and sketch them, adding text if they wished. In phase two they were given five minutes to choose one of their ideas and develop it further. In phase three, each team had four minutes to list the main advantages of their solution and give it a subjective creativity score from 1 (lowest) to 10 (highest). Once participants finished the task, they were asked to answer a few debriefing questions in which they provided demographic information and articulated their feelings regarding the experiment. 

Pilot study: Before the actual experiment, a pilot was conducted, to ensure the task feasibility and calibrate the timetable. Three dyads participated in the pilot study, which was not included in the main experiment analyses.

3.4 Judges

All design ideas were evaluated by three independent judges who were blind to team composition and the research goals. All three judges had several years of professional design experience, one in industrial design, one in architecture and one in graphic design and user experience. A training session with all judges preceded the assessments, which were done individually. In the training session one of the pilot outcomes was assessed by the judges together, to coordinate their scoring policies.

3.5 Metrics and analyses

3.5.1 Originality, usefulness, and compliance with brief requirements. The three naïve judges, working separately, were provided with photocopies of the teams’ sketches, in random order, one sketch per idea, and assessed each idea on the dimensions of originality, usefulness, and compliance with requirements. A Likert scale of 1 (lowest) to 7 (highest) served to assess the originality and usefulness of the design outputs. A scale from 1 to 3 served to rate compliance with requirements (1= not at all, 3= very much). These scores were subsequently transformed to a 1-7 scale, to match the originality and usefulness scores (IBM SPSS Statistics, see https://www.ibm.com/support/pages/transforming-different-likert-scales-common-scale).

3.5.2 Overall creativity. An overall creativity score was calculated as a sum of originality, usefulness, and compliance with the brief requirements scores (after the latter scores were transformed to a 1-7 scale).

3.5.3 Judges’ independent creativity scores. Judges’ independent assessment of each team’s creativity served as a separate indicator of creativity. Based on their subjective feelings, the judges were requested to give each team an independent creativity score between 1 (lowest) and 7 (highest).

3.5.4 Participants’ self-scoring. Participants’ self-scoring was utilized as another indicator of perceived creativity. Each team evaluated its creativity with a score between 1 (lowest) and 10 (highest). These scores were also subsequently transformed to a 1-7 scale (see details in section 3.5.1), to match the originality and usefulness scores.

3.6 Fluency

Fluency was measured by the number of ideas generated by each team.
3.7 Rareness

Flexibility is the ability to develop a solution from multi-angle considerations and to generate different categories of ideas (Hsu, Wang, Lin, & Chang, 2018; Roskes, De Dreu & Nijstad, 2012). We addressed one facet of flexibility — rareness, which pertains to ideas that are rare among the pool of all generated ideas in a specific setting, such as the experiment we conducted. Rareness scores were computed in two steps: First, we established a list of features of the designed artifact in question, whereby features of three parts of the artifact – table lamp – that is, Base (B), Arm (A), and Lampshade (L), were coded separately. Each idea was assigned three codes, one for each part of the table lamp (e.g., B1, A2, L3). Altogether, 27 code combinations emerged. The second step was to single out infrequent ideas, those with a frequency of 1 or 2 (that is, a unique combination of feature codes that appeared only once, or a combination that occurred twice). We then calculated the proportion of these infrequent ideas out of all ideas the teams in each team category generated. For example, the combination of codes “B1A4L1” that designated a combination of separate base, no arm and separate lampshade, was generated in an idea by a mixed team and occurred only once within the sample of all ideas.

To illustrate the teams’ output, Figure 1 shows examples of sketch ideas by teams of the three composition categories.
4 Results

General note: All scores were averaged per idea (where applicable), per team, and across each team category.

4.1 Originality

A one-way ANOVA showed a significant difference between the three team categories (F=2.649, \( p=0.076 \)) in originality scores. A post-hoc Tukey analysis demonstrated the main difference was between mixed teams (M=3.78, SD=0.90) with significantly higher scores than non-designers (M=3.10, SD=1.08, \( p=0.03 \)). However, the ranking differences between designers (M=3.40, SD=1.16, \( p=0.32 \)) and non-designers (M=3.10, SD=1.08) were not statistically significant. The ranking differences between mixed teams (M=3.78, SD=0.90) and designers was not significant at the level of \( p<0.05 \) (M=3.40, SD=1.16, \( p=0.1 \)), but is likely to become significant given a larger sample.

4.2 Usefulness

A one-way analysis of variance (ANOVA) examining the effect of team composition on usefulness yielded no significant differences (F=0.65, \( p=0.522 \)) among the three team categories (mixed teams: M=4.42, SD=0.91; designers: M=4.21, SD=0.97; non-designers: M=4.14, SD=1.20).

4.3 Compliance with brief requirements

The scores for compliance with the requirements of the brief were calculated twice: before and after the transformation from a 1-3 scale to a 1-7 scale (see section 3.5 above).

Scores before the transformation. A one-way ANOVA showed a significant difference between the three team categories (F=3.191, \( p=0.046<0.05 \)) in compliance with brief requirements scores. A post-hoc Tukey analysis demonstrated that the ranking of mixed teams (M=2.83, SD=0.30) was significantly higher than that of non-designers (M=2.53, SD=0.60, \( p=0.013<0.05 \)). The ranking differences between designers (M=2.74, SD=0.38, \( p=0.061<0.1 \)) and non-designers (M=2.53, SD=0.60) were statistically significant. But the ranking differences between mixed teams (M=2.83, SD=0.30) and designers (M=2.74, SD=0.38, \( p=0.352>0.1 \)) were not statistically significant.

Scores after the transformation. A one-way ANOVA showed a significant difference exists between non-designers and mixed teams in compliance with brief requirements scores (\( p=0.013<0.05 \)). A
significant difference exists also between non-designers and designers in compliance with brief requirements scores (p=0.0061). No significant difference exists between mixed teams and designers in compliance with brief requirements’ scores (p=0.352).

4.4 Originality + usefulness
A one-way ANOVA showed a significant difference between the three team categories (F=3.172, p=0.05) in (originality + usefulness) scores. A post-hoc Tukey analysis demonstrated that the ranking of mixed teams (M=4.32, SD=0.63) was significantly higher than that of non-designers (M=3.88, SD=0.68, p=0.022). The ranking differences between mixed teams (M=4.32, SD=0.63) and designers (M=4.05, SD=0.65, p=0.063) were statistically significant. But the ranking differences between designers (M=4.05, SD=0.65, p=0.347) and non-designers (M=3.88, SD=0.68) were not statistically significant.

4.5 Overall Creativity (Originality + usefulness + compliance with brief requirements)
Overall creativity is calculated by the sum of originality, usefulness and the transformed compliance with the brief requirements scores. A one-way ANOVA showed a significant difference between the different team categories (F= 5.063, p=0.008) in overall creativity scores. A post-hoc Tukey analysis demonstrated that the ranking of mixed teams (M=5.11, SD=0.49) was significantly higher than non-designers (M=4.55, SD=0.85, p=0.002) in the overall creativity scores. The ranking differences between mixed teams (M=5.11, SD=0.49) and designers (M=4.85, SD=0.58, p=0.064) were statistically significant. And the ranking differences between designers (M=4.85, SD=0.58) and non-designers (M=4.55, SD=0.85, p=0.08) were not significant, suggesting that this difference will become significant in a larger sample. These results are illustrated in Figure 1.

4.6 Judges’ independent assessment and participants’ self-scores
Judges’ independent scores: A one-way ANOVA examining the effect of team composition on judges’ independent assessment yielded a significant difference (F=11.393, p=0.01) among the three different team categories. A post-hoc Tukey analysis demonstrated that the ranking of mixed teams (M=4.39, SD=0.53) is significantly higher than non-designers (M=2.67, SD=0.67, p=0.00) in the judges’ independent scores. The ranking differences between designers (M=4.17, SD=0.81) and non-designers (M=2.67, SD=0.67, p=0.00) are statistically significant. But the ranking differences between mixed teams (M=4.39, SD=0.53) and designers (M=4.17, SD=0.81, p=0.58) are not statistically significant.
Participants’ self-scores: Four teams did not assess themselves and we eliminated them from the calculation. By using the formula recommended in IBM SPSS Statistics, these scores were also transformed to represent values between 1 and 7. A one-way ANOVA examining the effect of team composition on participants’ self-scoring yielded no significant differences (F=1.094, p=0.37) among the three team categories (mixed teams: M=5.93, SD=0.37; designers: M=5.50, SD=0.82; non-designers: M=6.50, SD=0.77). Figure 2 demonstrates these results.
4.7 Fluency and rareness

Fluency: The results of fluency calculations showed that designer teams generated the highest number of ideas (N=47), followed by mixed teams (N=35), which generated more ideas than non-designers (N=17). A one-way ANOVA examining the effect of multidisciplinary knowledge on fluency, yielded a significant difference (F=5.907, p=0.013) among the three different team categories. A post-hoc Tukey analysis demonstrated that the ranking of designers (M=7.83, SD=3.17) is significantly higher than non-designers (M=2.83, SD=1.47, p=0.01<0.05). But the ranking difference of fluency for mixed teams (M=5.83, SD=1.83) and non-designers (M=2.83, SD=1.47, p=0.14) is not statistically significant. The ranking difference of fluency for designers (M=7.83, SD=3.17) and mixed teams (M=5.83, SD=1.83, p=0.38) is not statistically significant. See Figure 3.

Rareness: The number of infrequent ideas (feature combinations that occurred only once or twice) by mixed teams (n=9) and designer teams (n=9) was equal and much higher than that of non-designers (n=1), but the percentage of rare ideas of mixed teams (R=25.7%) was higher than that of designers (R=19.1%) and non-designers (R=5.9%), as presented in Table 1 and Figure 4.

Table 1. Effect of team category on rareness

<table>
<thead>
<tr>
<th>Team category</th>
<th>Infrequent ideas</th>
<th>Total no. of ideas</th>
<th>Rareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed teams</td>
<td>9</td>
<td>35</td>
<td>25.7%</td>
</tr>
<tr>
<td>Designers</td>
<td>9</td>
<td>47</td>
<td>19.1%</td>
</tr>
<tr>
<td>Non-designers</td>
<td>1</td>
<td>17</td>
<td>5.9%</td>
</tr>
</tbody>
</table>
Figure 3. Effect of team category on fluency

Figure 4. Effect of team category on rareness

5 Discussion

This study explored the effect of different team (dyad) categories comprising designers, non-designers, and mixed teams, on creativity in design idea generation. Our results point to an overall trend whereby mixed teams reached higher scores on various creativity measures than did designers and non-designer teams, followed by designer teams, who reached higher scores than non-designers. In many of the cases the differences were significant or almost significant. These findings provide evidence that in design, where it has hitherto not been researched thoroughly, disciplinary diversity in teams can enhance creativity, similar to what many researchers found in other domains. The design activity in our experiment was very short, 17 minutes in all, which is nonetheless enough for a brainstorming-like idea generation session. Research teaches us that idea generation is a key component of the front edge of the process of design, which determines to a large degree the level of innovation that design is able to bring about (e.g., Design Council [UK], 2013; Toubia, 2006). Innovation, in turn, is fueled by creativity (Somech & Drach-Zahavy, 2013). For economic reasons innovation is much sought in today’s business world, and therefore team composition is an important issue that design research should undertake more rigorously. We calculated creativity in a number of ways. Following Finke (1990) and others we looked at creativity as a compilation of originality and usefulness. We then added compliance with requirements to the overall creativity score because compliance with requirements is a constant issue in real-life assessments of creativity. For example, the Sydney Opera building that was built at a scandalous budget that largely surpassed the estimates; the building breached other requirements as well and posed severe construction hurdles. Consequently, the architect was fired and became a persona non grata in Australia. However, the unusual form of the building became much liked for its originality by locals and tourists and the architect was later invited back to Sydney as a guest of honor, hailed for this creative tour de force. Our position was that historic anecdote apart, requirements must be complied with, especially when evaluations are submitted to comparison. In the case of the table lamp our participants designed, the brief stated clearly which materials could be used but some participants ignored the directions and used other materials, or they designed a ceiling lamp instead of a table lamp, and so on. We did not disqualify them, but their scores reflected poor compliance with requirements. It is interesting to note that non-designers conformed somewhat less to the requirements than did the other groups, and at the same time they boasted much higher creativity self-scores than the other participants. This may
indicate a low awareness of design norms: on the one hand that constraints should be respected, and on the other hand that not every idea that one manages to produce is likely to be considered creative. Despite that, mixed teams of which non-designers were equal members, scored the highest on every dimension of creativity we tested (with the exception of creativity self-scores). This seems to show that the dynamics within the mixed teams was such that the designers “enforced” some respect for the requirements, while being more moderate in their self-evaluation of creativity, probably because of their better acquaintance with the creative design landscape. All the same, the non-designers seemed to bring to the table unusual ideas that, coupled with the assumed superior representational (and other) skills of their designer partners on the team, yielded more original and more useful ideas. The usefulness scores of the non-designers were very close to those of the designers, which could indicate that designers thought that in a conceptual exercise like this usefulness is less important and would be dealt with later in the design process if it were to develop further, while non-designers, who understood perfectly what the table lamp was meant to do, paid much attention to the function.

It is interesting to look at the creativity scores assigned by the participants themselves, and by the judges’ independent assessments. These scores were not a compilation of originality and usefulness but were “gut feeling” assessments of the teams’ creativity (not of individual ideas), without any elaborations on what creativity consists of. The judges’ independent scores were very close to the calculated scores for mixed teams and designers, but considerably lower for non-designers, while they were only slightly lower in all calculated scores. This finding is difficult to interpret and since for designers and mixed teams the scores are in line with calculated scores, it probably does not point to a different conception of creativity held by the judges compared to the concept that calls for a composite score relating to originality and usefulness. One possible explanation is the judges’ taste for complexity of ideas, which seems to have been higher on average in the mixed and designer teams, while the ideas generated by non-designers tended to be simpler. Arriving at more complex ideas is largely aided by sketching skills (Verstijnen et al., 1998). Sketching proficiency may have also had an (unconscious) effect on judges, who may have preferred representations of higher quality. Since non-designers are presumably less or not at all skilled in sketching, their sketches were perforce often less attractive visually than those by designers, who may well have been the ones responsible for rendering the sketches in the mixed teams. The issue of sketch quality and its impact on assessment is beyond the scope of the current study, but we plan to address it in another study pertaining to the same experiment.

As mentioned earlier, the participants’ self-scores were considerably higher than the scores assigned to them by the judges. By itself this is not surprising, as self-assessments tend to be different and often higher than objective assessments (Haase, Hoff, Hanel, & Innes-Ker, 2018), but whereas the tendency in the case of mixed teams and designers resembled that of the judges’ scores, the unusually high self-assessment of the non-designers is surprising. It is possible that most of them have never tackled a design problem before, and the mere fact that they were able to generate ideas and come up with results may have been a pleasant and maybe surprising achievement, for which they prized themselves in the form of a high creativity score.

Given that mixed teams had the upper hand in all creativity scores (except self-scores), one must answer the question: Why don’t the designers do better, given their developed design knowledge and skills, particularly sketching (see e.g., Goldschmidt, 1991; Verstijnen et al., 1998)? The fluency and rareness results show that designers generate more ideas than the others (see Table 1), but in terms of rare ideas they are inferior to the mixed teams (measured as a proportion of the number of ideas). As it were, the number of ideas is not as important as their uniqueness, and in this respect, designers did not excel, although they did much better than non-designers. These results may well be a consequence of the brevity of the exercise. We know that in idea generation and brainstorming the tendency is to spell out routine ideas first; the more unique ideas appear only after the exhaustion of the former
Another factor that may have impacted this result is the designers’ tendency to center on structuring the problem first (Cross, 2018; Lawson & Dorst, 2009) and to postpone solutions (Goel 1995). It is difficult to adjust this mechanism to very short timespans, and this may explain the designers’ slow arrival at unique ideas – slow enough to prevent them from more meaningful results in terms of idea rareness in this experiment.

In this study the assumed designers’ superior sketching skills have also not played a very important role, presumably because ideas did not go through extensive development processes, which is where sketching is most helpful. The sketching skills of designers along with their other design expertise were enough to outperform non-designers, but not enough to compete with mixed teams, who enjoyed the same designer benefits, along with the added freshness of non-designers’ ideas.

In sum, we can say that this study shows that even in a small and random sample very clear tendencies of superior creativity of mixed teams over other teams in design idea generation are revealed, even though the level of significance is low. We therefore join the camp of those siding with disciplinary diversity in teams, which as we have shown is relevant also in the field of design.

6 Conclusions and limitations

We have ascertained that design is no different than other fields in benefiting from disciplinary diversity in idea-generation. This is important because the current tendency to widen the boundaries of design and include new actors from other field in its ranks when dealing with complex problems, raises doubt and suspicion in many designers’ quarters. This conclusion has consequences for both the workplace and education. Whereas many companies have already learned this lesson and do set up mixed design teams, independent design consultancies still tend to rely almost entirely on designers, not being aware of what they may gain from involving non-designers in their design teams. Likewise design education rarely sets up joint projects for design and other students, and when it does, it tends to fail because the mode of collaboration is not well conceived. The current study does not teach us how to succeed in design education that includes collaborative work with non-design students – this must be worked out separately, but at least it points to the need to proceed in this direction. We must remember, though, that we only tested idea generation, and fuller design cycles are yet to be investigated.

We should point out several limitations of this study. First, the size of the sample is small, leading to results that indicate primary trends but not many that reach standard significance. Second, we used dyads. The results may differ in the case of larger teams. Third, the exercise was very brief and simple, and tendencies may change when a task is more complex, and the timespan is longer. Fourth, participants were very heterogenous in more than one way. The amount of design experience of designers ranged from one year to dozens of years, and they came from more than one design field. The non-designers also came from a variety of fields. The experiment was held in English, which was not the native tongue of any of the participants but was the only common language they possessed: the non-designers in particular came from a number of different cultures. Despite these limitations we maintain that the study contributes to both the design literature and research on teamwork in general.

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Multi-disciplinary design teamwork: Quality of collaboration and implications for extending the frontiers of design in education

Hernan Casakin\textsuperscript{a} and Gaetano Cascini\textsuperscript{b}
\textsuperscript{a} School of Architecture, Ariel University, Israel, casakin@ariel.ac.il
\textsuperscript{b} Department of Mechanical Engineering, Politecnico di Milano, Milano, Italy, gaetano.cascini@polimi.it

Abstract. Design is a complex activity requiring disciplinary areas working in collaboration. However, how multi-disciplinary design teamwork affects the quality of collaborations from a social and task-related perspective, and how it can inform about extending the frontiers of design should be investigated. An empirical study comparing multi- with mono-disciplinary teams was conducted in the context of project-based education. Participants were students from two master’s courses: one involving different disciplines, and the other mechanical engineering only. A series of semi-structured interviews was carried out, and the produced transcripts were analyzed qualitatively. Multi-disciplinary teamwork was found to enable a comprehensive understanding of the design task. However, this requires skills and competences different than those from mono-disciplinary teams, what challenges team dynamics and collaboration. Implications for extending the frontiers of design in higher education are discussed.

Keywords: higher education in design, mono-disciplinary teamwork, multi-disciplinary teamwork, teamwork quality, teamwork in design education

1 Introduction

The merits of teamwork have captured much attention in social psychology and new product development (NPD) literatures (e.g., Barczak & Wilemon, 2003). The importance of teamwork has also been extensively debated in design (e.g., Badke-Schaub et al., 2007; Casakin et al., 2015). In this domain, team composition regarding disciplinary background has gained a vital significance due to the complex nature of the 21\textsuperscript{st} century’s global challenges (Gruenther et al., 2009). Today, society must tackle problems of unprecedented scope that contest established approaches and solutions. To deal with this situation, a multi-disciplinary collaboration offers a more comprehensive approach than that by teams composed of members sharing a similar background, also known as mono-disciplinary teams.

In this context, trans-passing the traditional borders of scientific disciplines, including those of the design domain, turns out to be a crucial and necessary step. Bearing in mind the increasing complexity of design problems, such transition requires the development of dedicated skills (Blessing et al., 2021). Hence, the attention given to this issue in design education. Among first initiatives in this direction, design studio courses aim at fostering multi-disciplinary project collaborations (De Vere et al., 2010; Dederichs et al., 2011). Courses like these can play a fundamental role for extending the frontiers of design. Nonetheless, there is an apparent lack of appropriate educational reference practices to encourage the development of multi- and trans-disciplinary skills and competences (Cascini, 2015).

Interactions in collaborative approaches can be largely affected by the disciplinary composition of the
team, with consequences for teamwork quality. This notion was investigated focusing on social-related and task-related aspects (Hoegl & Germunden, 2001). For example, Keating and co-workers (2013) studied the impact of multi-disciplinary team collaboration on educational outcomes, showing that most influential issues were related to interpersonal relationships, personal expectations, as well as to team dynamics and management. While studies about multi-disciplinary team collaboration can be found in design literature, most of them focus mainly on design performance (e.g., Nesterkin et al., 2016). Moreover, none of them investigated multi-disciplinary collaborations from a teamwork quality view or compared it with mono-disciplinary teams. Hence, no related studies can be found in design or in design education. Therefore, the present study – which is contextualized in higher education in the framework of project-based design studio – deals with the following goals. The first goal is to identify what are the social-related and task-related aspects of multi-disciplinary and mono-disciplinary design teamwork. The second goal is to investigate how teamwork quality from the perspective of social-related and task-related dimensions might differ when comparing multi-disciplinary with mono-disciplinary teams. Based on these, implications about how to extend the frontiers of design education are presented.

The research questions that will be addressed are:

- **RQ1**: What are the comparative social-related and task-related dimensions of multi-disciplinary and mono-disciplinary design teamwork?
- **RQ2**: How does multi-disciplinary compared to mono-disciplinary team composition influence the quality of design teamwork in terms of social-related and task-related dimensions?
- **RQ3**: How can an analysis of teamwork quality inform the debate about extending the frontiers of design in the context of higher education?

The work revealed that although working in multi-disciplinary teams enables a more comprehensive understanding of the design task, it requires capabilities and competences different than those from mono-disciplinary teams, which may challenge the quality of team dynamics and collaboration. Furthermore, working in multi-disciplinary teams can result in partly underexploiting specialist knowledge and competencies. It is proposed that these issues should be taken into consideration by both educators and practitioners, as well by those interested in extending the frontiers of design. Implications for teamwork in design education, and particularly for multi-disciplinary design studio courses are discussed.

## 2 Background

Designing has become a more complex activity than it used to be, and consequently information and knowledge other than from a single discipline are necessary to tackle problems. Design practice must deal increasingly with objects at different scales, from small industrial artifacts to cities, services, and organizations (Leblanc, 2021). Hence, a broader approach of not only the technological but environmental, scientific, social, and economic subjects is also necessary to cope with the new challenges that design poses nowadays (Blessing et al., 2021). Understanding and tackling such a multifaceted phenomenon demand more developed and interrelated knowledge, skills, and expertise. In higher education, the increasing interconnectedness among academic disciplines and the vast knowledge originating from the application of a variety of subjects has transcended specific academic fields (Kozmetsky, 1997). Consequently, the university started to be seen as the educational environment where to nurture ideas that may go beyond the frontiers imposed by the current and rather conservative organization of the fields (Ertas et al., 2003). Such a conception is gaining interest in design courses and is influencing design teachers to go beyond a mono-discipline educational approach, to center on domains that step ahead from traditional learning areas (Gerike et al., 2021).
This is partly due to the rich knowledge needed to deal with current design tasks, even in lab environments such as the design studio. Moreover, solving new and unique design problems demands the involvement of a spectrum of disciplines working in collaboration. However, there is a substantial lack of truly multi-disciplinary design educational programs and in most cases, these are not standard programs but honors ones. As part of an integrative pedagogical approach, teamwork can help rethink how design can be taught through the different disciplines in higher education.

2.1 Multi-disciplinarity, Inter-disciplinarity and Trans-disciplinarity

Three terms are being used in reference to the type of cooperation between different disciplines: multi-disciplinarity, inter-disciplinarity, and trans-disciplinarity. In spite of their differences, they are frequently and mistakenly used interchangeably (Grieke et al., 2021). Tharp and Zalewski (2001) defined multi-disciplinarity as a topic of research shared by many disciplines. Multi-disciplinarity is also related to studying a subject by multiple disciplines simultaneously (Nicolescu, 2005). The aim is to gain a large and common understanding of the phenomena by combining the different standpoints of the disciplines. While multi-disciplinarity extends disciplinary boundaries, it is achieved mainly in the framework and for the benefit of a specific discipline. Inter-disciplinarity, on the other hand, is about transferring methods from one discipline to another. Like multi-disciplinarity, inter-disciplinarity transcends the disciplines but with the goal of creating new disciplines (Nicolescu, 2005). Whereas trans-disciplinarity includes multi- and inter-disciplinarity approaches, its main goal is to understand the disciplines to unify knowledge (Nicolescu, 2005). Indeed, trans-disciplinarity encapsulates the notion of an integrated utilization of the techniques, tools, and methods from various disciplines (Ertas et al., 2003; Kozmetsky, 1997).

The present work is based on an empirical approach that centers on complex design problem-solving in higher education. In this context, we propose that studying design collaboration of students from a multi-disciplinary perspective constitutes a suitable approach to explore the possible extension of design frontiers. As noted before, the intricacy of products has overcome the narrow frontiers of the disciplines, and dealing with design entails the collaboration of specialists from different disciplinary areas (Eckert & Stacey, 2021). When design collaborations are materialized in the framework of a multi-disciplinary team, opportunities for gaining new cross-cultural knowledge and skills emerge (Casakin & Badke-Schaub, 2015; Leblanc, 2021). Teams of this kind are supposed to have the specialized knowledge necessary for centering on specific aspects, jointly with a holistic understanding on the topic (Fernandez-Orviz, 2021). A capability for sharing different views at different levels of detail can lead to the development of inspirational ideas. Not less important, multi-disciplinary teams can contribute to more meaningful, feasible and creative outcomes, and eventually to expand existing frontiers of the design domain.

2.2 Multi-disciplinary and mono-disciplinary teams and design

The advantages of multi-disciplinary teams over traditional mono-disciplinary ones have been studied in several fields with a focus set on team outcomes. A frequent approach in comparing the performance of these types of teams is to analyze quantitatively the produced outcomes by means of bibliometric indexes (e.g., Schummer, 2004; Levitt & Thelwall, 2008). Healthcare domain is a good example of this, where not few research on multi-disciplinary teams was carried out based on surveys and interviews. While related studies discussed a rich range of health issues that were efficiently tackled by multi-disciplinary teams, they also exposed several conflicts spanning from misalignments of team roles to problems in social dynamics (Jones, 2006). A main finding was the need to educate professionals capable of working in teams with members of diverse specializations (Dyer, 2003). Studies on multi-disciplinarity can be also found in design literature, and in project-based design
education. A few examples are works focusing on ICT technologies (e.g., Nelson & Ahn, 2018), and on virtual environments supporting team collaboration (e.g., Mengoni et al., 2009). Nonetheless, comparative design studies dealing with the dynamics of multi-disciplinary versus mono-disciplinary teams has yet to be carried out.

The diversity that characterizes multi-disciplinary teamwork, however, can be counterproductive to the possibility of successful collaborations. Many of the involved disciplines may not have worked in cooperation yet to solve a design problem. Along the years they have constructed their own knowledge, terminology, approaches, culture, preferences, and priorities (Eisenhart et al., 2012). Specialization in a domain enables to develop design expertise for the sake of improving task performance, while enhancing the quality of the produced outcomes. Nevertheless, it can also narrow the perspective on the broad picture (e.g., restrict the capacity of designers in a certain field to recognize the value of issues from other disciplines that are alien to them) (Rees, 2010). In this regard, transcending the frontiers of mono-disciplinary approaches is challenging, and demands understanding commonalities and differences with other disciplines (Gericke et al., 2021). In the context of our study, the notion of extending the frontiers of design is understood as the sharedness of existing knowledge, tools, methods, and experiences by a certain discipline that are unknown to other disciplines, with the goal of contributing to a common understanding of the design situation while gaining new knowledge. To this aim, successful design collaboration plays a critical role when it concerns complex and multifaceted projects. However, this may be affected by the quality of team collaboration.

2.3 Teamwork quality and design

The concept of teamwork quality, introduced by Hoegl and Gemunden (2001), assumes a critical role to study multi-disciplinary collaborative design and its influential factors. Teamwork quality is a thorough notion about the excellence of team interactions (Dayan & Di Benedetto, 2009). It is a critical aspect of team collaboration that was studied by focusing on social interaction factors – e.g., cohesion and mutual support, and task-related factors – e.g., communication and coordination (Hoegl & Gemuenden, 2001). These researchers found the two teamwork quality factors to be strongly related to team performance.

In another study, Dayan and Di Benedetto (2009) showed that the quality of interactions among team members is a fundamental skill needed to create good and innovative products. However, they showed that teamwork quality can be reduced due to difficulties in getting members to communicate successfully and work jointly. Teamwork quality was also found to affect educational outcomes and the success of collaborative learning (Curșeu & Pluut, 2013). The quality of social interactions at a team level showed to impact on knowledge creation, and eventually on team performance (Hong & Suh, 2017). Additional studies in the fields of R&D management and cognitive psychology highlighted the influence of task-related factors on teamwork quality. Kratzer et al. (2006) showed that low complexity tasks have a negative impact on the creative performance of R&D teams. In spite of the variety of works on teamwork quality, a primary focus tends to be set on its impact on team performance (Nesterkin et al., 2016). Some of these focus on the impact of training styles of multi-disciplinary teams on design performance (Reich et al., 2009), or on reflections about learning outcomes from cooperative project-based approaches in engineering education (Abdulaal et al., 2011).

A milestone is the work of Cooke et al. (2003), who investigated task-relatedness to teamwork knowledge, but still with a major attention on team performance. Relatively few works can be found on collaborative design dealing with social aspects and teamwork quality, and no studies on multi-disciplinary design investigated teamwork quality based on social-related and task-related factors simultaneously. Therefore, in this work we investigate how multi-
disciplinary compared to mono-disciplinary design teamwork affects the quality of collaborations in an educational environment, from a social and task-related perspective. Given the potential effect of teamwork quality on knowledge creation, we propose that studying the quality of team collaboration can inform about extending the frontiers of design.

3 Methodology

3.1 Design courses

To address the research questions, a study was conducted in the context of two programs: i) A master’s degree with students from architecture, industrial design and all branches of engineering disciplines. This took place in the 2019 edition of the “Design Methods and Processes” course of Alta Scuola Politecnica – ASP (Benedetto et al., 2010; Ajmone et al., 2016), a program jointly fostered by the Politecnico di Milano and the Politecnico di Torino; and ii) A master’s degree in the Mechanical Engineering study program at Politecnico di Milano, which included students who were enrolled in the “Inventive Design and Problem Solving” course.

The ASP is an honors program that comprises several courses organized as residential full-time weekly schools and a design project lasting one year on real-world problems (https://www.asp-poli.it/home/our-projects/). On the other hand, the Mechanical Engineering course aims at delivering theoretical competences and practical skills on methods and tools supporting technical creativity in conceptual design activities. It involved an annual project proposed by an entrepreneur from a company. Examples of project themes are household appliances (e.g., washing machine, dish washer) for single users, and an integrated system intended for the regulation of tire pressure.

The ASP project – representing the multi-disciplinary team activity – was used as a test group, whereas the Mechanical Engineering project – representing the mono-disciplinary – was used as a control group, i.e., as a benchmark to identify differences and similarities of teamwork quality in the context of design.

The comparison between the two case studies is considered relatively unbiased since one of the authors was the coordinator of both courses and provided similar directions and tutorship in both projects. It is believed that through a retrospective analysis of the team activity that took place in the ASP and Mechanical Engineering courses, participants can offer important insights that transcend the courses themselves and be of value to identify key aspects in the design educational context, with possible implications for extending the design borders.

3.2 Participants

Students were requested to opt-out if they were not interested in participating in the study. Eight out of 140 ASP students representing different disciplinary backgrounds and course grades, and another five out of 50 Mechanical Engineering students accepted the invitation to take part in the study.

3.3 Research approach

The research method is based on semi-structured interviews (e.g., Kallio et al., 2016). The use of semi-structured interviews showed to be successful in several studies that analyzed the dynamics of teamwork (e.g., Sandoff & Nilsson, 2016). In the present work, they were characterized by a dialogue partially based on a predefined protocol, which was adapted to the ad-hoc circumstances as demanded by the interactions with the participants. The structure of the interview sessions was partly based on teamwork quality (task and social-related aspects). Interviews also included other topics that are beyond the scope of this research. To avoid potential biases, they were carried out after the evaluation
process – when all students were assigned the grades for the two courses. Both authors coordinated the interview sessions and complemented each other by proposing topics for discussion. These were carried out in English, as both courses were delivered in this language.

3.4 Data collection and preparation

Due to the COVID-19 outbreak, interview sessions were held via internet using Microsoft Teams software and lasted for about 60 minutes. The meetings were videorecorded under the explicit consent of the participants. Then, the anonymized recordings were transcribed and segmented, each segment representing an exchange in the conversation between the interviewers and the interviewee. Video recordings were transcribed using an external transcription service. Thereafter, transcriptions underwent quality check to ensure that the verbalizations were properly captured. Transcript segments were also assigned a timestamp as a reference in the data collection. The final data set contained all utterances produced by the participants in the 13 sessions, which were classified according to participant and team type.

4 Findings

Firstly, the social-related and task-related dimensions are identified. Secondly, an analysis is carried out on the themes and topics related to the social-related dimension, and then on the task-related dimensions of teamwork quality. Illustrative short excerpts identified from the interviews are included to provide empirical evidence of the findings.

b Identification of social-related and task-related dimensions

To deal with RQ1, a qualitative analysis of the segmented transcripts followed a 3-step process:

- The authors carried out an independent analysis of the transcripts to identify and retrieve relevant topics addressed in the interviews, regardless of the disciplinary team composition.
- By consensus, they selected the topics they considered relevant to deal with the research goals and clustered them according to general themes. Thereafter, they classified the themes and related topics according to two main reference dimensions: i) teamwork quality, represented by social-related versus task-related issues; and ii) disciplinary team composition, represented by mono-disciplinary versus multi-disciplinary team background.
- Finally, authors revisited the transcripts to check the consistency between the identified topics and themes, and to select illustrative excerpts for each theme.

Figure 1 shows the themes and related topics identified in the second step, which are organized according to the two above-mentioned comparative dimensions. The social-related dimensions that are common to the two types of teams are characterized by four main themes that included: mutual trust, leadership, and project management and design process management. On the other hand, the task-related dimensions are classified into simplification of ideas, design novelty, robustness of solution, and common goals.

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6 MLT: quotations from ASP students; ME: quotations from Mechanical Engineering students.
To address RQ2, the following two sub-sections present the main findings of the 3-step process described above. Accordingly, the identified themes are analyzed into social-related and task-related dimensions and compared according to multi- and mono-disciplinary team composition.

4.2 Analysis of social-related dimensions

Teamwork quality is used as an overarching concept referring to the quality of team collaborations including social-related facets. In this sense, a team can be defined as a social system in which members collaborate on a common task. To capture the social nature of design team members working together, in this section we elaborate on the social-related themes identified in the study as follows.

4.2.1 Team interaction. A recent review (Nguyen & Mougénot, 2020) on team interaction in multi-disciplinary collaboration in the industrial sector summarizes the way that team composition affects the design process. The study mentions several key aspects deserving consideration such as: strengthening trust among team members, and dealing with team cohesion and communication barriers, caused not only due to language and jargon differences. In this regard, students from multi-disciplinary teams, even without being explicitly prompted on these issues during the interview, highlighted communication difficulties met in the team collaboration activities that led to the emergence of communication barriers and a reduced cohesion.

While no students highlighted criticalities due to limited trust, possibly because of the variety of team building opportunities offered by the ASP school, they commented about a lower efficiency in sharing knowledge. On the contrary, participants in mono-disciplinary teams explicitly manifested the ease of interaction with their teammates. Some of them also stressed the importance of being specialists in the industry related to the design task.

It is interesting to note that students in multi-disciplinary teams did not show the same confidence in their discipline field. Those who hold unique and critical competences critical for the success of the project, supported huge pressure. This was due to their role and responsibilities, and the impossibility to discuss in detail important decisions with others. Participants also mentioned the high engagement in team interaction, such as:

- MLT “the main difficulty is in the communication, because if you have different backgrounds you put different values on […]. Also small things could lead to infinite discussions […] slow down all the process and […] lose track of important things […].”
- MLT “you can speak about two different levels of knowledge: one that is very technical, that I can only share with the disciplines that are related to my own. And there is another one that I [must] trust”.
- ME “having the same [background] of mechanical engineers, we were able to evaluate the capacity of each other in a more precise way”.
- ME “One aspect of bringing out good design is to […] have good knowledge about the state of the art […]”.
- MLT “communication with the other members […] is important; I need a person [with whom I] could share opinions deeper on the theme. […] if you find a person that knows what you are doing and how you work […]”.

7 MLT “the main difficulty is in the communication, because if you have different backgrounds you put different values on […]. Also small things could lead to infinite discussions […] slow down all the process and […] lose track of important things […].”
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9 ME “having the same [background] of mechanical engineers, we were able to evaluate the capacity of each other in a more precise way”.
10 ME “One aspect of bringing out good design is to […] have good knowledge about the state of the art […]”.
11 MLT “communication with the other members […] is important; I need a person [with whom I] could share opinions deeper on the theme. […] if you find a person that knows what you are doing and how you work […]”.
they felt from the novelty of the viewpoints and competencies brought by their teammates.

4.2.2 Mutual trust. What concerns multi-disciplinary teams, when the knowledge needed to deal with the task was too specific to be understood by all disciplines, members of certain disciplines had no choice but to trust the expertise from other disciplines. However, trusting mates while dealing with a part of the design contributed not only to generate a better atmosphere and to enhance team cohesion, but also to learn from others, gain a broader picture about the design situation, and understand how to move on in the process. In the mono-disciplinary teams, trusting other members was easy and advantageous but for other reasons. The common knowledge of the engineers enabled them to understand design situations quickly even when the information shared by others was not completely apparent. This enhanced their confidence in the team, reduced work pressure, and created opportunities to collaborate and help each other. Eventually, trusting others played a role in improving the quality of the final solution.

4.2.3 Leadership. The influence of leadership on team interactions has been widely studied in literature, both at the individual, and group levels. At the individual level, leadership was connected to several positive aspects that include performance, work engagement, and creativity (Grandey et al., 2005), and work satisfaction (Giallonardo et al., 2010). In the context of the multi-disciplinary teams, leadership at the individual level was related to the personality of the team member. The leader was not seen as an individual with a strong personality who fights to inflict power to dominate the others. Rather, she was considered an open minded individual, cognitively flexible, and able to solve conflicts that emerged during the task.

At a team level, leadership was also found to enhance reflective discussions about the level of agreement among members, values, strengths, weaknesses, and progress to achieve shared goals (Yammarino et al., 2008). When members perceive the legitimacy of team’s leadership and seek to comply with team rules and decisions, they would remain more attached to and supportive of the team (Naumann & Bennett, 2000). In this work, students with an engineering background emerged as group leaders of the multi-disciplinary teams. Due to the nature of the addressed design tasks, they were those who coordinated the team actions to deal with the problem. The leader was considered to have special managerial capabilities to organize and coordinate actions among the sub-teams, which we can work faster and explain better the work to others”, ME “If there were at least two people from the same background […] there could be some conversation between teammates […]”.

MLT “I’m an expert in fluids. But for what concerns the yearly project, I didn’t see any fluid. So actually, in my field of study doesn’t really show up. But at the same time, I’m really satisfied because I really put a lot of effort and also because I learnt a lot [from others]”.

MLT “for example, the algorithm […] I can understand how it works. But if you say that it’s better to use five instead of ten, I trust you. Otherwise, I have to have another degree in computer science”.

MLT “I worked really well in my team because we shared knowledge and trusted each other […] and this was useful to me because I also learned something new […] and it helped to] be aware about the pros and cons of the solutions and then together we could decide how to proceed”.

ME “Even if it was 60 to 70 percent clear, we still understood what he meant because of our engineering background”.

ME “The engineering background allows you to understand more deeply what others were saying and you didn’t have to trust”.

ME “it [trust] helped a lot because if one is forgetting about one small detail, let's say about designing something, the other [engineers] can intervene and help him […] so that the [work] pressure will not be really high on that member”.

ME “[due to] the mutual support and collaboration with my teammates, we polished this idea that was really rough into the final design”.

MLT “It's not a matter of being the one who will control everything […] or tries to impose its own ideas [to others]”.

MLT “The team leader is a person that is more open to the opinion of all of us”.

MLT “people who are related to the more like technical school, they're trying to be leaders”.
were formed based on disciplinary background\textsuperscript{22}. The leader was also responsible for the cohesion of the team and for enhancing communication and understanding between the disciplines\textsuperscript{23}. In the mono-disciplinary teams, there was no natural leader. Partly due to their similar background, there was an efficient interaction between members, and a balanced responsibility for dealing with the project\textsuperscript{24}. When leadership emerged, it was mainly to mediate conflicts and help to take decisions by considering the opinion of the majority\textsuperscript{25}.

\textbf{4.2.4 Project management and design process management.} The need to develop designers multi-disciplinary team working capability has been discussed for more than 20 years. Project-based learning has been proposed as a reference educational practice to develop such soft skills since (Denton, 1997). Considerable attention was dedicated to influential factors such as the composition of the design teams, the nature and complexity of the task, and the assessment criteria. In this regard, past editions of the ASP school on “Design methods and processes” were analyzed to recognize the educational impact of this practice (Cascini et al., 2017). However, such studies did not compare the reflections made by participants of multi- and mono-disciplinary teams.

In this work, participants from the multi-disciplinary teams often referred to team collaboration and the design process to describe how they managed the task distribution, the interaction between teammates, and the fulfillment of the deadlines. Compared to their colleagues from mono-disciplinary teams, they showed a larger understanding about the importance of applying systematic methods not only for project management, but also for guiding the design process\textsuperscript{26}. As recognized since early studies in the field, team-working capabilities cannot be developed from a one-off exercise (Denton, 1997). Relying on past experiences rather than on available specific methods was characteristic in mono-disciplinary teams\textsuperscript{27}. Moreover, it turned out that for multi-disciplinary teams struggling with team management issues came at the cost of less time and effort dedicated to the task itself\textsuperscript{28}. In contrast, much of the focus of mono-disciplinary team members was set on the task and its related details, but at the expense of overlooking the design process and team management aspects. Besides, this sometimes turned out in useless iterations in the team, with a consequent waste of time\textsuperscript{29}.

\textbf{4.3 Analysis of task-related dimensions}

A main concern about the quality of a team’s collaborative work is how well its members share and process task-relevant information. To gain insight into the task-related interactions of design team members working together, in this section we elaborate on the themes into which design issues

\textsuperscript{22} MLT “There was usually the team leader that was going around and seeing what the subgroups were doing and trying to give coherent indications too”.

\textsuperscript{23} MLT “the leader […] was able to keep all the elements of the group together. So the communication worked […] well”.

\textsuperscript{24} ME “Communication was crystal clear, although we had no leader as such, we all took equal responsibility for the tasks.”.

\textsuperscript{25} ME “the sort of leader […] managed conflicting situations […] democratically”.

\textsuperscript{26} MLT “It was strongly requested to have a common view on the management and the organization between the team members, especially between very different disciplines. A main point to organize communication was to create a channel dedicated to a single topic that all of us can set in. […] team building is prior to anything else. Even, prior to the understanding of the problem, because you need to know each other to understand the problem”.

\textsuperscript{27} ME “I did projects during my bachelor, my teammates […] already did projects in teams. So all of us already know how we should structure our work in order to be proficient.”.

\textsuperscript{28} MLT “There is a critical number of people over which you don't have really effective coordination and collaboration”.

\textsuperscript{29} ME “If we had someone from product design, our product would have been better because those people know some nuances we don't. […] We spent some time on it [ a solution] and we didn't like it. We had some ideas about some things we would like to change, but we didn't know whether it is possible”.

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identified in the interviews were categorized. These include simplification of ideas, design novelty, robustness of solution, and common goals.

4.3.1 Simplification of ideas. Further insights that emerged in the interviews focused on the simplification of ideas generated in multi-disciplinary teams. Successfully transmitting design ideas in a common space may require some level of simplification (Craig & Zimring, 2000). Some interviewees reflected on the difficulties of interacting with colleagues with different backgrounds. They concluded that to enhance common understanding and communicate with others, specialistic disciplinary knowledge had to be simplified. To convince and increase the chances to get their ideas approved by other teammates, it turned out that simpler ideas were more effective and likely to prevail compared to other ones. Such a tendency towards simplification of ideas suggests that as far as specialistic knowledge is not requested by the task at hand, multi-disciplinary teams are more likely to avoid complex solutions, and instead they naturally prefer simpler and possibly more elegant alternatives. We found no indication of this behavior in the mono-disciplinary teams.

4.3.2 Design novelty. Design is as a best example of creative activity that mainly takes place in the conceptual phase and is characterized by the generation of ideas and solutions (Pahl & Beitz, 1996). In this process, designers jointly work with the aim of developing not only functional but novel outcomes. Novelty can be defined as “a new or unfamiliar thing or experience” or as “an object intended to be amusing because of its unusual design” (Oxford Dictionary, 2021). Some metrics have been proposed to evaluate the degree of novelty of a design process either in terms of “uncommonness”, or regarding the degree of change from a known solution (Fiorineschi et al., 2020). The creation of novel outcomes in teams with different design backgrounds is a relatively underexplored issue.

In our work, it was found that the various backgrounds of the multi-disciplinary team contributed to think about the design situation anew. Members invested effort in reframing the problem and redefining the design task. The variety of views of the disciplines helped enhance the novelty of the final solution. Interacting with other domains aided students to open their minds and to reason about the task in less familiar ways. Such interactions led to the production of unexpected solutions. Novelty was also the outcome of a balance between designers – who tried to push the borders of the familiar by envisioning unique ideas – and engineers – who thought about how to materialize these ideas in practice. In some cases, the novelty of the solution did not reside in producing revolutionary outcomes, but in considering existing solutions from different disciplines and combining them in a

30 MLT “my teammates try to explain me in a simple way […] the problems and something like this. And it works in both directions. So, for example, if there were problems related to the biomedical field, I tried to explain in a simpler way so they can be managed in a general way, not more in the medical field”.

31 MLT “it was a little bit difficult […] to introduce a debated discussion […] it was difficult to obtain the opinion of some engineers, let’s say, because they tend to limit their work on computational things or stuff, but they tend not to explain their position”.

32 MLT “we use [considered] a novel topic to address a not so novel solution because the solution already exists. [But] not as defined as one would expect […] and having [a team with] multiple backgrounds […] and different experiences helped a lot”.

33 MLT “you can apply knowledge and concepts that come from different fields. This generates something that is completely different and disruptive”.

34 MLT “the other disciplines take us to reason in a different way. So we were less focused on the daily path”;
MLT “an idea from a completely different background expands your way of seeing things […] and this] enhances your creativity […] you come up with some solution that is not just an addition between your knowledge and the others knowledge, but […] makes something more because it stimulates to think in a different way”.

35 MLT “it’s part of the multi-disciplinary nature of the task […] because they thought about some solutions that I could not have imagined [before]”.

36 MLT “we are dreamers [the designers] and we are always trying to create something like extraordinary, super unique. And sometimes it runs out of our budget or the reality so that […] the engineers are always trying to […] to balance those things”.

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single solution. In the mono-disciplinary team, the produced solutions were considered more valuable than novel. Rather than thinking in revolutionary ideas, the mechanism that contributed to searching for novelty consisted in adapting knowledge from existing products to the problem at hand. Although not completely novel, within-domain displays served as sources of inspiration to deal with the task. Potentially novel ideas were discarded since there was no member with the required skills to develop it. Hence, the chances of developing a novel outcome depended more on individual than on collective creativity.

4.3.3 Robustness of solution. Students from mono-disciplinary teams mentioned an ease in the interactions with their teammates, and the possibility to analyze and share with others details of the design task with an adequate level of common understanding (See section 4.1.1). However, they manifested difficulties about how to anticipate possible drawbacks when discussing new solutions. Moreover, to ensure the viability of their concepts, students expressed their wish to revisit their solutions with the aid of colleagues from different disciplines, even at the expense of unexpected variations of the operating conditions of their designs. This situation reflects the limited robustness of ideas generated by mono-disciplinary teams, meant as a reduced ability to fulfil the requirements under unexpected conditions. Issues like these were already noted by others, who recommended engaging multi-disciplinary teams in the evaluation of the robustness of product concepts (e.g., Goez et al., 2019).

Students from multi-disciplinary teams showed to be aware about the boundaries in disciplinary competences. However, they recognized the advantages of combining complementary points of view and knowledge resources from the disciplines to prevent drawbacks and limitations of their designs because of unknown aspects of the task.

4.3.4 Common goals. Design problems are ambiguous and can be defined by no clear initial conditions and no completely specified goals (Simon, 1996). Hence, while dealing with the design task members must define the goals to be accomplished at the different stages of the design process (Coyne, 2005). Establishing and sharing common goals requires a large range of interdependencies of individual information among the team members (Casakin & Badke-Schaub, 2017; Badke-Schaub et al., 2007). Defining common goals is critical to successfully tackle the related sub-problems and arrive at a well-integrated solution. The disciplinary background is supposed to

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37 MLT “the solution is quite innovative […] we integrated in a device a lot of things that came from other devices and that were not in a unique device.”.
38 ME “although we put in a lot of effort, which they [the company] appreciated a lot, the idea in itself was not so novel”; ME “the idea was not so novel […]but in terms of value it was a step in the right way for the project…”.
39 ME “we took a concept that is normally used in the automotive industry, and we completely changed [adapted] it to the context [of the task], something that it has never been done before in […] this context”.
40 ME “we took inspiration from the lipstick, how it works when you rotate, and it comes from a rotation that transforms into an actual axial motion […] but I would say it [the solution] was not novel in general”.
41 ME “if we had someone from the aerospace field, we feel he could have taken up the task and he could have made [developed] it into a creative idea, which might have been a good idea if it was economical for the company”.
42 ME “not everybody had innovative solutions, but it was all about […] if there was an innovative person”.
43 ME “So if we were not expert in materials, we searched them on the net. But obviously it's different with respect to having a certain background there where people made courses on this”.
44 ME “to solve a certain problem, we made a solution for which all the weight was on the user […] being mechanical engineers, we dedicated much time to problems that… [led to] a quite instantaneous solution”.
45 MLT “not about the knowledge, because, of course, we cannot be engineers in six days, but in terms of approach”.
46 MLT “their [teammates] point [of view] having elements with a completely different background helped a lot in trying to force us to view the thing from a different perspective”.
play a role in the way that designers approach problems and establish such goals. This situation seems to be more radical in teams where designers differ in knowledge, skills, and experience.

Differences in interests in the multi-disciplinary team influenced how members perceived the design situation, and how they prioritize the goals and approach the problem. Hence, a challenge for the multi-disciplinary teams was to agree upon shared design goals. In not few occasions they had to consider and negotiate their differences to deal with the goals. When they realized that their initial goals were difficult to achieve, they tried adapting them to meet the know-how of others. In general, team members had shared main goals, but their final solution not always reflected it. A main reason was that teams were subdivided into specialized sub-teams that worked independently of one another while developing a part of the solution. A sub-team organization affected the possibility of clarifying goals and sub-goals with other groups and reaching more integrated solutions. In some cases, the voice of the engineers was louder than others, and they imposed their goals over less influential disciplines such as design or architecture. The consequence was a lack of balance in the contribution of the disciplines to the final solution.

In contrast, members from the mono-disciplinary teams worked guided by task requirements from the outset. Since they were aligned with the kind of design to be developed, there was a common understanding about what the design goals were. Eventually there were few minor conflicts, which were quickly resolved as soon as the idea of what they wanted to achieve became clear. Due to their common background, they communicated easily, shared their knowledge, helped each other, and balanced their contribution to achieve the goals.

As a result of these, the final solution largely reflected the initial goals of the team.

5 Discussion

To deal with the research goals, in the following sections we elaborate on the differences between multi- and mono-disciplinary teamwork, and their importance for extending the frontiers of design in higher education. We refer to collaboration in teams by means of teamwork quality, represented by the task-related and social-related themes identified in this study.

47 MLT “the architects pushed a lot towards the management of the user experience”; MLT “because of the difference in background, as a computer engineer you can develop more easily the final product and is [...] a different approach than a space engineer”.

48 MLT “maintain a sort of dialogue [among the team members] that could work and led to a common goal. This was a main issue because there were very complex arguments [goals] that [...] if not managed in a correct way [...] could be very messy”.

49 MLT “people have different opinions. We have always like to [...] take into consideration all their opinions to make a decision”.

50 MLT “we have the chance to go more in the hardware part or more in the software project. So, we decided to proceed more in the softer partly because of the type of team members we have. We had people from computer science that are very good in doing software and we decided to proceed in this direction instead of the other”.

51 MLT “we had a more specific goal that we shared in common [...] however] [...] we were working more independently [...] and sometimes the solution that other subgroups developed was hard to put together”.

52 MLT “there were two mathematical engineers and three computer science engineers. So, you can imagine that it was really computer oriented [...] and not really focusing on the architectural aspect of the project”.

53 ME “We already knew what exactly we are targeting”.

54 ME “In terms of the goals [...] one part of the group wanted to go with one project and the other wanted to go with another, but at the end we all made the decision to pursue a common goal and just focused on one type of project”; ME “there were frictions [...] but when we started to have a firmer idea of what we were considering, we started again …working in one direction”.

55 ME “we tried to help everyone as much as we can because we knew that we share a common goal, and this would largely affect everybody”.

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5.1 Social-related and task-related dimensions in design teamwork

A first aim was to study what are comparative social- and task-related dimensions of multi-disciplinary and mono-disciplinary design collaboration into which teamwork quality can be categorized. Exploring these dimensions enabled to identify and gain insight about relevant themes regarding design teamwork quality. Hence, the theoretical approach concerned with teamwork quality proposed by Hoegl and Gemuenden (2001) proved to be effective to gain further understanding about design team collaboration in general, and particularly regarding team disciplinary composition. The themes that emerged in common allowed analyzing and comparing key aspects of multi-disciplinary and mono-disciplinary design collaboration in the context of higher education. These are discussed in the next section.

5.2 Effect of team disciplinary composition on design teamwork quality dimensions

Regarding task-related issues, it was found that disciplinary background affected how design goals were established. In line with what several authors observed, (e.g., Leblanc, 2021), multi-disciplinary teams managed to set goals that overcame in scope and complexity those established by the mono-disciplinary teams. A main influential factor was the variety of interests and views of the different disciplines, which in contrast to the mono-disciplinary teams contributed to extending the borders of the known and the familiar. The different backgrounds of the multi-disciplinary teams helped not only to define the design goals from several perspectives, but to rethink the design task. With the insight of the different disciplines, framing the problem played a role in enlarging the understanding and conceptualization of the task (Paton & Dorst, 2011), and ultimately in enhancing the generation of novel and unexpected outcomes (Suwa, et al., 2000). In contrast, the intra-disciplinary knowledge shared by the engineers in the mono-disciplinary teams aided in developing a deep understanding of the design situations and producing more valuable than novel solutions. This is consistent with Leblanc (2021) who noted that disciplinary expertise is useful when it relates to and enhances the understanding of complex phenomena. However, expertise often showed to miss accepting alternative approaches and thinking out-of-the-box.

Regarding social-related issues, keeping a balance between the different views and goals of multi-disciplinary team members required management skills, which demanded large effort and in some cases at the expense of task-related aspects. From this viewpoint, finding the appropriate balance between these conflicting aspects remained an open issue to be addressed. Moreover, working in multi-disciplinary teams required adapting communication to the profile of the team members. An unexpected finding was that simpler ideas, i.e., less grounded on specialist knowledge, were preferred because they were easier to communicate to teammates from different backgrounds. However, this tendency sometimes occurred without making a proper assessment of whether the more complex discarded ideas would have been better to meet the requirements of the task at hand. In this vein, Fox et al. (2017) showed that simplifications in communication may be counterproductive to match the complexities of the task.

Mutual trust was found to be a critical aspect to generate a positive work atmosphere in the multi-disciplinary teams, as highlighted by Maier et al. (2008). Mutual trust was required when the specific knowledge necessary to deal with the task could not be understood by all members, and hence it was shared in the team at a less deep level. Although trusting other disciplines implied renouncing to control every detail in the design process, it enabled to coordinate actions more effectively and learn new knowledge. In turn, the opportunity to learn new knowledge resulted in higher engagement of students in multi-disciplinary teams. A further consequence was the gain of a more comprehensive understanding of complex tasks from the perspectives of the other fields, thus leading to more robust designs, thanks to the anticipation of problems that might emerge.
In the mono-disciplinary teams, mutual trust strengthened team collaboration and performance in the different tasks. These probably enhanced the performance of the final solution but did not contribute to the creation of new knowledge. Maintaining a balance between mutual trust and constructive criticism can contribute to enhance a positive team climate, and foster design thinking (Casakin & Badke-Schaub, 2013).

Those students with an engineering background and high self-confidence emerged as natural leaders of the multi-disciplinary teams. They were seen as flexible-minded individuals open to the ideas of others, with singular managerial skills to coordinate actions among the disciplines. Jacoby-Volk and Bar-Eli (2021) emphasized the importance of encouraging natural leadership as opposed to formal management roles. In our study, while engineering leaders possessed the basic knowledge needed to organize and harmonize the work of various disciplines, they were found to largely interfere with the contribution of students belonging to other less represented disciplines than engineering. Hence, in multi-disciplinary teams, the role of dominant leaders could be counterproductive when the aim is to challenge the design borders to expand the knowledge space.

5.3 Extending the frontiers of design: implications for design education

A main pillar for extending the frontiers of design resides in promoting a more integral education based on a proactive interaction among different disciplines. Multi-disciplinary education can be implemented and encouraged by supporting team collaboration. Whereas design programs interested in extending the frontiers of design should contemplate the possibility of implementing multi-disciplinary team-based projects, they may also benefit from the findings of this study. Critical issues to be considered in a transition from mono-disciplinary to multi-disciplinary design education, specifically in the design studio are how to:

- Clearly communicate and share disciplinary knowledge and methodologies that are alien to others, to enhance cohesion and facilitate a common understanding among team members. These will require adapting own knowledge, terminologies, tools, approaches, and priorities to meet needs of other disciplines (Eisenbart et al., 2012).
- Define common goals while taking care of an appropriate balance of interests among the disciplines. Sharing common goals is fundamental for an efficient team performance, for dealing with the sub-problems, and for developing well-integrated solutions (Badke-Schaub et al., 2007). However, disciplinary background affects the way that students perceive problems and prioritize goals. Hence, how to reach consensus is a main challenge that can be dealt with by negotiating differences with other disciplines. This can be achieved by establishing priorities based on the know-how of the team members and adapting design goals accordingly. Such an approach would enable to not only align design intentions among team members with different backgrounds and interests, but also to reduce chances of producing unsuccessful solutions.
- Reflect and discuss ideas with other disciplines, being clear, flexible, and simple but not simplistic. Explaining, reflecting, and communicating ideas efficiently is a critical precondition for reaching a common understanding among students with different backgrounds, as well as for developing novel solutions. These activities can be implemented by the construction of a shared mental model of the team about the task to be achieved (Mohamed et. Al., 2000). To this end, a key activity should consist in communicating, applying, and adapting pre-existing individual mental models from the different disciplines, for the sake of progressively developing a common language in support of the construction of a shared mental model of the design task and the process.
- Develop mutual trust among the parties, guided by a good leadership. Supporting mutual trust between the disciplines is advisable from the beginning of the process (Casakin & Badke-Schaub,
particularly when the task is too complex to be fully understood by all disciplines. An open-minded team leader can help to not only mediating conflicts and keeping a harmonious and positive team climate, but to enhance confidence and encourage engagement and opportunities for collaboration among the disciplines. Eventually, all these will contribute to gain a broader understanding of the design situation, and to learn how to coordinate actions to move forward.

- Manage and coordinate design actions effectively to produce novel ideas and robust solutions, trying to anticipate problems never experienced before. To overcome the uncertainty of the early stages of innovative design process, it is recommended to integrate competences from multiple disciplines, being open of the complementary input of members with different backgrounds and views (Goez et al., 2019). Distributing tasks in specialist sub-teams and coordinating actions with other sub-teams at different stages of the process can help to efficiently integrate sub-solutions and produce creative outcomes, with a consequent time and effort reduction.

All these issues may play an important role in not only consolidating existing knowledge, but also in creating new one. Eventually, these will contribute to transcend the frontiers of the design disciplines, particularly in higher education.

6 Study limitations

From all possible mono-disciplinary backgrounds, the authors selected mechanical engineering as a control group. Hence, reflections on multi-disciplinary teams were made in contrast to mono-disciplinary teams with a strong engineering background. Compared to other engineering disciplines mechanical engineering students have larger horizontal competences, what may have softened to some extent differences with multi-disciplinary teams. Moreover, the task assigned to the multi-disciplinary teams was not always relevant to all the students to the same extent. The disciplinary background could have biased the way that the interviewees perceived and reflected about their teamwork experience.

Another issue is concerned with the sample, since the multi-disciplinary teams were composed of honors students, who presumably have higher capabilities than the “regular” students from the mechanical engineering course. However, it is believed that the effect of such limitation is moderated by fact that the analysis between the teams focused on the interactions among members, rather than on their outcomes. A further limitation is that students had limited professional experience as designers.

Due to the COVID outbreak, we did not have the possibility to design a setup aimed at exploring how to expand the frontiers of design specifically. Rather, we collected data by means of interviews from students who had participated in courses based on an established multi-disciplinary educational model. Nevertheless, we believe that the insights that emerged from analyzing and comparing these interviews with those from students of mono-disciplinary teams revealed interesting differences that may have helped to identify influential aspects for enriching the design experience. From this standpoint, we hope to have contributed to the central theme of DTRS13.

7 Conclusions

The study aimed at exploring what are the comparative social-related and task-related factors of multi-disciplinary and mono-disciplinary design teamwork. A further aim was to gain a further understanding about the ways that teamwork quality can benefit from social-related and task-related interactions among designers with different disciplinary backgrounds, and what the main challenges are. We also expected to understand how multi-disciplinary teamwork can contribute to extend the frontiers of design. Data collected from 13 semi-structured interviews was analyzed, with a focus on the quality of the interactions developed during the design activity. A comparison between multi-
disciplinary and mono-disciplinary teamwork quality shed light onto the existing dichotomy between the more comprehensive approach of the former, and the narrower but deeper approach of the latter. In addition to nurturing the development of knowledge and design skills, caring for teamwork quality is crucial to improve multi-disciplinary team collaboration. To this aim, universities should implement curricula supporting multi-disciplinary environments where design students could be trained to collaborate with pairs from other domains. However, changing the way design is taught nowadays will demand overcoming existing disciplinary boundaries and preconceptions set in higher education. This work can be seen as an attempt in this direction. Additional studies should be conducted to gain additional understanding about design multi-disciplinarity in both education and practice. Eventually, they will contribute to a further development of a trans-disciplinary and better integrated design science.

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References


What is happening when designers from different disciplines work together: Characterization of the design behaviors and design spaces of mechanical and electrical engineers working in teams

John Gero and Julie Milovanovic
College of Computing and Informatics, University of North Carolina at Charlotte, USA, john@johngero.com; julie.milovanovic@crenau.archi.fr

Abstract. Multidisciplinary teams are key in tackling the complexity of the artifact designed. In this article, we study multidisciplinary teams’ design behaviors by combining protocol analysis, Natural Language Processing and network science. We analyzed three teams composed of professional mechanical and electrical engineers. Teams engaged in designing with similar processes and spend more cognitive effort on evaluating their design when collaborating. Creating a network of the concepts explored based on designers’ disciplines produces their design spaces and illustrates the influence of context knowledge on the design situation. Mechanical engineers tend to tackle user-centered issues while electrical engineers focused more on product related one. But, for most of the concepts covered (e.g., end users, technological aspects) we observed collaboration between disciplines. Using networks to represent design spaces could become a tool to support team design collaboration.

Keywords: Concept network, Design cognition, Design Space, Design team, Multidisciplinary, Protocol analysis

1 Introduction

Design teams are more and more complex as they become more heterogenous, including designers from different backgrounds. Designers in a teamwork toward a shared and common goal (McGrath et al., 2000) to address the design task at hand. Compared to individual designing, co-designing is impacted by team members’ interactions (Détiéenne et al., 2012; Valkenburg & Dorst, 1998), at both the design and social levels. Factors such as leadership and expertise (Cross, 2004; Gero & Kannengiesser, 2004) design background (Gero et al., 2014; Zimring & Craig, 2001) or gender (Laeser et al., 2003; Milovanovic & Gero, 2019) can have an effect on how co-designing unfolds in a team. Working in teams can be challenging as team members need to synchronize their ideas toward a common shared concept (Bierhals et al., 2007; Cash et al., 2020). Engineers from different disciplines hold similar yet different sets of design skills (Visser, 2009), that requires fine-tuning when co-designing. Teams’ homogeneity related to their functional background can positively impact the team task performance as the team relies on a larger set of skills, cognitive patterns and expertise (Carter et al., 2019; Stewart, 2006). On the other hand, aligning viewpoints and ideas can be challenging in heterogeneous teams, and might delay the achievement of the task (Carter et al., 2019). Semantic coherence within a team tends to affect their creativity and performance positively (Dong et al., 2004) although micro-conflicts among team members can also have a positive effect on the team performance (Paletz et al., 2017).

In this study, we explore the effect of team members’ discipline on design teams’ cognitive behavior, design spaces and semantic topics explored while designing. To do so, we analyze a set of three
design sessions of professional engineers grouped in teams of three. Teams were all composed of engineers from two different disciplines: mechanical and electrical. The protocol analysis methodology was used to analyze our protocols (Ericsson & Simon, 1984; Kan & Gero, 2017; Van Someren et al., 1994) with the Function Behavior Structure coding scheme (Gero, 1990; Gero & Kannengiesser, 2014) and a model of co-design (Gero & Milovanovic, 2019) to locate the teams’ co-design processes.

Determining the design behaviors and design space exploration of mechanical and electrical engineers working in teams can provide new directions toward developing tools to support co-design by developing designer’s awareness of the complementarity of their cognitive processes and skills while designing. Our findings provide a new perspective on design team interactions through co-designing by integrating the relationship between design solutions topics within the design space. It relies on an analysis of the semantics of designers’ utterances, a common approach in design research (Dong, 2005, 2007), that has not been adequately explored. Design research could benefit from more semantic driven studies on design thinking.

2 Background: multidisciplinary design teams in design studies

Multiple factors influence team performance. In their meta-analysis, Stewart (2006) defined three main categories of factors: group composition, task design and organizational context. Group composition refers to the team size, structure, heterogeneity, and characteristics of team members (gender, personality, age). Task design relates to the task itself, and how the activities within the task are differentiated and integrated. It also includes intrateam organization and management, the team and sub-team autonomy and coordination. The last group of factors, organizational context, includes leadership and supervision through the interface of the team leader and the broader organization, such as a department or the company itself.

The assumption in team composition is that individual abilities grouped together provide more resources to the team. But specific skills from team members should combine in the ‘right’ way to increase team-level performance. Studies on teams’ homogeneity or heterogeneity in relation to team performance provide insights to team composition (Carter et al., 2019; Stewart, 2006). On one hand, heterogeneity should enhance creativity in the teams as diverse skill sets are combined, but on the other hand, homogeneity should support fewer conflicts in the team as it includes similar team members (Stewart, 2006). For creative tasks, such as designing, heterogeneity tends to increase the team performance as it requires different expertise (Stewart, 2006). Team members with similar functional background, or discipline expertise, are more likely to identify problems in a similar way, and are less likely to propose a richer set of alternative solutions (Carter et al., 2019). Teams including team members with different functional skill sets will rely on more knowledge, cognitive patterns and cognitive styles, which can benefit solving tasks at the team level (Carter et al., 2019). It could also slow the team process as integrating different ideas and perspectives can be challenging.

In the study presented here, teams are composed of mechanical and electrical engineers. Mechanical and electrical engineers tackle different design problems within the same design task (Riboulet et al., 2005). In practice in industry, both can work in isolation in product development, although collaborative optimization beforehand helps avoid long development loops between designers (Riboulet et al., 2005). A case study of product development at Microsoft highlights that communication and understanding of each engineer’s expertise favor the decision-making process, boost innovation and helps keeping the timeline of the project development (Li et al., 2017). For example, for the development of a scrolling wheel for a mouse, the mechanical engineer would focus on the physical component, the electrical engineer would tackle how to transmit data to microcontrollers while software engineers would define how to communicate the data from the
scrolling wheel to the computer (Li et al., 2017). Problems are tackled at the team level to decide on possible adjustments dealt individually by each engineer. A holistic understanding of the product was key in developing better products (Li et al., 2017).

Even though factors such as the task, designers’ expertise or disciplines affect designers’ approach, designers display similar cognitive behavior while designing (Akin, 2001; Gero et al., 2014; Visser, 2009). Design is a cognitive activity that is not defined through a professional status (Visser, 2009). Designers usually tackle design problems through the relationship between sub-problems or subsystems. The approach to designing can vary depending on the discipline. For instance, designers with industrial or architectural background usually adopt a more intuitive approach to problem solving, whereas engineering disciplines tend to be more analytical and knowledge driven (Akin, 2001; Roozenburg & Cross, 1991; Zimring & Craig, 2001).

When entering the workforce, designers rely on the skills they acquire during their education. Discipline differences are rooted in pedagogical approaches to teaching designing and to professional cultures. Engineering education shapes future engineers’ models of designing, technical skills and capabilities for collaboration (Dym et al., 2005). In engineering, capstone design courses were implemented to bring the practical side of engineering into engineering curriculums (Froyd et al., 2012). Today, teaching design through studio is common across disciplines. But learning objectives of project-based courses tend to differ depending on the discipline. For example, industrial and architecture studio courses tend to be innovation driven compared to mechanical engineering design courses that are performance driven (Goldschmidt et al., 2014). Learning goals set within design courses impact future professionals’ approach to designing. Empirical studies in design suggest that these different approaches to designing can lead to exploiting diverse design patterns and processes (Gero & Jiang, 2014; Kan & Gero, 2011). Mechanical and electrical engineers possess different ranges of skills and expertise related to their discipline, yet as designers, they mobilize similar cognitive design processes (Gero et al., 2014). In fact, their approach to designing is similar. In multidisciplinary design teams, they are perceived as system thinkers and problem solvers (Li et al., 2017).

3 Research question

In this study, mechanical and electrical engineers worked in teams on a design task. We explore the effect of team members’ discipline on design teams’ cognitive behavior and their exploration of the design space. Through design processes, designers advance in the design activity by structuring the design space based on the design situation and their expertise (Cross, 2004; Gero, 1990). The design space is a representation of the ideas and concepts that designers develop over time to propose a design solution that materializes into a design artifact (i.e., a product, a building, a service). Disciplinary backgrounds shape technical knowledge that can influence how designers explore and expand their design space. The research questions are as follows:

1) What is the effect of discipline expertise on design teams’ cognitive behavior?
2) What is the effect of discipline expertise on semantic topics explored while designing?

Based on findings from prior studies described in section 2, we expect to find more differences in the type of concepts each engineer explored than in the cognitive design processes they engaged in. Semantic topics are likely related to each engineer’s functional professional skills and should reflect that expertise. Mechanical and electrical engineers’ approach to designing is considered similar, compared to other designers (i.e., architects, industrial designers). Hence, we expect participants to display similar cognitive design patterns.
4 Methodology

4.1 Data collection

Engineers participating in the study worked at a company providing systems and products for the aerospace and defense industry. Thirty engineers (5 females and 25 males) randomly formed ten teams of three engineers. Most engineers from this group were electrical engineers, and others had backgrounds in mechanical engineering, computer science, and physics. Each team was given the same task, to design a next-generation personal assistant and entertainment systems for the year 2025 (see Appendix). They were invited to focus on what this system would be, how this system works and interacts with people, and what the personal assistant and entertainment system would provide to end users. The team had 60 minutes to define a concept description and sketch it on a white board. All team members were collocated, and a research assistant stayed in the room as participants developed their design. The company requested the experiment to be done outside of the work environment for privacy reasons. Each design session was video recorded to be analyzed (Figure 1). No incentives were given to participants.

This dataset of 10 design teams was collected for a larger research project and was used for another study that looked at the effect of the working environment on design teams’ behaviors (Milovanovic et al., 2021). In the exploratory study reported here, we selected a subset of 3 teams composed of mechanical engineers and electrical engineers. The remaining teams from the dataset that were not composed of both mechanical engineers and electrical engineers were not selected as they did not fit the scope of the research. Here the analysis focuses on analyzing results related to participants’ engineering discipline, mechanical or electrical. All team members of the three teams were male engineers. All engineers were used to working together as the company uses agile manufacturing and production processes. Even if team members have not previously been part of the same team, they are used to working in the same organization environment. This way, although the experiment was carried out in vitro to better control the setting, the interpersonal interactions among members reflected their normal work behavior. All the participants were experts in their domains and had around ten years of expertise in their fields.

Figure 10. Experiment setup and organization with examples of discussion between team members. Teams were composed of either two mechanical engineers and one electrical engineer, or one mechanical engineer and two electrical engineers.
Describing design processes and collaboration

In this study, we utilized the Function-Behavior-Structure (FBS) ontology to describe design knowledge and processes (Gero, 1990; Gero & Kannengiesser, 2014). Many frameworks have been used in the past decades to describe design processes (Lawson, 2006), for example the C-K theory (Hatchuel & Weil, 2013) the reflective practice (Schön, 1983; Valkenburg & Dorst, 1998) or designers’ cognitive actions (Suwa et al., 1998; Suwa & Tversky, 1997). Most integrate concepts related to synthesis, analysis and evaluation as three main design processes (Lawson, 2006). Using the FBS ontology to explore design cognitive process is relevant as its descriptions of function, behavior and structure do not require additional ontological concepts. Moreover, it has been used in empirical studies analysis in diverse domains (Bott & Mesmer, 2019; Hamraz & Clarkson, 2015; Sakao et al., 2020) which supports its reliability to explore design processes. The FBS framework represents six design issues (see Figure 2):

- Requirement (R) includes the design brief and is outside of the designer
- Function (F) is what the design object is for
- Expected Behavior (Be) represents an expected behavior of the design object
- Structure (S) represents elements and their relationships that go to make up the design object
- Structure Behavior (Bs) is behavior derived from a structure
- Description (D) is an external representation of the design object.

The FBS framework also describes a total of eight cognitive design processes as a consequence of transitions between the six design issues, as shown in Figure 2:

- Formulation, a transition from a requirement (R) to a function (F), or from a function (F) to an expected behavior (Be)
- Synthesis, a transition from an expected Behavior (Be) to a design structure (S)
- Analysis, a transition from a design structure (S) to a behavior from structure (Bs)
- Evaluation, a transition from an expected behavior (Be) to a behavior from structure (Bs) and inversely
- Documentation, a transition from a design structure (S) to a description (D)
- Reformulation 1, a transition from a design structure (S) to a different design structure (S)
- Reformulation 2, a transition from a design structure (S) to an expected behavior (Be)
- Reformulation 3, a transition from a design structure (S) to a function (F).

Figure 11. FBS design knowledge and process framework (Gero, 1990; Gero & Kannengiesser, 2014)
4.3 Coding the design protocols to obtain information on collaboration and design processes

The protocol analysis methodology was applied to analyze the design sessions. Video protocols were transcribed, segmented and coded using the Function-Behavior-Structure framework represented in Figure 2. In this study, we analyzed collaborative interactions between team members based on their engineering discipline. Each segment was coded with the engineer’s discipline, mechanical or electrical. Two teams comprised two mechanical engineers and one electrical engineer whereas the other team was composed of one mechanical engineer and two electrical engineers. As explained above, FBS design processes are identified as transitions from a specific design issue to another specific design issue (Figure 2). A process formulated by a single engineer, implies that both design issues forming a design process are verbalized by the same engineer. We identified a co-design process as an FBS design process where a first engineer formulates the first design issue, and the second designer verbalizes the following design issue (Gero & Milovanovic, 2019). With a dual coding scheme, we were able to identify dominant design processes for mechanical engineers, electrical engineers and collaborative processes between mechanical and electrical engineers. Processes and interactions are based on a syntactic model, looking at the activity in a temporally linear manner, not based on semantic associations or turn taking (see Table 1 for an example of protocol coding).

Each session was coded by two different trained coders. When a disagreement occurred, coders arbitrated each segment together, and relied on an external coder’s input if they could not reach an agreement. In total, three coders worked in pairs to code the data. The average coder agreement for all sessions is 80%, which ensures the reliability of the data analyzed.

Table 8. Example of coded protocol with design processes and interactions

<table>
<thead>
<tr>
<th>Utterance</th>
<th>FBS code</th>
<th>Design process</th>
<th>Designer</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>And then you got to have, you know, with the TVs and then connecting</td>
<td>S</td>
<td>Synthesis</td>
<td>Mech. Eng.</td>
<td>Elec. Eng. &gt; Mech. Eng.</td>
</tr>
</tbody>
</table>

4.4 Measuring design space exploration with NLP and networks

Tools from network science provides a new perspective on studying design teams, design tasks and design spaces (Adolphe et al., 2020; Leenders et al., 2016; Parraguez & Maier, 2016). To measure the design space explored by engineers during the design sessions, we created a graph to represent the entire design space produced by all the designers through the concepts they mentioned. Elements within the design space are concepts or ideas that are formulated by designers. The graph also accounts for relationships between concepts and their frequency of occurrence. To build the graph, the input data was prepared using a Natural Language Processing (NLP) script in Python (nltk package) and the Gephi software to visualize the graphs (Bastian et al., 2009). We used a python script to clean the design protocols with NLP tokenization. Doing so, punctuation and stop words were removed...
from the protocol, and we selected tokens tagged as nouns (nltk.pos_tag() function in the nltk
package). To create the graph, we considered each token (i.e., “home”, “people”, “concept”, “app”) as
a node. Edges between nodes are created when both tokens appear in the same protocol segment. The
frequency of the co-occurrence of tokens within a FBS segment provides the weight to graph edges.
As each segment is assigned to the speaker, we were able to track who established a relationship
between tokens, a mechanical engineer or an electrical engineer.
Figure 3 illustrates an example of the entire design space for this specific task for all three sessions
combined, represented by the network of topics explored by all the engineers. The network
representation chosen is based on a force directed graph (Fruchterman & Reingold, 1991). The
concepts that are highly connected appear in the center of the network while concepts at the outskirt
of the network usually connect to only one other concept. Such networks provide a relevant visual
tool to better understand the design space explored by engineers based on their discipline. In Figure 3,
blue edges represent connections made by mechanical engineers and pink edges represent connections
made by electrical engineers. A node, such as “people”, is connected to other nodes with blue and
pink edges, meaning that both groups of engineers mentioned “people” but with different connections
to other concepts. Nodes connected to other nodes by edges of a single color imply that these topics
were covered by only one type of engineer. Node size represents the node degree (number of
connections with other nodes) while edge width accounts for co-occurrence frequency of concepts.

Figure 12. Graph example of the entire design space represented by the concepts verbalized by all the engineers
in all the teams designing a personal entertainment system. Blue edges represent connections made by
mechanical engineers and pink edges represent connections made by electrical engineers.

Graph theory provides topological measures for networks that we can apply and interpret in studying
the exploration of design spaces. Here, we looked at network density and modules within the graph.
Network density is the ratio of the number of edges within the network to the number of possible
edges in the network. It provides an idea of how well nodes are connected to each other, in this case,
how well concepts are connected to each other. Modularity provides an estimation of how a network
breaks into smaller sub-networks or communities (Newman, 2006). Using Gephi’s clustering function
for modularity (Louvain method), we are able to define modules within the network that corresponds to a chunk of the design space explored. Modules have dense connections between the nodes within the module and sparse connections with nodes in the other modules. Modules are “small worlds” in social networks. Defining such modules can help us determine groups of topics where engineers collaborate or if some modules are discipline specific.

5 Results

5.1 Designers display different design behaviors based on discipline

The results indicate differences in the cognitive effort expended by engineers in designing, based on their engineering discipline. The average distribution of FBS design processes for all three sessions, for electrical engineers, mechanical engineers and the collaborative processes between them is presented in Figure 4. Electrical engineers tended to put more effort into analysis compared to mechanical engineers. They spent 38.6% of their cognitive effort on Analysis. Mechanical engineers put more emphasis on reformulating design solutions, Reformulation 1 design process, as such a process represents 43.2% of all their FBS design processes. The distribution of Evaluation design processes is twice as large for collaborative design processes between mechanical and electrical engineers than for discipline-specific design processes. For other processes like Synthesis and Reformulation 2, the distribution of processes is similar for all types of interactions.

![Figure 13. Average distribution of individual and collaborative design processes based on design discipline](image)

5.2 Designers explore different design topics in the design space based on discipline

5.2.1 Results based on discipline expertise. The network of concepts is built from the segmented protocols as described in the methodology section. In total, 2,536 segments were used as input (1,115 for mechanical engineers and 1,421 for electrical engineers). Nodes represent concepts discussed by engineers during the design session while edges show the relationship between concepts based on the protocols. In order to visualize highly connected topics, we used a threshold based on node degree to select nodes with a higher node degree than the average. Since, on average, nodes have 15 connections to other nodes, the threshold was set at 15, and only nodes with 15 or more connections are represented in the networks shown in Figure 5. Figure 5 illustrates subgraphs of dominant concepts for mechanical engineers (Figure 5(a)) and electrical engineers (Figure 5(b)). The mechanical engineers’ subgraph comprises fewer nodes (393 nodes) than the electrical engineers’
subgraph (602 nodes). However, the mechanical engineers’ subgraph has a higher network density (0.27), than the electrical engineers’ subgraph (0.018). This suggests that mechanical engineers explored fewer concepts than electrical engineers but made more connections between the concepts explored.

![Figure 14](image)

Figure 14. Subgraphs representing relationships between concepts explored by engineers based on their discipline: (a) mechanical engineers and (b) electrical engineers. A threshold based on node degree was applied to highlight prevalent concepts explored by engineers. The node degree threshold of 15 is selected, which is the average node degree for the entire network of concepts.

The analysis of the design space for the design teams shows some overlap of the topics that designers focused on. For instance, “people”, “home”, “entertainment” and “need” are key nodes in each sub-network (see Figure 3 in the Methodology section). Each cohort also discussed topics specific to their discipline. For example, mechanical engineers explored concepts related to the category of users (e.g., “parent”, “family”, “children”) and user wearables (e.g., “glasses”, “watch”, “wristband”, “monitoring”, “heart rate” and “sleep”) (Figure 3(a)). On the other hand, electrical engineers expended cognitive effort in exploring product-related concepts (e.g., “marketing”, “package”, “energy”, “processing”).

Using Gephi’s clustering tool with network modularity, 5 main modules were identified (Figure 6). Those 5 modules represent 90.5% of all the nodes in the network. In most modules, both mechanical engineers (pink edges) and electrical engineers (blue edges) made connections between nodes (see Figures 6 (a), (b) and (c)). For two of the modules, we observe the dominance of electrical engineers’ connections (blue edges in module 4 in Figure 6(d)) or the dominance of mechanical engineer’s connections (pink edges in module 5 in Figure 6(e).

Module 1, representing 40.1% of the network of concepts, relates to the end users with concepts like “people”, “families”, “need”, “use”, “assistant”, “avatar” and more. Module 2 representing 20.2% of the network of concepts describes the product in context with topics like the “home”, “cameras”, “monitor” for a specific usage related to measuring data (“heart rate”, “sleep”, “temperature”). Module 3, representing 11.6% of the network of concepts, focuses on a function of the product’s technological aspect that deals with “technology”, a “server”, “internet”, and a “cloud”. For all these modules, mechanical engineers and electrical engineers brought complementary ideas, using similar ideas (nodes) and connecting (edges) them to different other ideas.
Module 4, representing 10.7% of the network of concepts, is dominated by blue edges illustrating connections made by electrical engineers. In this module, the focus is on one of the requirements for the product “entertainment”. It relates to some uses for the product like “exercise” to the components of the product, for instance the “apps”, the “software”, “data”. The last module, representing 8.0% of the network of topics, is dominated by pink edges showing connections established by mechanical engineers. In this module, the concepts represent features offered by the product designed, as “games”, “music”, “video”, “movie”, “homework” that connects to users (“families” and “children”).

6 Discussion

In this study, we explored whether the disciplines of team members impact design behaviors, design spaces and design space exploration for teams of electrical and mechanical engineers. We observed differences in design behaviors related to disciplinary background. We also found that the part of the design space covered changes based on designers’ discipline.

The divergences in the distribution of design processes based on discipline highlights slightly diverse cognitive design styles. Mechanical engineers put more cognitive effort into Reformulation 1 processes, whereas electrical engineers put more cognitive effort into Analysis. Both types of process focus on the design solution itself. While Analysis infers behaviors from design structures, Reformulation 1 processes implies rethinking design structures. Both types of designers display a design behavior focused on the solution, which agrees with previous empirical findings (Jiang et al., 2014). Mechanical and electrical engineers are both defined as analytical and system thinkers (Akin, 2001; Li et al., 2017) which provides an explanation for the dominance of Analysis and Reformulation 1 design processes. When collaborating, Evaluation processes become dominant compared to individual design processes. This finding supports the relevance of collaboration between disciplines as it triggers more evaluation between the current solution and design expectations. In the Microsoft project case study, communication between engineers from different disciplines was key when identifying problems and laying out possible adjustments for the product solution (Li et al., 2017). Navigation between problems and solutions is at the core of the Evaluation process, which echoes these previous findings on multidisciplinary team members communication while designing.

We expected few differences in design cognition based on discipline as both mechanical and electrical engineers tend to hold a similar approach to problem solving. Looking at the overall distribution of design processes, the data analysis provides indications of similar design behaviors although some divergence appeared as well. Interestingly, design behaviors were different for interdisciplinary codesign processes. Collaboration tends to co-opt a larger the array of design patterns designers engaged in during the design activity, which could lead to a richer outcome in terms of the design artifact.

Exploring the use of NLP and network science to study the extent of the design space explored depending on the discipline helped visualize the functional expertise of each type of designer. The design processes analyzed and discussed above act as a vehicle for concrete elements discussed by the participants. Mechanical engineers and electrical engineers explored complementary parts of the design space while designing. Some concepts overlapped between engineers including “people”, “home”, “entertainment” and “need”. Concepts specific to disciplines were more user related for mechanical engineers and more product related for electrical engineers. When looking at clusters of concepts based on network modules, we observed that the three main modules (covering the larger number of concepts) contained a high participation from both types of engineers. It suggests that for this task, multidisciplinary collaboration helped cover more of the design space within modules. Those modules dealt respectively with the end users, the product in context of usage, and technological aspects of the product.
As more disciplines come into design, combining expertise is key to improving the design process and its outcomes. This study looked at two disciplines and could be applied to any number of disciplines in a team. Revealing how designers interact and the amount of design space they cover could benefit team organization and management. Engineers bring specialist knowledge to interdisciplinary teams, hence need to put effort into communicating their design language and context knowledge to other designers from different backgrounds. Such efforts could enrich the design artifact produced. In this study, we showed that the design space covered was extended based on the collaboration between engineering disciplines. We could argue that covering more of the design space could lead to more design alternatives and a better end product.

In this study, we focused on cognitive processes of the design teams but other factors such as social interactions impact how the design activity unfolds in a team. Teams can divide into sub-teams based on different characteristics. Sub-teams emergence within teams is shaped by faultlines, hypothetical dividing lines based on attributes of diversity, that are embedded in the situational and social context of the team environment (Carton & Cummings, 2012; Thatcher & Patel, 2012). In our dataset, sub-teams organization around discipline was not dominant as team members collaborated on multiple topics (see modules of the concept network). The social organization of the team through leadership, project and conflict management can impact how the team progresses in their design activity. In future work, we plan to integrate such factors into our analysis.

In this study, one limitation is that the performance of the artifact is not evaluated. In our future work, we will include such metrics to better understand the relationship between the amount of design space explored and the design artifact quality. More metrics can be added and represented from the topics network. Through analyzing concepts that are first occurrences (first concept for one topic) in the protocol data (Gero & Kan, 2016), we can define the size of the design space and the semantic distance between concepts. Such metrics can provide a proxy to measure divergent thinking and creativity, which could complement subjective outcome evaluation, for instance with the Consensual Assessment Technique (Amabile, 1982).
Figure 15. Subgraphs representing relationship between concepts explored by engineers within modules: (a) module 1 representing 40.1% of topics, (b) module 2 representing 20.2% of topics, (c) module 3 representing 11.6% of topics, (d) module 4 representing 10.7% of topics, (e) module 5 representing 8.0% of topics. Edges in pink represent relationships between concepts formulated by mechanical engineers. Edges in blue represent relationships between concepts formulated by electrical engineers.

7 Conclusion

Working in multidisciplinary design teams has become the norm with the increasing scale and complexity of designs. It requires a synchronization between designers from different discipline backgrounds, which can be challenging. The potential of interdisciplinary design teams is to increase performance by designing better products more effectively and efficiently. In this study, we analyzed the design behaviors of teams composed of mechanical and electrical engineers. Using protocol analysis, we were able to determine similar and different design behaviors between mechanical and electrical engineers. More importantly, when codesigning, engineers from different disciplines engaged in processes that were not dominant for discipline-specific processes. The topics covered within the design space was extended based on discipline-specific context knowledge. The richness of design processes and potential for design alternatives in these design teams show the relevance of multidisciplinary teams.
This study was a testbed to integrate new design cognition metrics using NLP and network science. The tools used provide an automated way to study semantic relationships within design protocols. Network representations based on word co-occurrences provide an additional dimension of design thinking analysis. Networks representing relationships between ideas and concepts while codesigning could help the design team in their process (Gyory et al., 2021). Other forms of expression embedded within the design activity such as gestures (Kang & Tversky, 2016), physiology and neurocognition (Borgianni & Maccioni, 2020; Gero & Milovanovic, 2020) are additional area of focus in order to broaden the characteristics of designing that are studied. Considering all these characteristics in design research will enrich our understanding of design cognition and can benefit team design through developing real-time tools to assist designers.

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References

Appendix

Personal Entertainment Systems (PES) is one of the most comprehensive entertainment companies in the world. In order to keep its leading position in the industry of entertainment, PES cooperates with many agents to explore the possibilities of new types of entertainment. Your design team has been invited to help in designing the next generation of a personal assistant and entertainment system suitable for family use in the year 2025.

Concept Design

In the context of engineering, a characteristic feature of the product design-related function is the description of products. Concept design includes a thorough roadmap from concept generation to production to product launch. See figure below:
The aim of concept design is to prepare for concurrent engineering by specifying the fundamental solution to the design problem.

Task
Your team is tasked with producing concept designs of a personal assistant and entertainment system suitable for family use for the year 2025.
For this project, your team should focus on:
• what this system would be,
• how this system works and interacts with people, and
• what the personal assistant and entertainment system would provide.
Your goal is to produce a number of concepts and then develop one of those concepts into a detailed design. At the completion of the session, please present sketches (using the whiteboard) and a verbal description of your solution. Your team will have 60 minutes to complete this task.
6 Studio experiences
Harnessing cultural empathy through design anthropology: An alternative design pedagogy approach

Kenny Segal\textsuperscript{a} and Jonathan Ventura\textsuperscript{b}.  
\textsuperscript{a} The Department of Inclusive Design, Hadassah Academic College, Jerusalem IL, kennys@hac.ac.il  
\textsuperscript{b} The Department of Inclusive Design, Hadassah Academic College, Jerusalem IL, jonathanve@hac.ac.il

Abstract. What is a cultural object? For over a decade we have been teaching a unique practice-oriented course for product designers focusing on three distinct cultures of wood: classic Japanese carpentry, Western and Southern African wood cultures, and the ascetic design of the Shakers. Instead of working in a classic manner of presenting the students with a design brief describing our intended result, including a clear function and market-value, we drove the students to start thinking about cultural philosophies, norms, and conventions, as well as religious principles. Mixing various Israeli cultures (Palestinian, Ethiopian, and more) with a contemporary interpretation of these three cultures created a new approach towards the essence of both empathetic design as well as vernacular design. Through the unique cultural traits of wood, and understanding the Other, empathy is embedded within design practice.

Keywords: design culture, design anthropology, wood, pedagogy, empathy.

1 Multi-cultural design and the essence of wood

Do not make something if it is not useful, but if it is both necessary and useful, do not hesitate to make it beautiful, as long as the decorative elements are an inherent part of the design and do not interfere with function (Sprigg et al., 1991: 130).

For the last twelve years we have been teaching the course "Design and Culture through Wood" at the Department of Inclusive Design at Hadassah Academic College in Jerusalem. Throughout the years we have been aiming at four main pedagogic goals: first, to teach our students that contemporary design starts primarily at the socio-cultural elements of each material cultural in which it is created. The essence of multiculturalism, in our eyes, is the ability to truly understand varying cultures and embed their point of view in our own, which brings us to the second goal. Second, as a department specializing in inclusive design, we wish to highlight the importance of empathy and care not only through the ‘regular suspects’ of healthcare or education design, but a holistic approach relevant to design practice. Third, as design thinking (Brown, 2009) became an overarching methodological and strategic approach for businesses and NGOs, we wished to present our own local interpretation of the concept. Understanding local cultures, vis-à-vis industrial design’s tendency to present global and standardized outcomes imbues the concept of design thinking with a different meaning. Using theory, cultural, historical, philosophical, and religious knowledge help students to reflect and reevaluate not only the outcomes of this course, but their approach to the discipline. Our final goal was to articulate contemporary Israeli and Jewish culture vis-à-vis contemporary design. The course focuses on three distinct cultures of wood: The Shakers, a protestant sect originating in the North-Eastern parts of the US in the late 1700s; traditional Japanese culture, focusing on the major religions in Japan, along the ensuing aesthetics and philosophies; and finally, the various cultures of Africa, and specifically those
of the East and West coasts along central and south Africa. During this studio, the students must choose a culture, an era, or a tribal culture, identify, and articulate a central philosophy, religious belief or aesthetic trait and generate a design brief. I.e., translating this abstract knowledge into material and visual configurations of a designed object. Naturally, the essence of the studio is not to copy or duplicate another culture’s material artifacts, but rather to re-interpret these through a contemporary Israeli point of view.

We can summarize our overall pedagogic core values as consisting of several elements: first, we wish to present the students with an alternative to the classic industrial design process of identifying a need/problem/opportunity, outline a brief, conduct research, map-out the field etc. Returning to the core values of design thinking as presented by IDEO, we offer a different interpretation of the model. During the first weeks of teaching, we tell the students to stop thinking about value, function, market research and a detailed mapping of design partners and shareholders. Instead, we focus on core socio-cultural values, philosophical or religious principles and poetic yet practical vernacular design. A second principle, which also echoes the core values of IDEO, is the anthropological principle that understanding comes from a combination of empathy and a lack of judgment. Third, the pedagogic choice of focusing on a single material takes out of the equation a big part of the classic design process. We chose this path since it allows us to focus primarily on the cultural content of each project, rather than on various attributes of different materials. However, as each of the taught cultures developed differing design technologies, this element is manifested through the student’s understanding of the link between material and production methods. Finally, this ‘backwards’ approach towards design, in which the classic design process is reversed derive from our understanding of the current and future global and local realities, as well as our notion of the designer’s role in society. Apart from the COVID-19 pandemic, the world is rife with political shifts, refugee currents, economic inequality, rampant power struggles by tech companies and more. In this complex reality, and as a direct result of our definition of inclusive or social design in society. We believe, as a department, that designers should be more concerned about design’s influence on society, the climate and our current material and visual reality. As such, we stress the importance of the designer as an agent of socio-cultural change, through understanding the individuals and communities with which we work. These elements became embedded in the very core of this course.

Another key point of the course, as it evolved, however, was not only the ability to shift from the abstract to the material, but rather to harness varying scenes of socio-cultural artifacts to develop empathy among young designers. As an inclusive design department, our core values of empathy reside between healthcare and social design, yet we found it extremely interesting to also harness classic design approaches to imbue our students with empathy towards different cultures (Segal and Ventura, 2019a).

Our department’s title switched from ‘industrial design’ to ‘inclusive design’, a switch based on shifting values from the classic approach towards design, focusing on supplying the industry with functional solutions, to a more socially- and people-oriented approach. While industrial and product design differ in the scale of manufacture, links to industrial partners and more, a common denominator would be a somewhat pragmatic and functional approach focusing on identifying needs or searching for problems in existing products, thus offering alternatives. Questions relating to the definition of product design today still present designers with difficulties, such as: what is design? Is it a separate discipline from industrial design? Does product design stem from Art or is the opposite correct? Our view is that product design is a primordial activity stemming from the basic needs of humanity’s survival which, with time, developed to become an encompassing cultural phenomenon (Segal and Ventura, 2019). Based on this view, speaking of the field of product design, describes only the physical outcome and not the overall cultural activity. We will refer therefore to Design - an interdisciplinary activity to be recognized and measured through the prism of culture. Furthermore,
considering what we call the design situation (see Ventura, 2016), rather than design practice, we enroll into the material product a holistic and broader socio-cultural scenario in which it is designed. This, in turn, includes norms, a specific vernacular context, religious and philosophic attributes, as well as the various intended design partners. Conversely, Julier (2006: 70) emphasizes correctly that design culture strives “to imply collectively-held norms of practice shared within or across contexts.” Manzini (2016: 54) adds another layer to Julier’s definition of design culture, surmising that “it is mainly the culture of the designers themselves and of the communities in which they operate: the culture on which design itself is based and thanks to which innovative meanings can also be proposed.”

We do not wish to engage the age-old debate on the definition of culture. This has rallied anthropologists and other researchers for decades. The contemporary variant of culture defines it as a “social domain that emphasizes the practices, discourses, and material expressions, which, over time, express the continuities and discontinuities of social meaning of a life held in common” (James, 2017: 53). This definition follows the footsteps of anthropologist Clifford Geertz (2012; 1973) enrolling into this complex concept socio-cultural norms, as well as material and visual products of a specific culture. Conversely, culture is not only constructed of things, abstract notions, ideas and stories, but a common continuous structure. While a key notion executing this notion was either religion or national government, in the last decade design has a foothold as well. In other words, just as literature or visual arts, material and immaterial designed products mirror one’s cultural values. Following design’s temporal natural, we are talking not only of a social group’s past cultural values, but those of the present and in some cases the future as well.

It follows then, that design is a material manifestation “of social meaning of a life held in common”. This is an exciting proposition as we can study designed artifacts and through them get an insight into the “continuities and discontinuities” of local social meanings, norms, and values (see, Ventura and Ventura, 2017). The obvious tool for studying norms and values of societies is cultural anthropology but a more specific tool would be required to fulfill the proposal of studying culture through objects. The relevant tool in our case, therefore, would be design anthropology which focuses on cultural variation through the study of objects using accepted anthropological methodologies (see for example, Otto and Charlotte Smith, 2013; Julier, 2013). Specifically, Gunn et al. (2013: xiii) claim that “practitioners of design anthropology follow dynamic situations and social relations and are concerned with how people perceive, create, and transform their environments through their everyday activities […] design anthropology practices occur across different scales and timelines and involves many disciplines, each bringing their own distinct ways of knowing and doing”.

Gunn and Donovan (2012: 9) stress the importance of the socio-cultural relationship between the designer and the end-users. A crucial point they consider in the fluxing relationship between design and anthropology is the difference between what they term dA, Da, DA:

dA – the theoretical contribution is for anthropology rather than design. Design follows the lead of anthropology in terms of adopting theoretical understandings or becoming the subject of anthropological study. Da – fieldwork is in the service of design. Framing originates from problem-oriented design approaches rather than engagement with peoples. Anthropology is put in service of design, for example ethnographic studies are used for establishing design requirements. DA – disciplines of design and anthropology are engaged in a convergence of efforts each learning from the other. DA is a shift from informing design to re-framing the social, cultural and environmental relations in both design and anthropology.

Gunn and Donovan (ibid: 1) rightfully claim that a central resemblance between anthropology and design is the ability to interpret daily activities: "central to engaging with others is finding ways of imagining oneself into another person's world.” This very idea, of understanding one’s perspective through imagination stands at the heart of empathy as a human trait. Indeed, using previous
definitions of design anthropology as a basis, we follow its evolution to social design (Ventura and Bichard, 2017). We propose that design anthropology does not focus solely on supplying research methodologies and theoretical venues to practitioners, but rather imbue the discipline with core values needed to tackle the wicked problems of design (see Buchanan, 1992). One of these deals with the moral essence of design, as well as the designer's role in society, to both of which cultural empathy is much needed. One of the key traits of empathy is understanding another's point of view, thus interpreting a specific situation from a different approach. While designers conduct these methods as part of the classic design process, through our course, the essence of cultural understanding is not dependent on market research, product value or functionality, but rather on understanding other cultures for the broader and deeper value of Humanism. Therefore, using wood as a common denominator allows us to isolate other variables to focus on culture, understanding and interpretation.

Our solution, then, was to level the playing field and allow for comparative research by choosing a classic, raw material and mapping its implementation in specific cultures that have a tradition of working with said material. The material we chose was wood, a magical natural material that has been used by mankind to survive for an estimated 200,000 years. Through the “looking glass” of material, a whole new dimension is added to the understanding of objects and design. Alongside the object, its cultural function, and the behavior of the users, we decipher the relevant cultural values, traditions, and rituals, local crafts, and techniques - all on one platform of raw material enabling a broader comparative study.

Incorporating this methodology within the practical side of design culminates in an approach that sees the designer as a creative visual-material interpreter. In the case of design practice, the object, understood through social/cultural meaning allows for the designer to create new meaning or objects by changing context, or social meaning while utilizing all the different disciplines required in one complex object. So, through the looking glass of wood, using the methodology of design anthropology to understand a complex social meaning, designers can create new cultural artefacts by implementing an interdisciplinary approach in a multi-layered cultural object.

To illustrate our pedagogic values, as well as our practice-based approach, we have outlined a few of the students’ projects, chosen out of over 450 projects accumulated over 12 years. These were chosen to highlight the importance of design anthropology to the practice of design, as well as the ability to harness empathy in design. We based our interpretation on a previous research methodology labeled “visual-material content analysis” (Ventura and Ventura, 2018). Naturally, deciphering these unique objects offered quite a challenge, one that brought us to complex yet articulated solution. Using design anthropology as a basis, thus considering a specified socio-cultural layout for each object, we needed a broader outline for material interpretation. Since semiotics is a typical answer, we believe it is not enough, due to its fluid and in some cases too flexible nature (see Ventura and Shvo, 2018). Thus, adding interpretive analysis, based primarily on design phenomenology and design hermeneutics, we imagine each object as a text or a narrative holding a sensorial as well as a descriptive nature. Following this method, we interpret the chosen objects according to several attributes: the configuration, aesthetics (shapes, colors, textures), construction technologies (derogation, joinery etc.), thus allowing for a richer interpretation of the socio-cultural values embedded in these designed objects. This approach presents researchers with various possibilities for integrating empathetic design in pedagogy and practice. These include a deeper, thorough examination of socio-cultural attributes and decipher their meanings in a material object. Furthermore, as a pedagogic tool, one can either interpret existing objects (in a curatorial or historical courses, for example), or create new objects with the students (in industrial design, product design, jewelry design, fashion, or architecture for example). The key notion would be to harness empathy not solely through the classic spheres of inclusive design or disability studies, but through a broader plethora of objects.
2 Japanese shakers

A recurring trigger for religious tolerance in our course came from bringing together classic Japanese values with the three monotheistic religions based in Jerusalem. As all three (Islam, Judaism and Christianity) demand a single devotion to its own core value system, the animistic, flexible, and liberal approach presented through Japanese artifact confronted Israeli students with acute questions. An interesting cultural ‘mirror’ presented in various projects, then, conduct a ‘face-off’ between two seemingly similar cultures, yet upon a deeper examination, broaden the student's empathy and understanding towards differing value systems.

In the first project, designed by Gleb Tukschok, we identify several key points echoing between two distinct cultures: first, the strict relying on what would later be termed by the Bauhaus school "truth to materials" (Pevsner, 2005), i.e., leaving the materials the front stage without obscuring the material itself with patina or gloss. Second, while different in philosophy, both The Shakers and Japanese traditional aesthetics, share a principle of simplicity and austerity. A classic semiotic approach, therefore, would have focused on the aesthetic similarities, yet these stem from completely different value systems. While classic Japanese design's austerity generates from Zen Buddhism, the Shakers' origin of approach lies in a strict Protestantism calling for hard work, asceticism, efficiency, and modesty before God. In other words, while the first resolves around the tension between the individual and their community, the second depicts a tension between the individual and their God.

While Shaker in design, we can clearly see the Japanese philosophy in this series. The water container (above image on the right) seems roughly hewn, an almost natural piece of wood, yet the bottom of the bowl shows a true craftsmanship. Following a Zen approach, this bowl looks as effortlessly undesigned as possible, leaving it as natural as nature intended. The same is true concerning the whisk (chasen), in which each filament is made of piece of wood polished and shaped to perfection, bolstering the same effortless design. Again, while the base of the object is made of maple, the pale
wood echoing Japanese design, the filaments are made of American walnut, an echo to Shaker design. The teaspoon again resembles a natural twig, picked from the nearest forest, yet a closer look reveals the Shaker exact functional and ergonomic contours of a carefully designed object. Instead of the classic bamboo, this unique spoon is made of a combination of Oak (classic in Shaker design), Indian rosewood and touches of wenge. The array of wood, along the technique of stack lamination enabled for a feel of wabi sabi we can clearly see in the almost natural and twig like design of the spoon. Finally, the hishaku seems like any other, yet a close look at the handle reveals the classic design of a Shaker ladder-back chair, the fine mark of a professional cabinetmaker. While the lower part of the vessel echoes the mastery of Shaker artisanship, the upper part resembles the un-perfect pottery of Japanese craft. The essence of empathy and cultural openness in this project derives from the very way wood is perceived in both cultures. The nuance of woodwork emphasizes the similarities and differences between the two cultures, while keeping a distance, thus allowing for a reinterpretation rather than a redesign or a simply act of copying another cultural style.

3 African-shaker chairs

The notion of bridging two differing cultures through an act of design is even more acutely pronounced when juxtaposing African cultures and the Shakers. When comparing two cultures, or to be more exact – three (the designers’ Israeli identity as well), shifting one’s stance from a distant knowledge to a deeper understanding, brings forth empathy almost effortlessly. In this project, two chairs’ configuration combined with a cultural philosophy regarding the place of a person in the greater social structure, demonstrates an interesting mix between African and Shaker aesthetics. Naturally, questions regarding our place as individuals in a broader societal context, has been the backbone of sociological theories and social psychology as disciplines. However, understanding these dilemmas in other cultural contexts imbues young designers with empathy and broadens their professional horizons.

Famously, the Shakers believed in a combination of hard work, asceticism, and scripture-based faith. Therefore, their furniture mirrors this central belief system, favoring functionality and frugality over lavishness or indeed what Veblen (2007 [1899]) termed ‘conspicuous consumption’. Among their many contributions to modern design we can find the reclining chair, along with the ladder-back chair and more. Since cleanliness was close to godliness according to Shaker belief, furniture had to be easy to clean, light enough to move when dusting, not to gather dust and of course – be highly functional (Kassay, 1980; Andrews and Andrews, 1964). Two of the most famous Shaker chairs were the ladder-back chair and the rocking chair. Aside from the ladder-back functionality to hang the chair on a peg while cleaning the floor, this frugal design is also economic in wood use and stronger. The rocking chair, in turn, was used for knitting, as well as for a hard-earned rest from the day’s hardships, preparing one to the next day’s challenges. Among else, these two iconic chairs influenced various leading designers, especially so in Scandinavia, as would attest the famous work of Danish designer Hans Wenger (Becksvoort and Sheldon, 2000).

Usually, these chairs were made from strong and cheap wood, such as oak and ash, while the seating was made of either wood or cloth weaving. As each Shaker furniture was a materialization of a

![Figure 3. Shaker reclining African chair (notice the figurheads on the ladder back)](image)
specific function, each was built according to specific craft knowledge and logic. As the rocker was to be moved around the living room and lifted when cleaning, it had to be light. Similarly, the Shaker-milking stool had to be small enough to fit next to the cow, as well as strong enough to support the weight of the person sitting on it. Therefore, the Shaker stool was made of a single piece of wood, molded into a specific ergonomic shape according to the intended milking person, and fitted with three legs for easy use (Fine Woodworking, 2001).

Following the strict and functional philosophy of Shakers design yet wanting to add a twist to these timeless pieces, the designer Roy Aryeh, made a detour to Western Africa and Japan. The Malawi chair if well-known for its simplicity, craftsmanship and straightforwardness. As we have seen, this chair is built from two crafted pieces of wood, joined together by the angle of each facet. Usually, each African chair is adorned with a personal addition – a depiction of a bird, an animal, a person or favored possession of the owner (Sieber, 1980). Another influential motif in these two chairs is the mask tradition of the Fang tribe of Gabon, usually used for tribal rituals. These masks are a testimony of classic Western African minimalism and figurative art. Lengthy in proportion, heart-shaped facial features, along narrow eyes, and lengthy nose.

The last contribution to these two chairs is the Japanese bath stool (koshikake). This Japanese stool is traditionally made of cypress and measures around 30cm, upon which people soap and rinse themselves prior to entering the tub (Koizumi, 1986). This simple yet sturdy stool is made of three pieces of wood joined together by a single peg.

The result of these three cultures of wood is an African-Shaker rocker and a Japanese-Shaker milking stool. The rocker is made of maple and a crisscross cloth for the seating. This unique configuration is based on the basic configuration of the Shaker rocker with a touch of the Malawi chair, as well as two protective figurines on top of the ladder-back. The chair’s strength is a result of an elegant use of Japanese joinery. In turn, the milking stool is based on the classic Japanese bath stool yet is made from red eucalyptus by derogation carving. Contrary to classic Japanese design, the single joint is made in a somewhat exaggerated manner, to symbolize the user's importance, according to Western African tradition. Surprisingly, these three cultures are materialized in these two chairs in such a manner that seems almost natural. Indeed, this seemingly natural ease is a key pedagogic strategy attesting to the students’ application of empathy towards differing cultures in their practice.

Another interesting fusion between the Shakers cabinetmaking and African woodwork can be seen in

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56 http://www.imj.org.il/imagine/galleries/viewItemH.asp?case=21&itemNum=202855
a chair designed by Chen Adler. The chair, titled "Women Rock" imbues the configuration of a classic Shaker rocking chair with cultural traits of the Ethiopian Karo women. The chair incorporates two models of powerful femininity as derived from both cultures. Austere and ascetic in nature, the Shaker religion hold women in high regard, as Ann Lee, founder of the Shakers, served as the head of the congregation, as well as other women who served in various high-ranking positions along the years. In fact, celibacy freed women from raising children and added to the existing equality among the Shakers. While the congregation would not be considered feminist in contemporary terms, its tendency towards gender equality far succeeded contemporary societies (Andrews, 2012; Foster, 1991).

Adler's chair is based on the Karo femininity model of scarification, red ochre, and beads. Adding these cultural features to the classic Shaker rocker created a surprising result. The Afro-Shaker rocker was planned in such a manner to clearly highlight two classic chair configurations: the shaker rocker and the African chief's chair. Using a mixture of maple and American walnut allowed for an immediate recognition of each configuration. The chief's chair bolsters the classic African slant of the backseat, as well as "scarification" marks on the seat, symbolizing the chief's power. In such a manner, the elegance and austerity of the Shaker rocker are highlighted by the presence of the innate power of the chief's chair.

The essence of empathy, and indeed the holistic nature of design anthropology is manifested in these chairs in several manners. First, as mentioned, the notion of comparing the three cultures, as well as the designer’s own Israeli identity accentuates their equal importance. Second, using these cultures and wood as a cultural ‘anchor’ allows the designers to tackle broader and thornier issues, such as gender, family structure, an individual’s role in society and more.

4 Kokeshi as a platform for tolerance

"Beauty" is a currency system like the gold standard. Like any economy, it is determined by politics [...] In assigning value to women in a vertical hierarchy according to a culturally imposed physical standard, it is an expression of power relations in which women must unnaturally compete for resources that men have appropriated for themselves. Beauty is not universal or changeless, though the West pretends that all ideals of female beauty stem from one Platonic Ideal Woman (Wolf, 2002:12).

Indeed, as part of our broader approach to use various practice-based methodologies to approach socio-cultural subjects through design, the fluid perception of beauty and the importance of gender in various cultures is paramount. In her classic book The Beauty Myth (2002), Naomi Wolf highlights the culturally oriented definition of feminine beauty in Western society. The culturally embedded norm of feminine beauty, accordingly, is a result of patriarchal conventions embedded in Western society, culminating in contemporary consumer culture and popular media. Famously, Wolf stresses that beauty is viewed as an objective goal women must embody, and men must possess these model women. Griselda Pollock demonstrated the depiction of femininity and the role of women as objects created for the enjoyment of spectators (men of course) in art history (Pollock, 1988; Parker and Pollock, 2013). Indeed, a useful starting point to imbue students with empathy towards other cultures lies in the comparison between various notions of beauty. Is the lip-disc worn by the women of the Mursi tribe in Ethiopia any different than silicone enhancements or Botox shots in Western society?
Of course, delving into the various aspects of embodiment and theoretical aspects of power and the body are beyond the capacities of this article, yet, we will shed light on several issues regarding the body and femininity, nonetheless. Consumer culture turned the feminine body into an unnatural and technologically molded type unreachable and separated from the "normal" body. The image of the young, slim, muscular body consisting of 0% fat became the global norm, depicting large breasts, a slim waistline and flat stomach (Grogan, 2007).

A central materialization of these feminine bodily perceptions is seen in dolls, and especially so in the case of Barbie. Following various researchers, we can clearly see that Barbie's body is unrealistic, unnatural, and unattainable, yet, it is the best-selling doll, influencing body images of men, women, and children alike. As is the case with many other toys and especially with dolls, children report dissatisfaction with their body image (Worobey and Worobey, 2014). Mattel, building and manufacturing Barbie, send several child-models across the US calling to 'get in shape' as Barbie. Furthermore, one of the most important features of Barbie are her accessories, ranging from makeup to hairdo's to bags and clothes, broadcasting a distinct and exact femininity and sexuality (O'Sickey, 1994). The result is a Western depiction of feminine beauty, specifically distributed in various media, influencing all (Gimlin, 2002) in her plasticity and global appeal, in her manifestation as an almost posthuman technological entity (Toffoletti, 2007).

In this project, designed by Hila Raam, we can see a materialization of three models of femininity, based on a more flexible definition of the term. The empathy in this project stems from the understanding of the Westernized patriarchal view of the feminine body, as well as questioning what are body image norms and what should be designers’ contribution to this important question. The famous Western depiction of feminine beauty, then, is the classic 60-90-60 figure, depicted, among else, in the Barbie doll. Typically, the ideal feminine beauty in Japan calls for long, shiny black hair, white skin, and slender body (Spielvogel, 2003). Alternately, the classic African feminine model, as seen in various art pieces and archaeological figurines boasts large breasts and bottom, echoing fertility and health (Lifshitz, 2009; Shakarov and Senatorova, 2015). In this project, the platform of kokeshi dolls is used to illustrate and question inherent cultural depictions of feminine beauty.

Following the classic craft of the kokeshi, each doll is made of four parts (a head, torso, waist, and

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57 A good starting point, among many, would be the volume *Embodies Practices* (1997) edited by Kathy Davis.
58 A good starting point would be David Hume's classic essay "Of the Standard of Taste" (2008 [1757]).
59 Famously, in medieval Japan, feminine beauty also included shaved and painted eyebrows and blackened teeth, along whitened face, and small, red-painted lips.
legs) along the doll’s traditional size. It typically depicts classic Japanese beauty: long and slender features, flat chest, and pale skin, and made of maple. The maple adds not only the paleness, but also a general flawlessness to its grain, further accentuating the pursuit of flawless skin in Japanese tradition. The African doll bolsters generous breasts, bottom, and waist. This *kokeshi* is made of walnut, a darker tree rich with grain features and natural ornamentation, alluding to tribal painting and scarification. The Western doll depicts a muscular, statuesque, and somewhat unnatural physique. The slender waist, large breasts, smaller head, and muscular legs are further accentuated by the unnatural tan of the reddish eucalyptus. The playful element of mixing the three dolls alludes to the arbitrariness of the judgment of beauty and our own definition of beauty vis-à-vis other cultures.

5 Japan and the essence of tolerance

"I can see you are a man of the way (Dao)," Dōgen said. "Please tell me, what is the true Way?"

"The universe has never concealed it", the cook said and turned back to his work. (Dōgen in McDaniel, 2014: 48).

Using the *kokeshi* outline as a material configuration to develop empathy among students is highly useful since it allows for articulating various socio-cultural attributes. Apart from embodiment, religious tolerance is highly important in a multi-cultural society such as Israel in general and Jerusalem particularly. In fact, one of Japan's most unique attributes is its tolerance towards non-local religions. Conversely, three of the most central religions in Japan are not indigenous: according to US Department of State, 51% of Japanese identified with the Shinto belief, 34% are Buddhists and a meagre 2% are Christians. However, contrary to other cultures, in Japan a person can believe in two sets of faiths, unlike Judaism in which the faithful must be solely Jewish. Religious tolerance and freedom of belief is rooted in the essence of the state taking precedence over all else (Isomae, 2014). In that matter it is understandable that Christianity did not take root in Japan due to its exclusivity ethos. Indeed, while during the 17th century Christianity was banned in Japan, while prior to the Meiji reforms it enjoyed a new-found tolerance (Nosco, 1996).

The history of these four religions and their impact on Japan reflects the history of Japanese culture. Indigenous in nature, Shinto ("way of the gods") is one of the two central religions in Japan, bolstering around 100,000 shrines and 20,000 priests recognized by their unique attire. Earliest records of Shinto date back to the 6th century and survived as a socio-cultural and historical religion till today. The above-mentioned religious flexibility is seen in the fact the while Shinto is the largest religion in Japan, supported by around 100 million citizens, only a small percentage of the populace identifies themselves as Shintoists. Conversely, it would be wrong to define Shinto as a classic religion, but this unique belief-system is embedded in history and practice alike. These include the shrine rituals (since *kami* reside in shrines), as well as holidays and festivals (Breen and Teeuwen, 2010).

Unlike Shinto, Daoism and Buddhism are not indigenous to Japan. Dao was brought to Japan from China, as a philosophic and religious way to reach the Way.

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60 [http://www.state.gov/j/drl/rls/irf/2006/71342.htm](http://www.state.gov/j/drl/rls/irf/2006/71342.htm)
This Chinese belief system was developed between the 2nd and 6th centuries and revolved around the writings of Lao Tzu (especially the famous *Tao Te Ching*). While contemporary Daoism consists of an almost endless variation of approaches, the central ethos revolves around reaching an understanding through oneself (Kirkland, 2004). Daoism is hard to define since it was never united under one rule. In addition, Chinese religion is a mixture of the three teachings (Buddhism, Confucianism and Daoism). Historically, Daoism and Confucianism were related, yet in contemporary Japan few will identify themselves as Daoist. The roots of Dao go back as far as the 4th-2nd centuries BCE (Oldstone-Moor, 2003). Buddhism was introduced to Japan much later. The first official record of Korean king Song Myong sending an image of the Buddha along with several sutras date to 538, yet researchers claim Buddhism reached Japan unofficially much earlier. Prince Shotoku studied Buddhism, erected shrines and is considered the father of Japanese Buddhism (Matsuo, 2007).

The basic configuration of all the figurines, designed by Harel Oberman, follows the dimension and proportions of the classic *kokeshi* doll. Their head is similar and made of cherry, while the bodies vary according to the principal Japanese religions. The Shinto *kokeshi* is made of maple and follows the abstract shape of the Shinto priest's robes. The maple echoes the white collar and black clothes, made of wenge timber. The Buddhist *kokeshi* depicts the a-symmetric orange robes, leaving the right shoulder bare. The doll is made of a combination of maple and red eucalyptus. Finally, the Dao *kokeshi* echoes the ornate and flowing robes of the Daoist monks, made of eucalyptus and cherry. While very un-Israeli in its beginning, this project led our students to reflect upon the need of religious empathy in a multi-cultural city such as Jerusalem.

The material phenomenon of the *kokeshi* doll has taken a turn from its traditional depiction into the current style described as *kawaii* ("cute"). This new style is manifested in the use of pink coloring and limbless figures. As we have seen previously, the overall length of the doll is around 20cm and it is made of two distinct parts, a torso, and a head, joined by a process of heat and pressure. Today *kawaii* refers to an amalgam of concepts such as beautiful, loveable, cool, funny, quirky, and more. The rise of Japanese culture of cute in 1980s meant that girls did not only want adorable accessories, but to become *kawaii* themselves. Several key design features turn something into kawaii: pastel colors, big round eyes, a large head, and general roundish features (Okazaki and Johnson, 2013). Indeed, this cuteness serves as a sort of a ‘poisoned apple’ depicting a sugary coating hiding explosive topics ranging from social and economic inequality to gender bias, religious intolerance, and territorial

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61 By that we are referring to Bourdieu’s famous theory of mimicking a ruling cultural field to shift the power balance between reform and orthodox powers (see, Bourdieu, 1984; 1993)
politics. Through these seemingly alien cultures, the students reflected and confronted their own agendas and belief systems.

Cuteness is not automatically linked to aesthetics, since, as Harris (2001) put it, it is closely linked to the grotesque and the malformed. Yet, marketing agents link more and more products with cuteness, emanating images of helplessness and happiness. In an almost sadistic manner, the cute is a result of an awkward situation in which a blundering and helpless figure finds itself. Furthermore, kawaii gives people the chance to hold on to childhood and postpone the pressures of adulthood (Avella, 2004). While either the traditional *kokeshi* is usually lightly adorned or not at all, the creative *kokeshi* is a direct result of the culture of *kawaii*, identified by brightly colored graphics and a shiny patina. In this project, designer Roni-Lee Berri chose to turn to three major African tribes (Maasai, Karo and Surma) to recreate the traditional *kokeshi*’s minimalism via African symbolism.

Their unique red cape (*dagang*) easily recognizes the Maasai, an indigenous semi-nomadic tribe residing mainly in Kenya and Northern Tanzania. One of the most recognized rituals of the Maasai is the "jumping ceremony", in which young men demonstrate their prowess, strength and agility through a series of jumps. Unlike many other tribes, women have a strong voice in their community. Their shaved heads, bright colorful clothing, beads, and the removal of one of the lower teeth identify them. Women also stretch their earlobe, in which a piece of jewelry or a bead is inserted to keep the gap open (Gupta, 2005). The unique red robe, worn by men and women alike has become a material and visual sign of the tribe (Klumpp, 1981).

The Ethiopian Karo is a small tribe residing on the banks of the river Omo. Scars adorning the chest identify the women of the tribe, symbolizing their strength and endurance to bear and grow children and maintain the household. The unique hairstyle of the women resembles a helmet. Men also scar themselves, usually symbolizing a victory or a successful hunt, by cutting their flesh and rubbing the wound with ash (DeMello, 2014).

The Surma tribe, also residing in Ethiopia, was once nomadic but are now famers. The men of the tribe are famous for their stick ritual in which young unmarried men face each other with long stick (*donga* sticks). The winner, knocking down his opponents, is carried on a wooden platform to a group of young women, one of which will choose him as her husband. The women of the tribe are known for their lip discs. Six months prior to the young woman's marriage, her mother gives her a small ceramic disc that will keep changing in size, gradually broadening, and enlarging the opening in the girl's lower lip. The longer the disc, the larger the dowry the young bride will receive. Once more, the capacity to endure pain, as well as the patience and commitment shown through the lip disc are socio-cultural standards of femininity and worth (Russell, 2010). The Surma are also known as masters of body paint, using their whole bodies as canvas. Every morning during the courtship season, the men, women, and children of the Surma go to the riverbank and gather white chalk. Mixed with water the chalk becomes white paint used to paint their bodies (Beckwith, 2012).

The result of this unique fusion between the platform of the *kokeshi* and the three African tribes as cultural context is extremely interesting. While keeping the proportion of traditional *kokeshi*, the graphics of each doll was excavated from one of the three tribes. The main part of each doll was made of maple, keeping the whitish color of the traditional *kokeshi*. Additional choice of wood was made according to the visual attributes of each tribe.

The Maasai *kokeshi* is recognizable by the lengthy earlobes and the typical red robe, both of which are made of the reddish Bubinga wood. The Karo *kokeshi* is recognizable by the women's unique hairstyle, resembling a reddish helmet, along a V-shaped pattern symbolizing the tribe's scarring rituals. Both the hair, as well as the scar pattern are made of light Wenge wood. Finally, the Surma *kokeshi* is recognizable by the lower lip disc, along a unique tunic worn on one shoulder, leaving a single breast bare. Both lip disc as well as the Surma tunic are made of dark Wenge wood.
as we have seen, building upon seemingly alien cultures, through a material common platform (the kokeshi dolls) allows students to confront and challenge their own beliefs and convention, triggering a deeper sense of professional empathy. These empathy-driven narratives are found not only through cultural objects, but also through common myths and legends, as we shall see next.

6 Red Riding Hood netsuke

Once upon a time there was a little girl who was so sweet and kind that everyone loved her. Her grandmother, who loved her more than anyone, gave her a little cap made of red velvet, which suited her so well that she wanted to wear it all the time. Because of that, everyone took to calling her little red riding hood (Pullman, 2012:137).

As is the case with visual or material culture, folk tales are a vessel to identify and distribute global and local norms, values, and identities. Anthropologists were adamant in their understanding of the correlation between myths, tales and socio-cultural systems (Lévi-Strauss, 1955; Bidney, 1953; Leach 2013, among many others). The various types of myths, tales, legends, and other culturally imbued narratives surpass the modest scope of this volume. However, suffice to say that narratives in their many types, highlighting or neglecting a moral punch, are a globally accepted form of narration (Eller, 2014).

Famously, folk stories and myths mirror are needs, fears and moral constraints, much in the Freudian tradition, which explains the number of dreams and surreal parts in various famous folk stories found in cultures around the world (Ashliman, 2004). In other words, coined by anthropologist Edward Sapir, our socio-cultural raison d’être is mirrored in the structure and sounds of our language (Mannheim, 2015). The centrality of the Red Riding Hood tale can be seen in its versions found in Korea and Japan (Dundes, 1989).

The Aarne-Thompson Index is a well-known classification system for folktales was developed in 1910 by Finnish Antti Aarne and was translated and enlarged by American Stith Thompson in 1928. In this system, tales are classified according to themes, heroes, and other variants, in a manner enabling researchers to compare various folktales in different cultures. The categories include animal tales, ordinary folk tales, jokes and anecdotes, formula tales and unspecified tales (Zipes, 2000). The story of Little Red Riding Hood, numbered 333 in the Aarne-Thompson index holds global attributes of good and evil, nature and culture, youth and adulthood, wisdom, and naiveté and more (Ashliman, 1996). It was through this fable that the designer of these specialized netsuke attempted to rephrase the role of folktales in contemporary lives and their points of correlation between three different cultures – Africa, US, and Japan.

The first literary version of Little Red Riding Hood was written in 1697 by Frenchman Charles Perrault and titled 'Le Petit Chaperon Rouge'. Perrault probably knew an older oral version of the tale in which an unnamed peasant girl meets a werewolf:

*The wolf asks her whether she is taking the path of pins or needles. She indicates that she is on her way to becoming a seamstress by taking the path of the needles. The werewolf quickly departs and..."
arrives at the grandmother’s house, where he devours the old lady and places some of her flesh in a bowl and some of her blood in a bottle. After the peasant girl arrives, the werewolf invites her to eat some meat and drink some wine before getting into bed with him. Once in bed, she asks several questions until the werewolf is about to eat her. At this point, she insists that she must go outside to relieve herself. The werewolf ties a rope around her leg and sends her through a window. In the garden, the girl unties the rope and wraps it around a fruit tree. Then she escapes and leaves the werewolf holding the rope (Zipes, 2000: 301-2).

Contrary to the original version, in which the girl fends for herself, Perrault turned her into a spoiled, naïve, and helpless peasant wearing a red cape, symbolizing her sinful nature. After wagering a bet with the wolf, she loses both the bet and her grandmother. Upon arriving at the grandmother’s house, she climbs into bed with the wolf and after asking him several questions is devoured in much the same manner as her grandmother. The morale of the tale is simple, dictating the fate of immoral girls, showing interest in unknown men. Only in 1812, the brothers Grimm added to their version the Jäger (gamekeeper) who saves both the girl and her grandmother (Zipes, 2000; Haase, 2007). Following Tehrani (2013), the echoes of this classic tale in other cultures brought to fruition the materialization of three sets of netsuke depicting this epic tale of dichotomous forces embedded in a simple depiction of good and evil.

The series, designed by Gal Berlinka, include nine netsuke figurines, three from each culture, representing a good character, a bad character and a neutral one. While the role of the good and bad characters is easily understood as a depiction of social norms, the neutral character's role in to create a certain ambiguity necessary to further highlight the differentiation between good and evil. In structuralism, a mediator whose role is to highlight the differences, as well as the relation between the two binds the two binary oppositions (Mascia-Lees, 2010).

In the Western tradition, the good character, symbolizing morality is the huntsman, reenacting order in the chaotic situation caused by evil. The bad character, symbolizing nature, chaos, ferocity, baser instincts (following the classic structuralist anthropology), is obviously the wolf. The neutral character, symbolizing naïveté, childhood, John Locke’s tabula rasa and the amenability of youth, is obviously Little Red Riding Hood. We can clearly see these three netsuke crafted from a combination of maple, Wenge and red Eucalyptus via stack lamination.

In the African (Yoruba) tradition, the good character, symbolizing order and safety, is Zangbeto, the keeper of the forests, fighting witches and thieves. The bad character, symbolizing nature, chaos, ferocity, baser instincts, is Anansi, the mischievous spider. Unlike other trickster gods, Anansi serves as mediator between his father, the sky God Nyame and the world. The neutral character, symbolizing naïveté, neutrality, helplessness facing nature and an innate ability to get in trouble is man (Haase, 2007; Abiodun, 2014). The three Yoruba netsuke are made of Wenge wood and crafted via a classic African technique of derogation.

In the Japanese (Shinto in this case) tradition, the good character, the discoverer of the Japanese archipelago, the chief of earthly kami, Sarutahiko-Okami, usually depicted sporting a long black beard. The bad character, symbolizing fear, loneliness, ghostly death, and the unknown is Yurei, usually depicted as a pale woman with long black hair. The neutral character, symbolizing mediation and intelligence and bewitchment, is the likeable messenger of the kami, the fox spirit of Kitsune (Williams, 2009; Picken, 2010; Davisson, 2015). The three Japanese netsuke are crafted from a combination of Wenge and maple via joinery.

The depiction of good, evil and neutrality differ in various cultures, leading to differing style and techniques. Therefore, empathy derives not only from variations in cultural values, body imagery or religious beliefs, but of the very definitions of good and bad as well. Through learning about the Other, as well as understanding and accepting differences, designers hone their craft in a positive
direction to include and cater for excluded communities and reflect about the very essence of industrial design – the standard.

7 Of culture and empathy

The word materia is the result of the Romans' attempt to translate the Greek term hyle into Latin. Hyle originally meant 'wood' (Flusser, 2013: 22).

As we have seen, our main pedagogic approach lies in two parallel layers. First, we wish to present the students with the importance of theoretical and methodological understandings of different cultures, not only as an academic necessity, but as a key factor to trigger practice-based innovation. By starting a project with a deeper socio-cultural understanding of a situation, scenario or concept, the designer opens up an almost endless array of possibilities. Furthermore, through this research one identifying with and understanding the other, thus triggering empathy through an unexpected path.

Going back to Henry Dreyfuss' influential work Designing for People (2003 [1955]), brings to our attention that while function, assembly and aesthetics are important, the deeper meaning of an object is as equally important. Flusser, in his mischievous fashion, calls to attention the linguistic-semiotic relation between the essence of craft and wood as a cultural matter. The final phrase of the above quote illustrates the importance and deep relation between design, materials, and culture, as we have seen throughout this volume. Wood, culture (philosophy, religion, norms, rituals and objects and technology, as we have seen) and design have become so integrated in the works presented here they have become almost synonyms. In this last section let us frame these works in contemporary design issues redefining the designer and the design process.

The Bauhaus and its offspring offered a universal mode of design. Integrating new technologies, modes of production and a global semiotic material and visual language, their legacy transcends time. While political at its essence, the late 20th century, and the early years of the 21st century brought forth global design characterized by the strength of brand identity, advanced ergonomics and rise of the software (could-computing, autonomous cars, apps etc.) brought forth a new form of global design. While German designers redefine Korean car brands, Japanese designers’ rule over the Italian Mecca of design, global design is here to stay. However, facing political turmoil, amidst eco-social movements, anti-branding and economic crises, the importance of the local has never been more acute. Rather than turning to the not-so-fresh concept of the "glocal" we wish to suggest a different route, turning to two well-known concepts – design culture and craft.

As the number of cultures far surpasses the number of states throughout the world, the importance of integrating cultural aspects to the design process is crucial. However, as we have seen in this volume, the issue is not to imitate or copy, but rather understand and create a different interpretation, or rather of fusion of another culture's principles and one's own. In this article, we followed the footsteps of design culture researchers such as Guy Julier (2013) and Glenn Adamson (2013), highlighting the cultural aspects of design and the interdisciplinary aspects of the discipline. However, our focus and scope is different. Through understanding different cultures, under the material umbrella of design, we define design anthropology not just as a theoretical or applied addition to design practice, but as an inherent addition, one that should become part of the practice. Penny Sparke (2013) discussed at length the intricacies of the cultural and historical elements on the evolution of design, bringing forth a culture of consumption and rise of the era of design. Julier (2013) describes "design culture" as something designers do, but also as part of the flows of global culture, embedded in communication, media, and social norms. As Julier rightfully explains, design culture deals not only with ways products are produced and planned, but also used, lived, perceived, and understood in our daily surroundings. Julier describes design culture as consisting of several layers: process, context-informed practice, organizational or attitudinal, as agency (the ability to generate social change) and finally, as
pervasive but differentiated value. As a result, Julier (2006) calls for a shift of attention from "visual culture" to "the culture of design", focusing on the broader issues and layers of design as a socio-cultural agent. Indeed, our deeper pedagogic raison d'être lies in the notion that empathy in relation to design practice resolves not through the obvious and 'easy' choices, such as design for inclusivity or design and disability but rather through the unobtrusive title of 'design and culture'. Through a deeper understanding on another’s culture, the designer questions their own belief system, norms, and conventions.

In this article we highlighted a different approach towards design that in many ways contradicts many of the design pedagogical approaches used by designers. Rather than start by defining the design brief according to a problem, functional issues, or target population we started by defining a cultural, social, ritualistic, religious, or philosophical attribute of a specific social group. We then move to redefining this abstract feature vis-à-vis visual and material features and finally proceed to defining an object and manufacturing technologies. In a way, our design process went as follows: by bringing cultural attributes to the center of the stage we believe designers will take their place as Renaissance humanistic agents, materializing socio-cultural concepts and influencing society. In doing so, using wood as a major material, the idea of "makers" will be imbued with an extra layer of relevance and meaning. While the term "craft" suffers from a multitude of trendy new names (neo-craft, new-craft, post-craft, etc.), Glenn Adamson (2007; 2013) calls for integrating the term "makers". As we can see throughout this article, craft should not be reduced to material folk product or historic leftovers, but rather a mode of contemporary innovation. However, we believe that this term far transcends its William Morris-imbued meaning to conclude contemporary designers integrating new (3D printing for instance) and traditional (cabinetmaking) technological ways of production. As the production and use of materials derive from socio-cultural traits the designer focuses on the design situation rather than just the product, rendering the designer's work to a much broader vista of a cultural interpreter.

As we believe design anthropology is crucial for young designers, as an innovative creative tool, this article helps redefine the possibilities of this sub-discipline, not only as a supplier of theoretical or methodological venues, but as a practice-based trigger of innovation and interpretive empathy towards the other. Understanding and identifying with others will not only help us better understand our place in the world but more importantly, redefine the very role of designers in their communities, as well as their impact in society.

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Factors, strategies and criteria in design convergence

Naz A.G.Z. Börekçi
Middle East Technical University, Department of Industrial Design, nborekci@metu.edu.tr

Abstract. A study was carried out for investigating design convergence in a 2-in-1 hand-held stick vacuum cleaner project conducted with graduate design students. The design process was composed of three stages, problem analysis, idea generation and evaluation, defining three sets of divergence-convergence activities. The study is mainly based on the responses of the students (n=30) to a survey distributed in class. The survey consisted of six open ended questions that inquired into the 2-step convergence carried out in the idea generation stage, 1) for the generation of six alternative design solutions from a morphological chart containing sub-solutions for product sub-functions, and 2) then for the development of one final design solution. The data was subjected to thematic and content analyses. The findings reveal five factors, five strategies, and eight criteria that explain how acts of design convergence have taken place for the students.

Keywords: Convergent thinking; design convergence; design education; design methods.

1 Introduction

In the double-diamond design process model, based on the linguist Banathy’s (1996) dynamics of divergence-convergence model, and later on popularized by the Design Council, UK (2019), a series of ‘divergence followed by convergence’ acts take place, the first set for framing the design problem, and the second set for naming the design solution. Divergence in design has been an objective in the pursuit of situated solutions to a design problem, as this provides designers with a widened solution space containing numerous and diverse alternatives (Jones, 1980). Convergence, on the other hand, is the narrowing down of these alternatives, requiring an assessment, selection and transformation of those that they find best matching the problem (Jones, 1980; Lawson, 2005), and this may prove to be more difficult. During design exploration, we expect our students to generate many ideas and suggest methods for them to support divergence. On the other hand, we seldom offer them methods of convergence for proceeding from many ideas to few, as this seems to be inherent in their design activities carried out during the course of the design process, and the related activities depend on the nature and requirements of the design problems dealt with. Based on the interest that this issue has raised for me, with this paper I inquire into how design convergence takes place for students, as they prepare for the delivery of their design output.

1.1 Aim of the paper and research questions

Referring to convergence as pinned in the double-diamond design process model, in this paper I address the following questions:

- What are the acts of design convergence?
- How does design convergence take place in reference to these acts?

The study described in this paper first reviews the conduct of a short-term design project on 2-in-1 hand-held stick vacuum cleaners (2-in-1 SVCs from hereon) carried out three years in a row in a graduate design methods course. In the first year when this project was applied, the decision-making
activities of the students took my attention, and therefore, in the following two years, I followed the same design process for the same project topic, and additionally I gave the students of those years, a survey as the follow-up of the project outcomes, questioning their acts of design convergence. The process of the project was planned based on the double-diamond design process model, with a series of activities employing tools and methods supporting divergence and convergence. Towards the end of the 5-week project, as they were preparing for their project delivery, students were given the survey forms to reply in written. The survey in both years contained open ended questions, and responses were collected for a total of 30 students. The questions were related to the design convergence activities of the students, following design divergence through which they had generated numerous alternative sub-solutions for 2-in-1 SVCs. The aim was to identify the influences that contributed to and thus explain their process of design convergence, first for developing six alternative design solutions, then for sifting them into one final design solution.

This paper begins with a literature review on design convergence in order to provide a theoretical framework on the design convergence activities to set basis for the analysis of the survey responses. Then, the design process for the 2-in-1 SVC project is described in reference to the activities of divergence and convergence, illustrating with examples from the class activities and project deliverables made for each stage. Finally, the survey responses are analysed in reference to the project, and the findings are presented explaining how design convergence has taken place for the participants.

1.2 Design convergence

Convergence is the cognitive effort of narrowing down by eliminating alternatives and refining those selected. Design convergence involves assessment, decision making and design synthesis. The main thinking type involved in this process is convergent thinking.

1.2.1 Convergence as a stage in the design process. Jones (1980) names the three stages of the design process as divergence, transformation and convergence, which are methodologically separated according to the requirements of a well-working process at the systems level. In divergence, the design problem is identified, objectives are defined, and the primary uncertainties are resolved. In transformation, design exploration is carried out, yielding alternatives to evaluate in terms of the secondary uncertainties related to the problem area. In convergence, the alternatives are reduced until a final design solution is obtained.

The stage of convergence has certain features, as Jones (1980) explains. As the problem is dealt with more and more closely, those alternatives that are not worth investing in, need to be identified quickly and put aside, making persistence and rigidity of mind and method critical (Jones, 1980). Design exploration in the transformation stage takes place more at a general level, therefore some sub-problems may have been avoided during this stage. During convergence, these sub-problems may prove to be critical and have to be dealt with, calling for negotiation, which may result at the cost of some of the design decisions made earlier. The representations of the design alternatives will have to be more in detail, for an effective assessment. The design iterations will require approaching the design solution both with an in-out and an out-in strategy, meaning the external form will need to be considered simultaneously with the internal arrangement of components, towards a match (Jones, 1980).

1.2.2 Convergent thinking. Convergence involves design acts which integrate and further synthesize ideas through deductive generation towards developed and finalized designs. In divergence, alternative ideas are generated, and in convergence synthesized ideas are explored (Lubart, 2016). Basadur (1994) states that it is convergent ability that transforms divergent thinking into creative output; accordingly in their study, Zhu, Shang, Jiang, Pei and Su (2019) provide
evidence that divergent thinking can play a role in creativity only when convergent thinking capacity reaches a certain level.

Studies have shown that convergent thinking is more impactful on problem-solving in creative contexts; it is also acknowledged that convergent thinking provides control in chaotic activations caused by divergent thinking (Webb, Little, Cropper & Roze, 2017). Convergent thinking may benefit from less impulsiveness and risk-avoidance when creative problem-solving (Shen, Hommel, Yuan, Chang & Zhang, 2018). Creativity requires divergent thinking for lateral transformations, as well as convergent thinking for vertical transformations; divergent and convergent thinking are seen in the creative phases of design process as happening in cycles, linking forward movements with past movements, and in each cycle, ideas are generated through divergence then explored and evaluated through convergence, for transformations to be complete (Goldschmidt, 2016). Hence it is possible to refine and finalise design solutions. Ability to deliberately control the activation and usage of divergent and convergent thinking correlates with the success in creative ill-defined problem-solving and of its result (Wolf & Mieg, 2010).

1.2.3 Role of knowledge and information in convergence. Cropley (2006) explains that knowledge is of particular importance in convergent thinking, as it is the source of ideas, pathways to solutions, and criteria of assessment. Knowledge prepares the mind to check and test alternatives, compile further information and make strategic decisions; this preparation is important so that during convergence, the existing can be refined based on new insights, and intuition from the decision maker’s part can also play its part (Cropley, 2006). In this process, speed, accuracy, unambiguity, logic, and recognizing the familiar are among keywords that play role in decision-making, and are all closely linked to knowledge (Cropley, 2006). Successful design convergence takes place when designers are able to make use of other knowledge types besides design knowledge and are able to avoid “conservative thinking styles” (Jung & Chang, 2014, p. 1), meaning those that obligate designers to keep to known rules and procedures (Zhang, 2009), prevent them from taking risks and restrict them from moving away from previously recognised solutions.

During design convergence, information (knowledge, designs, variables, etc.) will need to be organised, and hierarchical classification schemes are a way of doing this (Müller-Wienbergen, Müller, Seidel, & Becker, 2011). Such schemes allow the organisation, categorisation and ordering of information, and tools such as the interaction matrix, classification trees and weighting trees (Cross, 2000; Roozenburg & Eekels, 1995; Wright, 1998) can be given as examples. Lawson (2005) explains that measurement in design requires a balance of quantifiable and qualifiable judgment of alternatives against criteria. For example, ordering design solutions according to preference will require assessing each design against each criterion, then combining these assessments. Three issues will surface as difficulties: 1) not all criteria will be of equal value, requiring a weighting among them, 2) some criteria will require objective judgment whereas others will require subjective judgment, and 3) these judgments will have to be combined for an overall assessment. Quality and quantity in design evaluation is intertwined, and inevitably, this will also include value judgments. Values may be subjective, such as goodness and usefulness, as well as objective, such as those defined in standards and regulations. As values will be relative, it is important to develop a common scale of measurement considering the advantages and disadvantages of a decision for all parties involved, and with which the decision makers and the stakeholders agree to an optimal degree (Lawson, 2005). A group (e.g., design team) determines the criteria against which to assess the alternatives based on information, and the quality of information given prior to the process affects convergence. Particularly when the process is not rushed and time is allowed, team coherence takes place, leading to better design performance, and better formulation of the assessment criteria (Fu, Cagan, & Kotovsky, 2010). Convergence will be considered successful when the decision makers are convinced that they have chosen the best possible solution to an ill-defined problem.
1.2.4 *Framework of convergence for this study.* Convergence, reducing the alternatives into one, is a function of the acts of *critical assessment* made in terms of many factors, *design synthesis* made through the integration of relevant information with detailed design representations, and *decision making* made by matching solutions with the design problem, all requiring a decisive attitude that is based on well-informed judgments. *Decision-making*, as a mechanism of convergence, may be subjective, e.g., based on personal attitudes, as well as objective, e.g., based on a match between the project objectives and design decisions. Convergent thinking lies in the core of convergence and is best supported with methods and approaches that facilitate, but also control, both the generation (through divergence) and the exploration (through convergence) of alternatives, and the compilation and processing of knowledge towards design synthesis. Having thus answered the first research question for this paper, “what are the acts of design convergence”, this study investigates the involvement of these acts in the process of a design project carried out with graduate design students, with an attempt to explain how design convergence takes place.

2 *The design project: 2-in-1 hand-held vacuum cleaners*

Three academic years in a row (2017-18, 2018-19 and 2019-20), a short-term design project was conducted on the renewal of the 2-in-1 hand-held stick vacuum cleaner (2-in-1 SVC), for a graduate course on design methods. This course is given for 14 weeks in a semester, and the weekly teaching hours is 4. The course aims to teach various design methods and provide a medium in which these can be applied on short projects. Following 4 weeks of lectures, two projects are conducted in the course; one follows a problem-oriented process, and the other follows a solution-oriented process. The process described in this paper was followed for the first project of the semester, integrating various design methods into a structured, problem-oriented design process, from idea generation to design development and evaluation. In the above-mentioned academic years, the same design process has been used for the conduct of the 2-in-1 SVC project, and the project took 5 weeks in total (20 hours).

2.1 Participants

Throughout the 3 academic years, a total of 47 students participated in the project (Table 1). The courses were conducted entirely in English. The survey respondents were students from the 2018-19 and 2019-20 academic years. A total of 33 students attended the course in these years. Thirty were master of science students, and three were PhD students. Thirty-two were from a design background (30 industrial design, 1 architecture, 1 graphic design) and one was from a non-design background (mechanical engineering). Thirty-one students were Turkish, and two were from other nationalities (1 Egypt, 1 Pakistan). Thirty of these students responded to the survey (3 Turkish students from a design background did not respond).

<table>
<thead>
<tr>
<th>Participations</th>
<th>Female</th>
<th>Male</th>
<th>MS</th>
<th>PhD</th>
<th>Design background</th>
<th>Non-design background</th>
<th>Turkish</th>
<th>Other Nationality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-2018</td>
<td>7</td>
<td>7</td>
<td>11</td>
<td>3</td>
<td>11</td>
<td>3</td>
<td>12</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>2018-2019</td>
<td>10</td>
<td>4</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>1</td>
<td>14</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>2019-2020</td>
<td>9</td>
<td>10</td>
<td>17</td>
<td>2</td>
<td>19</td>
<td>-</td>
<td>17</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>21</td>
<td>41</td>
<td>6</td>
<td>43</td>
<td>4</td>
<td>43</td>
<td>4</td>
<td>47</td>
</tr>
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</table>
2.2 Design process and project conduct

The design process was composed of three stages. The students were expected to make an individual final submission. Each step of the stages required output submitted individually, except for the morphological chart, which was carried out in teams. The students were asked to work in groups (interactively, or simply in parallel), even when a task required individual submission, in order to help each other, keep up with the pace of the class, enhance the cognitive effort, and enrich the content of the output. For each academic year, the project process was well-documented with the anticipation of such a study. The submissions made for each step of the process were digitally collected, forming a large set of visual material, for future reference. The following sections provide a general description of the process stages, covering all three academic years.

2.2.1 Problem analysis. The design process begins with Problem Analysis. The project briefing is made, the goal is set for product modifications, project dimensions are discussed, and students are asked to consider various issues such as the user, use environment, usage, maintenance and storage. Following, students carry out in-class product trials with numerous 2-in-1 SVCs brought to class for function analysis (Cross, 2000; Pahl & Beitz, 1996; Roozenburg & Eekels, 1995) and operational sequence analysis (Kirwan & Ainsworth, 2005) (Figure 1). Table 2 shows the 2-in-1 SVCs used in the product trials for all three years. This is followed by an analysis for quantified structure (Tjalve, 1979), where the interaction between the components is studied first in 2D as diagrams and then in 3D with simple mock-ups, showing the configurations of the components in their correct proportions and rough forms (Figure 2).

![Figure 1. Left: Product trials in class, 2019-20. Centre: Study of component configurations during product trials, on whiteboard, 2018-19. Right: A function analysis study, 2017-18](image)

Table 2. 2-in-1 SVCs used for product trials

<table>
<thead>
<tr>
<th>Arnica Tria Pro</th>
<th>Arzum Hera</th>
<th>Fakir Darky ÖKO</th>
<th>Fakir Franky</th>
<th>Vestel Rüzgar 3000</th>
<th>Homend Dustrider</th>
<th>Rowenta Extreme cyclone</th>
<th>Fakir RCT 144 Turbo</th>
<th>Sinbo</th>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-2018</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018-2019</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019-2020</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
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</table>
2.2.2 Idea generation. The process continues with Idea Generation, relying heavily on the Morphological Chart method (Cross, 2000; Pahl & Beitz, 1996; Roozenburg & Eekels, 1995; Wright, 1998) for design divergence and convergence. This method involves idea generation for the components of a decomposed design problem, not looking for novelty in particular, but aiming for quantity and variety. The method asks for the design problem (in this case, the 2-in1 SVC) to be decomposed into its sub-functions (i.e., product components each fulfilling an individual function). Identification of 8 to 12 sub-functions is recommended for this task (Cross, 2000; Roozenburg & Eekels, 1995; Wright, 1998). These sub-functions are placed in the rows of the morphological chart.

Then for each sub-function, 6 ideas (sub-solutions) are generated in the cells of the row, each different in terms of the means that can fulfil the sub-function. Offering alternative sub-solutions for all the sub-functions yields a chart with numerous sub-solutions (e.g., 12 sub-functions x 6 sub-solutions = 72 sub-solutions) to pick from and combine into an overall design solution, with the combination possibilities being almost endless.

This functional decomposition calls for a thorough understanding of the essential function of the product and how it operates (Srinivasan, Chakrabarti & Lindemann, 2012; Wright, 1998), and is done in a brainstorming session with the class. The sub-functions are open to design interventions that can reflect as improvements on the overall final design solution. Once the chart is conjointly completed, students may now individually select sub-solutions for the sub-functions and combine them into overall design solutions (Figure 3). This calls for a 2-step convergence, the first step resulting in six alternative design solutions represented in 2D (Figure 4, left).

With a break from design activities, a brainstorming session is carried out with the class, where project objectives are determined altogether, and then ranked in order of importance, using an interaction matrix (Jones, 1980). In the second step of convergence, students reflect on their six alternative design solutions and select one to develop into a final design solution (Figure 4, second). The students are expected to finalize their design individually and present as a full-scale paper-based model (Figure 4, right). Model making is done in class, with shared tools and materials, and an opportunity for interactive discussions among class members (Figure 4, third).
Figure 3. Left: Sub-functions identified for the morphological chart, 2017-2018. Center: Team working on their morphological chart, 2019-2020. Right: Completed morphological chart, 2018-2019

Figure 4. Left: Convergence step 1, six alternative design solutions from the morphological chart; Second: Convergence step 2, one final design solution, Doruk Öktem, 2019-2020. Third: Model making in class, 2018-2019. Right: Full-scale model for 2-in-1 SVC, Yağmur Merve Arık, 2017-2018

2.2.3 Evaluation. The process concludes with two rounds of Evaluation. The list of rank-ordered objectives is used as reference to evaluate the design ideas represented as full-scale models, during an expert opinion jury session (Figure 5, left, centre). Each idea is presented to the jury and class. Jury members give feedback to each student on their design solution. In the background, peers listen to the discussions and occasionally participate, filling in individually, in real time, a shared online document, applying the searching for visual inconsistencies method (Jones, 1980) for the visual and functional contradictions in the design and for suggestions on how to improve these, in reference to the project objectives, personal opinions, and jury feedback (Figure 5, right). This online form is accessible to the students, who are then expected to improve their design according to the qualitative feedback given by the peers, and the experts, for the following week.

Figure 5. Left: Jury for expert opinion, Ayşe Kaplan 2018-2019. Center: Jury for expert opinion, Hakan Dinçer, 2019-2020. Right: Peer evaluation during jury; students filling the online visual inconsistencies form, 2017-2018
The models are revised and submitted for the following week’s final evaluation. This is a quantitative peer evaluation, based on the *relative importance ratings* (RIR) for the project objectives, determined altogether through brainstorming, using the *objectives weighting tree* (Cross, 2000; Wright, 1998) (Figure 6, left). The objectives are revised and explicitly defined during the activity, which leads to an increase in their number (e.g., 14 objectives determined earlier, may result in 23 elaborated objectives for the final evaluation) and each is given a relative importance rating (RIR). The final design models are exhibited, and the students act as panel members, evaluating each design solution on their charts, in reference to the rated objectives (Figure 6, right). Each chart produces quantitative scores for the designs, which are then combined, to yield the accumulative scores. These scores provide a rating of the appreciation given to the final design solutions. Rank ordering the final design solutions according to their scores open up a final interactive discussion on the qualities of the designs, before the project is closed.

**Figure 6.** Left: Objectives weighting tree for RIRs, on class whiteboard, 2018-2019. Centre: Presentation to class, Yashar Kardar, 2017-2018. Right: Class listening to peer presentation, with exhibited models for RIR evaluation, 2019-2020

### 2.3 Convergence in the design process

For this study, the design process followed was reviewed for the acts of divergence and convergence, and a series of diamonds were identified on which three design iterations were based (Figure 7).

**Figure 7.** The triple-diamond design process model for the 2-in-1 SVC project

#### 2.3.1 Divergence-convergence in Stage 1 Problem Analysis

The first takes place in the *Problem Analysis* stage, where product trials and the accompanying function and operation sequence analyses contribute to defining the problem space, followed by an exploration of 2D quantified structures to
open up the solution space. The stage concludes with an act of convergence, where students carry out reflection on the numerous 2D quantified structures and transfer a number of these into 3D mock-ups.

2.3.2 Divergence-convergence in Stage 2 idea generation. This stage is characterized by a divergence effort made for the decomposition of the product into its sub-functions and design exploration for sub-solutions using the morphological chart. Having completed the chart interactively in teams, students then individually carry out acts of convergence in 2 steps, where they first combine the sub-solutions into six overall alternative design solutions, and then transform these alternatives into one final design solution (Figure 7, Convergence Step 1 and Convergence Step 2, indicated in red). Between these steps, the brainstorming session for project objectives provides an opportunity for students to reflect on the criteria on which they can ground their decisions for idea exploration, assessment and selection.

2.3.3 Divergence-convergence in Stage 3 evaluation. This stage is characterized by the expert and peer reviews offered to the students for their design ideas. In terms of divergence, feedback given in the expert opinion jury, parallel to the peer feedback given on visual inconsistencies, provide reference to students for their design revisions. Students are expected to consider this qualitative feedback, and reflect them on one final full-scale model submission, to the degree which they find fit, requiring convergent thinking.

3 The survey

With the aim of investigating the acts of design convergence within the design process, a survey was prepared and distributed to the students of the 2018-19 and 2019-20 academic years. Table 3 shows the number of respondents to the survey in each year.

<table>
<thead>
<tr>
<th></th>
<th>Questions 1-4 (No. of respondents)</th>
<th>Questions 5-6 (No. of respondents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018-2019</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>2019-2020</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

The focus of the survey was the two steps of convergence taking place in the Idea Generation stage, where students narrowed down their design ideas first into six alternative design solutions, and then into a final design solution (Figure 7). The survey was distributed to the students at the end of their model making activities for their final submission; this was found to be a suitable time for reflection as students had concluded their designs at this stage. The same six open-ended questions were posed in the survey in both years. The first four questions inquired:

1. The factors that affected the selection of sub-solutions from the morphological chart to bring together into six alternative design solutions;
2. How the sub-solutions were processed into overall alternative design solutions;
3. The factors that affected the development of the final design solution; and
4. The strategies used for the development of the final design solution.

The final two questions were on the priorities of the students. The questions inquired:

5. Which project dimensions were considered for the alternative design solutions; and
6. Which project objectives were considered for the final design solution.
3.1 Analysis of the data

The survey was distributed to the class as a two-page print form (one double-sided A4), and the students were given time to respond and submit (Figure 8, left). The forms were gathered in folders. The collected data was written verbal statements of qualitative nature, and this data was analysed using thematic analysis (Braun & Clarke, 2015) and content analysis (Krippendorf, 2018). The responses for each question were read through across all forms, and each response was summarised and transferred by hand as annotations onto a sheet (Figure 8, centre). The annotations were colour coded according to thematic content, and then transferred onto a digital spreadsheet, where they were grouped into topics according to the questions (Figure 8, right). These topics were then revised for content related to the students’ acts of convergence.

The aim of the analysis was to derive and compile the approaches of students to design convergence, and all hints were considered of equal value; therefore, the analysis did not include frequency count for mention and no hierarchy between the themes were sought for. All the same, the findings presented in the following section from time to time use “all” referring to all of the students, “most” referring to more than two thirds of the students, “many” referring to between one and two thirds of the students, and “some” referring to less than one third of the students.

Figure 8. Left: Example survey form filled by respondent, 2019-20. Center: Annotations from survey forms on sheet showing codes (themes) in colour. Right: Example page from digital spreadsheet grouping topics (content)

3.2 Findings

The findings reveal numerous themes collected under three main titles, namely factors (“what”) that the students considered, strategies (“how”) that they followed, and criteria (“why”) they used for judgment during design convergence.

3.2.1 Factors. Factors were the issues that students considered for convergence; they were related to decision-making in particular. Factors were identified from the responses given to the survey questions 1 and 3, but responses to all questions were also cross-checked for related content. Five factors were identified from the survey responses.

1. User: According to the survey responses, the user came forth as the most prioritized project dimension for the students, mentioned by all. The user was in many instances described as a single person living alone in a small flat, 1) expecting “practicality”, “ease of usage” and “effortlessness” from the 2-in-1 SVC, supported with ergonomic features a) preventing fatigue from repetitive arm movements and long-term handling, and b) allowing easy gripping of the handle. Consideration was given to adjustable stick height, adjustable handle for hand-held component, balance, and a “flexible centre of gravity” that could be changed according to the component being used (i.e., handheld, or stick vacuum). 2) Physical interaction with the 2-in-1 SVC was expected to be easy as well as “speedy” in terms of a) converting from stick to hand-held vacuum cleaner, b) removing the hand-held component from the stick, c) assembling and disassembling components and accessories (e.g.,
filter, bin, nozzles and accessories), d) charging batteries, e) accessing and putting away accessories, and f) cleaning, maintaining and repairing the device. 3) Weight reduction, foldability for storage and space-saving purposes, and portability from room to room were among considerations for providing “healthier usage conditions” for the user and their “well-being”.

2. User experience: Positive user experience was considered, with 1) easy to access controls on body, handle and stick, 2) feedback mechanisms such as displays, touch screens, sound and light for warning, and process information, and 3) understandable interfaces for product mode, speed and suction power selection as well as adjustments for different accessories used for different surfaces or dirt types, and 4) effective feedback (e.g., in terms of remaining battery level) to prevent interruptions during usage. Besides usage, a positive experience was also considered for storage, such as 5) making the device compact, flat or keep upright for space saving purposes, and 6) not having “different accessories lying around” but instead finding means to keep them together neatly.

3. Use environment: The use environment was considered as the home, with usage in different parts of the home that have 1) different surface types, such as carpets, wood flooring or ceramic tiles, 2) different levels of difficulty such as stairs, corners or underneath cupboards, 3) different heights such as floor, furniture upholstery, top of door frames, and curtains, and 4) sources that generate various dirt types. These were mainly resolved with nozzle accessories and features that a) were either multiple and different, or few and multifunctional, b) could detect the changes of surface types and adapt adjustments (e.g., suction power) and features (e.g., retracting brush) accordingly, c) could detect the type and amount of dirt, and adapt accordingly with adjustments to settings and accessories, and d) with angular or curved stick structures that allow reaching to “difficult areas”, “narrow corners” and “small areas”.

4. Design features: 1) Maneuverability of the 2-in-1 SVC as both hand-held and stick, as well as the manipulability of the components during usage and maintenance (e.g., removing, emptying and replacing bin) were among the priorities. 2) A self-standing structure was defined for the 2-in-1 SVC during usage as well as during storage. 3) Components such as nozzle, filter compartment, dust bin and handle were mentioned in terms of “design”, “geometry” and “aesthetics”, with an emphasis on “consistent visual identity”, not only for visual appeal but also for solving use related problems (e.g., nozzle design allowing to reach narrow corners). 4) Differentiation from as well as resemblance to the products available in the market, were mentioned as considerations. Differentiation was sought through features such as transparent bin, exhaust panels, multifunctional and adaptable nozzle accessories, direct access to filter via a separate compartment, and solutions for positioning, winding and storing cable.

5. Design directions: Students described concerns for developing solutions “with a meaningful message”, and “that solved problems rather than create ones”. To achieve this, they reported 1) determining goals for themselves (e.g., ergonomics, special user groups), 2) deciding on a concept and following it through (e.g., flat, for space saving purposes), and 3) developing themes (e.g., comfort, adaptability, cute house robot). These goals, concepts and themes were used to generate ideas for sub-solutions, assess and improve them, group them (e.g., technological sub-solutions, mechanical sub-solutions), then bring them together into overall alternatives. 4) Once the project objectives were set, in the second step of convergence (developing one final design solution), all students mentioned that they aimed to respond to these. The most frequently mentioned project objectives were user comfort, ease of use, enhanced user experience, user friendliness, and usefulness. One student mentioned that combinations of these objectives provided “added value” to the final design solution.

3.2.2 Strategies. Strategies were the ways in which the students carried out convergence; they were related to design synthesis in particular. Strategies were identified from the responses given to the survey questions 2 and 4, but responses to all questions were also cross-checked for related content. Five strategies were determined from the survey responses.
1. Strategies for selection: Students reported having selected the sub-solutions to bring together 1) based on “problem hierarchy”, in terms of the most problems resolved with a component. These problems were those identified during product trials, as well as through past personal experiences. Students also mentioned 2) selection according to “function priorities”, and “most important and relevant features”. One student mentioned having a main functional focus (e.g., form that can be both hand-held and stick without any component removal) and bringing together sub-solutions that fitted this idea. Another student mentioned 3) rank-ordering alternative sub-solutions in terms of importance while deciding on whether to incorporate them as a feature or not. 4) Priorities (e.g., user comfort, ergonomics, adjustability), criteria (e.g., realizability, cost-efficiency, functionality, compatibility) and project objectives were also used in selection. A number of students indicated 5) “liking an idea”, “favoured idea” and “personal preference” as reasons for choosing sub-solutions. Finally, 6) the qualities of the sub-solutions were also a reason for selection. Some students indicated that they selected according to visual appeal and “aesthetic match”, whereas others indicated that they selected according to types, such as “technological sub-solutions”, and “mechanical sub-solutions”.

2. Strategies for elimination: Some students also limited the number of alternatives to consider by eliminating sub-solutions that were “unrealistic”, “non-practical”, and “considered extra” (e.g., additional feedback mechanism, nozzle extensions for different surface types). During design synthesis, if a sub-solution would not fit an overall form as a design feature, this was also a reason for elimination.

3. Strategies for building configurations: While transforming the designs, some students reported 1) grouping sub-solutions first, according to a) determined concepts or themes; b) specifications or selected functions; c) working principles for the overall design; d) visual appearance for the form; and e) those that they “would like to work on”. Once the sub-solutions were grouped, some students 2) studied the interactions between them, and configured the ensemble accordingly. Others reported 3) determining a main component and building other sub-solutions around it; or 4) combining each sub-solution with its neighbouring component first, making changes to the sub-solutions and building the form on the way. Some students reported that they 5) decided on the overall form first (indicating that they “already had rough ideas for the forms” to begin with), then decided on the “location” (configuration) of the components on the body. Others stated that they 6) grouped the sub-solutions according to the main functions to which they related (i.e., hand-held vacuum, stick vacuum), brought them into two combined larger components, and then studied configurations for the two ensembles to bring them together into overall design solutions. One student indicated that s/he 7) determined one or two features that s/he would like to have common on all six alternatives and chose the remaining sub-solutions in order to variate the alternatives. All respondents, except for two, indicated that they 8) checked and modified components for compatibility with each other and also with the overall resulting configuration. Two students indicated that they 9) made no changes in the sub-solution designs and combined them directly.

4. Usage of methods: Many students followed a methodological approach in assessing sub-solutions, building the alternatives, and developing the final design solution. A quotation from one of the respondents illustrates the process that s/he followed: “I reviewed the morphological chart, chose some sub-solutions to combine, so I had rough ideas for overall form to begin with. Then in my mind I modified the underlying ideas in each into different configurations, eliminated sub-solutions accordingly, and adapted the sub-solutions I wanted to use. I used my project criteria to assess the alternatives and further develop their designs.” Some students mentioned the methods used in class for the project in the decision making and design synthesis processes. Relative arrangements of components, tried out in the method of searching for quantified structures, were reported to form the basis for the structural configurations onto which the sub-solutions were built, whereas interaction nets were mentioned to be used in determining how components could come together. The
morphological chart method was commented upon, as being useful in generating numerous and diverse ideas, opening up possibilities for variety in the alternatives rather than repeating similar design ideas. One student mentioned having used scenarios for empathy building and design assessment. One student mentioned having made an online product survey “to check how features are used together” during convergence for six alternative design solutions.

5. Usage of tactics: All students used certain design tactics in their second step of convergence, while developing their final design solution.

a) Tactics for transformation

Combination: Students reported having combined features of two main alternatives, features from multiple alternatives, and features from all six alternatives. Combinations were made by bringing solutions that “made sense together” and bringing “the best features” from all alternatives into a new design solution.

Addition: In some cases, the combination of features into the final design solution required that some sub-solutions were eliminated, and new ones were added instead. Students reported having used new sub-solutions from their morphological chart, as well as entirely new ideas they devised according to the requirements of the transformation.

Adaptation: Students indicated that for the final design solution, form had to be adapted according to the “component operation”, “aesthetics” of the overall design, and “assembly style” of the components. One student reported having transferred the structural assembly of one of the six alternative ideas onto the alternative selected as the final design solution. One student reported having transferred minor but useful details from other alternatives onto the alternative selected as the final design solution.

Modification: Modifications on features placed on the overall design solution were made for “design quality”, ensuring match between the design solution and project objectives, according to experience from product trials, and according to personally set criteria (e.g., easy separation of handheld vacuum component from stick structure).

Negotiation: Transforming sub-solutions into an overall design required that design features were negotiated for aesthetic as well as functional compatibility. For this, students mentioned having developed additional details for neighbouring component connections, and for components to nest, host or accommodate each other. In some cases, this design negotiation had to end with the elimination of some sub-solutions, and addition of new ones. Design negotiation also took place between a component and the overall structure and form of the design, resulting with changes of features on either.

b) Tactics for evaluation

Diversification: Students indicated that they aimed for variety and diversity among their six alternative design solutions. For this they combined different sub-solutions, took into consideration different specifications for each alternative, and also made use of the various goals, themes and concepts they determined for themselves.

Differentiation: Students indicated that they strived for differentiation in their final design solution from products available in the market, products used in the class for trials, and alternative design solutions that their peers generated. For this they reported to aim for “developing an entirely new idea” or changing features of their solutions in terms of design, and “adding value” to their designs by responding to the usage problems they identified during product trials.

Revision: While making design decisions, students reported reviewing the objectives list, the morphological chart for overlooked ideas, and their alternative design solutions. While making these revisions, students indicated that they crosschecked their designs with their personally set criteria, to identify unattended features, or features that would make their final designs distinct.
Refinement: Some students indicated that before representing the final design solution, they carried out 2D, as well as 3D, design explorations for the refinement of their design ideas. Working first off-scale for component configurations, then in full-scale for the final design model was reported to be beneficial in the development of the final design solution, as students were able to act out the vacuuming-related tasks in real size and explore the design decisions accordingly.

3.2.3 Criteria. Criteria were the values that the students constructed for convergence; they were related to critical assessment in particular. Criteria were identified from the responses given to the survey questions 5 and 6, but responses to all questions were also cross-checked for related content. Eight criteria were revealed from the survey responses.

1. Aesthetics: Visual appeal was an important criterion, both in selecting the sub-solutions and in representing them in an overall form. Many students chose sub-solutions and adapted them into an overall form, whereas many others first considered the overall form and then chose sub-solutions accordingly. Configuration of the components was considered critical for visual appeal and another criterion was a “coherent design” for the 2-in-1 SVC as a whole, as well as when the components are separated (e.g., components do not look incomplete when hand-held is removed). Students used sub-solutions that they found “compatible” in terms of form and similar in style, those that they believed had a “common visual language”, and that “matched in aesthetics”. Students described their effort as achieving “form harmony in the combined components”, “visual completeness”, and “unity in form”.

2. Functionality: Functionality of the product was another criterion in bringing sub-solutions together. During selection, most students reported having aimed for the “mutuality”, “compatibility”, “suitability”, “matching”, and “convenience” of the sub-solutions, sub-solutions that “complement each other”, “similarities in working principles”, and “connectedness” or “relatedness” of the components that would “work well together”. While bringing the sub-solutions together, adjustments were made to their “working principles”, “underlying ideas”, and “means in order to achieve the essential function”.

3. Product performance: As the device was composed of two main components, each with specific functions, the main criterion was good performance from both. Other criteria for product performance were mentioned in terms of 1) usefulness and covering functional requirements, 2) capability in vacuuming dirt, 3) motor capacity, 4) dust bin capacity, 5) long battery life, and 6) footprint, or environmental cost of usage.

4. Features and specifications: Many students took the “essential function of the device” as the essential criterion in selecting sub-solutions and transforming them into design alternatives. Students indicated that they decided on the critical features first, or made a list of specifications first, and then determined the sub-solutions to combine accordingly. A fewer number of students reported to consider the two functions of the device, namely hand-held vacuum and stick vacuum, as separate pursuits, with criteria specific to each.

5. Variety: Most students reported to aim for variety in the overall features in each design, to be able to generate distinct alternatives. For this they chose to “incorporate as many components as possible”, selecting different sub-solutions for each alternative design solution. Addressing different specifications in each alternative was also used for variety. One student indicated that s/he combined “more than one sub-solution for a same sub-function” in order to enrich the design details.

6. Simplicity: Two students reported to aim for simplicity, one of them indicating that s/he made variations for each alternative in reference to a common list of specifications, and the other indicating that s/he chose to use some features that were common in all alternatives.

7. Realisability: A fewer number of students reported that they examined the morphological chart to select realisable ideas (i.e., those that could be transformed into design solutions). “Extreme” or “not suitable” ideas were considered but not used; those that were not in line with the criteria that students
set for themselves were ignored. Ideas were also selected depending on whether they could be modified for realisability.

8. Feasibility: Manufacturability, low production cost, and feasibility for “immediate launch to market” were also mentioned as criteria. Students strived to improve selected ideas in order to make them “realisable in terms of production”.

4 Discussion and conclusions

This paper presented a study with graduate design students that attempted to explain design convergence. As per the first research question of this paper, acts of design convergence involve decision-making, design synthesis and critical assessment. As per the second research question of this paper, design convergence takes place in reference to these acts through the involvement of various factors, strategies and criteria. Factors are the considerations behind the design decisions made and provide with directives for informed design moves. Strategies are the ways in which design synthesis is carried out and following them leads to design transformations as combinations of design moves and knowledge integration. Criteria are the values strived to attain or make judgment against during critical assessment and adopting them allows to situate and contextualise the design transformations. Based on its theoretical framework, this paper argues that these factors, strategies and criteria formed the mechanisms for design convergence that took place for the 2-in-1 SVC project carried out in the graduate design methods course.

These mechanisms have been identified from responses to a survey carried out among the graduate design students who had approached the end of a rigorous design process for a familiar and non-specialist product (2-in-1 SVC). It can be argued that these mechanisms came into action during design convergence because the problem area was familiar to the students to begin with, and the problem frame was established with relevant information and well-defined limits. Also, the design process was methodically planned step-by-step, making it easier for the students to apply acts of convergence, and recognise and describe them upon reflection.

It is believed that these mechanisms of design convergence were facilitated with certain provisions.

4.1. Preparedness with methods, materials and mindset

It was seen that following a methodological approach in the project conduct made it easier for students to make design moves in each step. Students knew that any outcome for a particular step would be related to the design task to be carried out in the following step, explained in the literature as task interdependence (Sutton & Hargadon, 1996). Working in groups also supported the students in making timely decisions and set the bars for an optimum level of quality in the submissions (Börekçi, 2017).

Being prepared for convergence with the necessary skills and experiences, quality of information, and number of ideas were also found influential. Product trials were useful in building empathy in students. They were able to try out the products, as well as see their peers use them, and compare the various features in terms of design and performance. Idea generation through divergence, using the morphological chart, which aimed for quantity, variety and diversity in means, formed an expanded solution space with options for the students to choose from. Studies for quantified structures, carried out before the morphological chart method, seem to have influenced the students’ assessments in structural configurations and therefore overall form possibilities, allowing the students to simultaneously explore external form and internal component arrangements. It was seen that, during design divergence many of the students had already made assessments as to the workability of the ideas, their possible combinations, and the design directions they wanted to take. Another beneficial
experience was working with mock-ups that supported 3D exploration, and particularly full-scale models that allowed acting out with gestures.

4.2 Experience in evaluation and decision-making

Due to their undergraduate educational experiences with backgrounds in design and engineering, the students were familiar with evaluation in design processes, and they were also experienced in giving and receiving criticisms, including self-criticisms. It can be said that students had judgmental awareness, which was helpful in decision-making, design synthesis and critical assessment. Even when students mentioned “personal preferences” or “liking” as a reason for their decisions, when selecting design features there was an explainable and informed judgment involved. This could be related to a feature’s aesthetic or functional appeal, an advantage that was seen in its use, its workability towards improvement, its match with a higher value, and its qualities that constituted an attractive challenge for the students to decide to undertake.

It was seen that the students were selective from among the numerous sub-solutions on a morphological chart, meaning, rather than eliminating, they tended to review all (less complex) ideas and pick up those that they found fit. As for the six alternative design solutions, students were seen to be more eliminative, meaning they tended to put aside an overall alternative more easily. This may have been in order to limit the cognitive effort by leaving a lesser number of (more complex) alternatives to assess. This may also be due to having already assessed the qualities of these alternatives while bringing the components together into an overall design solution and having made a judgment on whether the outcome could be utilized or matched with the project objectives.

Design convergence is a critical stage in the design thinking process and requires a significant cognitive effort that evaluates the outcomes of design divergence by determining the most appropriate idea, transforming it, and situating it within the problem context, thus concluding the design process. It is hoped that this paper may be of interest to design educators, practitioners and researchers who wish to further understand design convergence and find ways of supporting the related acts. I would like to thank the students who took part in this study.

References


Curriculum by design: Design Thinking as a three-dimensional approach

Ruth M. Neubauer and Christoph H. Wecht
New Design University, St. Pölten, Austria, ruth.neubauer@ndu.ac.at; christoph.wecht@ndu.ac.at

Abstract. Design Thinking has become an important method of change. As this is a tool, it needs to be conceptualized and taught in a way that grasps its full capacity. We argue that current conceptualizations can be improved by considering concepts of materiality from science and technology studies. We illustrate a material-reflective approach that captures design thinking as a tool that is active in three dimensions: reflective towards the world, reflective towards its methods, and as such reflective of itself and its own configurations.

Keywords: design thinking, materiality, reflective, science and technology studies, STS

1 Introduction
Design has an immense potential as a method for seeing the world, understanding relationships, and for shaping those relationships towards more desirable ways of working and living (Buchanan, 2015). Organisations adapt design thinking as methods of problem solving, for navigating production processes, for promoting new mindsets, and as a radical reinvention of the human experience (Dell'Era, Magistretti, Cautela, Verganti, & Zurlo, 2020). However, the theorising of this capacity of design is still catching up. Studying, practicing and teaching design thinking as a method of innovation is a new challenge. Design has a strong practical tradition as a discipline that is done by the designer, and it is therefore theorised as an individual form of thinking and doing (Margolin, 2013). How could designing be theorised so it lends itself to being taught, applied and learnt as ‘design thinking’ in the wider context, outside of the designer studio, done by ‘non-designers’? How can we prepare ‘non-designer’ design thinkers in ways that take advantage of the full potential of design? Many design thinking courses have popped up around the globe. Prominent among those, Stanford’s (Carter, 2016) and IDEO’s design thinking processes (IDEO, 2012). Many projects have been implemented with these design thinking processes. But these current abstractions of design thinking, to be used outside of the traditional world of design, can be improved. We claim that they do not fully appreciate, capture and utilise the potential of design. They often understand design ability as a product of mental processes, which risks blackboxing design and making it inaccessible (Kimbell, 2011, 2012; Teal, 2010; Tonkinwise, 2018). The current abstractions do little to explain how design ideas materialize. Concepts of materiality, however, can illuminate this and provide the theoretical substantiation that explains how ideas materialise and tangibly impact on the world.

This paper focuses on the material-reflective activity of designing in order to attempt a new theorising of design thinking. We illustrate design as an activity where designers and materials act together through imaginaries, which are active artefacts in the design process. We draw on a conceptual framework, ‘configuring artefacts’, which visualises the trajectories of imaginaries from an ephemeral thought to a tangible design decision (Neubauer, 2022).

A key idea in this paper is three-dimensionality which illustrates our claim that the design process does not only hold the capacity to innovate and renew the world, but also has the capacity to renew its own conditions – therefore has the capacity to renew itself. Design activity does not only move things
forward, but moves around itself simultaneously, changing the world while it changes itself and all participants of the design process.

We claim that a process that does not only drive change but embodies change as an active process in itself, is an ideal learning environment for developing practitioners’ knowledge and experience.

Our ‘curriculum by design’ is a process that can be used to teach and practice design thinking; a process which the authors have started to develop during a research project. The ‘curriculum by design’ is being developed during, and is applied across, a three-year bachelor study programme, building the theoretical foundation of teaching ‘design thinking’. We have split the research into three tracks, according to the three years of the study program. Track 1 is focused on design as a practice of making and reflecting, track 2 makes accessible the different methods in design, and track 3 teaches design as a set of methods that itself can be and will be changed during the design project. The three tracks describe design as a three-dimensional tool where each dimension teaches a particular aspect of design.

This project advances design research, design as a practice, and design as a curriculum, in showing how the makeup of design is theorisable, practicable and teachable as an activity outside of the traditional design studio.

2 The Reconfiguring artefacts project
The research project, named Reconfiguring Artefacts, takes place in an academic learning environment with design thinking expert practitioners, teachers and novices, working on different design projects conducted in smaller teams. Teaching and researching design can both be understood as practices that generate knowledge (Ejsing-Duun & Skovbjerg, 2018). As practitioners, teachers and researchers of design, we see the design studio as a site for practice, teaching and research.

In this research project, we ask the question: How do we design with materials and how do these materials in turn (re)configure our designing? We are interested in better understanding and conceptualising the role of material artefacts on how they help our ideas become real. The materials and toolkits play an important role in the design thinking process (Ball & Christensen, 2020; Sanders & Stappers, 2012; Dorothé Smit et al., 2016). They are ‘linking the imagination to its material form’ (Bleecker, 2009, p. 4). Therefore, in our study we pay particular attention to the materiality of ideas and materials’ role in the design process.

2.1 Research methodology
Our research methods are set within RtD - Research through Design (Stappers & Giaccardi, 2017). We make artefacts and use these artefacts to abstract and reflect on the new situations arising. The tension between making and reflecting evokes new knowledge to emerge (Frayling, 1993, p. 5). The research uses configuring artefacts as an analytical framework (Neubauer, 2022). The design artefacts are here understood as imaginaries that are both material and idea, and these material-idea imaginaries are active collaborators in design projects. They can be traced and observed how they help designers create new situations. Configuring artefacts is anchored in concepts of materiality according to an STS – science and technology studies – tradition (Barad, 2007; Law, 2004; Mol, 2002; O’ Riordan, 2017; Suchman, 2007), which assumes that the world as we know it is made of temporary stabilised products of interactions. It describes the world to be made up of sociotechnical relations, which have material and ideal quality. In STS, these relations can be read to analyse social and technical systems.

The framework uses STS to understand how an intervention can be made in situations of design. As humans interact, these material and ideal relations are made and broken; they move and are negotiated, and, most importantly, they stabilise (always temporarily) as facts, objects and
environments that surround us. They stabilise until they are destabilized again through intervention that gets them to form new relationships; new configurations of relations. These interventions can be done through design artefacts, which are proposals and dedicated speculations on future configurations of these relations (Neubauer, 2022, p. 87). But rather than mirror the future, they are active players in bringing this future into being, by helping designers knot the necessary relationships (p. 88). In design, artefacts are thus cultivated as imaginaries that have the agency to bring ideas into being. These imaginaries might be sketches, prototypes, models, maps, or stories. In configuring artefacts, imaginaries are described as relational beings that relate various points of reference, and it is through their relating, that the ideas they embody gain agency and become powerful (p. 90). They relate different people, things, practices, and they relate across tangible objects and intangible ideas, across fact and fiction, across now and future. In this relating practice, imaginaries materially implement an imagination about the future, and they are thus moving the world forward, reconfiguring it, and creating new conditions.

The practical activities and the imaginaries through which we develop the ‘curriculum by design’ will be described in the following three tracks, that are organised according to each year in the three-year bachelor program. We research and (re)design the relations of our design practice in three different tracks of research and teaching, where we follow different projects in each track. The projects were conducted in an educational setting at a university, with bachelor students studying design thinking and management. Because the educational design studio is typically organised around design projects (Tovey, 2015), this educational setting can be used to study design practice. Different from other education systems, designers’ learning takes place in a “studio-based atmosphere” and through practical working (Julier, 2000, p. 54). Thus, this research project serves the teaching, the learning and the researching of design. The design studio provides multiple benefits: While we, the authors, teach design and our students learn to design, we can use this setting also for researching design, which serves the practice and theory of design. This is why we will in the following text use teach / research in close conjunction. The activities serve the aim of improved ways of teaching design thinking, as well as developing further the practices and theories of design.

Inspired by Frayling’s three approaches to design research (1993), we set the scene differently in each track of research. We use Frayling’s approach slightly differently than perhaps intended. Instead of choosing one of the three design research approaches which he outlines, we use each approach as the guiding method of one track.

Track 1: In the 1st year design studio, we teach / research the basic knowledge of designing, as reflection in action. We conduct research into this design practice (Frayling, 1993, p. 5), gaining knowledge about design activity and the artefacts used, enlisting ethnography (Gobo, 2008; Pink, 2009; Pink, Horst, et al., 2016; Pink, Sinanan, Hjorth, & Horst, 2016).

Track 2: In the 2nd year design studio, we teach / research different methods of designing. We research for design practice (Frayling, 1993, p. 5), by gathering materials and embodying the knowledge in the artefact (Volonté, Rampino, & Colombo, 2015).

Track 3: In the 3rd year design studio, we teach / research the designing of methods of designing. We research through design (Frayling, 1993, p. 5), design practice being its own method of doing and reflecting (Vaughan, 2017). While reflecting on our spatial and material conditions of design practice, we intervene in our practice to create new conditions for our design practice, thus innovating our design practice itself.

In the following illustrations of the three studios, we will describe in more detail the dimensions of the three-dimensional approach, as well as the studios’ development and substantiation as knowledge-producing research tracks. According to the R&I methodology and understanding the curriculum as the object of this design research project, the following outlines of each track are simultaneously
reflection, documentation, and current state of design of the respective part of the curriculum. Therefore, the following text does not only represent the knowledge of the research but is also one of the imaginaries of the object ‘curriculum by design’.

2.2 Track 1: Reflective designing

In the 1st year design studio, we research and teach the method of reflection-in-action (Schön, 1983, p. 49), which guides the students in learning how to act as designers. The design artefacts made in design are imaginaries, or proposals about the future. Therefore, the students learn to make imaginaries that help them to materially develop their ideas. The template reinforces the particular method of reflecting on the design moves (Schön, 1983, p. 79). For the students, this template also means a set of rules to follow. In concepts on communities of practice, rules have the role to describe and enforce the standard practice (Wenger, 1998, 2000).

During the design project, the students are provided with the reflective template that guides them in developing their idea. The template shows the students what standard practice to follow, in order to be a designer, act as a designer and do design. We have written in detail about the reflective template in a paper that was presented at a conference (Neubauer & Wecht, 2020b). As researchers, in this studio we observe how well the students are able to use the templates we given them. The reflective template is being developed and changed as part of the research project, in reflection on the usability of the template. We test the template’s ability to guide the students in making their imaginaries, and we iterate it based on the insights. We use ethnographic inquiry (Gobo, 2008), based on Frayling’s approach to research into design (Frayling, 1993, p. 5).

The template asks students to formulate a question and then answering the question through a drawing or an object. The question is a theoretical reflection, while the answer is the practical attempt to act on the reflection. The template encourages students to continue with question–answer pairs until they have explored and developed the idea far enough to become tangible. The underpinning concept is that of reflective action, teaching students the reflective approach of keeping a dialog with the artefact – a drawing, a model, or a prototype. Schön explored the tacit knowledge that designers have when they work, and that they develop through reflection-in-action (Schön, 1983, p. 49). The template is based on Schön’s description of the design situation as a dialog, where materials ‘talk back’ to designers, each time they make a ‘move’ (Schön, 1983, p. 79). A design move “transforms the design situation relative to the state in which it was prior to that move” (Goldschmidt, 1996, p. 72). Designing can be understood as a conversation between the designer and the artefact. The template makes the students aware of this reflective relationship between themselves and their artefacts. The template prompts the students to formulate a question (e.g., what would it look like from that angle?) to which they can respond with a drawing or a word description. The template encourages the students to inquire their own perceptions and to engage with their concepts deeply. Once they have found an answer, they will be encouraged to explore another question, and so get to know their idea, challenge their idea, and make it more and more solid.
The theoretical background given to the students is the understanding that objects and environments are not solid by nature, but that they are continuously in a state of emergence. Objects can be many different things, depending on how they are embedded in a practice. A bottle can hold wine, or it can be a candleholder. A bottle can also become a murder weapon, a thank you gift, or the road to addiction. Objects and their functions turn solid when they are enacted as part of practices (Barad, 2003; Gherardi, 2010; Orlikowski, 2007; Suchman, 2007). As designers, we also enact an object (a design) in our practices of design. Through our methods we make the object; through our viewing and observing (Button, 2000; Dijk, 2010; Portigal, 2013; Young, 2015), imagining and making metaphors (Coyne, Snodgrass, & Martin, 1994; Graff, 2018; Lockton et al., 2019), and our visualising and narrating (Buxton, 2007; Kolko, 2011; Lawson & Dorst, 2009). We emphasise in our teaching that a design does not magically come into existence, but that it emerges in action. As designers, we enact a design – we conceive of a design as an idea, we explore the idea, we probe it, we reflect on it. As designers, we weave our designs into our surroundings through imaginaries such as drawings, models and narratives (Neubauer, 2022, p. 88).

In this abstraction of the emergence of designs, we follow physicist Barad, who postulates that objects or subjects do not exist by themselves but exist in the relationships that make them so (Kleinman, 2012). Objects can be understood as relations that bundle through being enacted. ‘Intra-actions’ between the material and discursive relations make the objects (Barad, 1998, 2003, 2007). The more enacting, the more ‘matter’ and the more ‘real’ an object becomes. ‘Agential realism’ is a term established by Barad (1998, p. 106), and is the name of this concept of how matter comes into being. Applying agential realism to design, places the object of design as the emerging product of the interactions around it. Design theorists A.Telier speak about the ‘object-in-design’ that is never fully present, but is pulled into being through constituents – such as plans, drawings, models – that speak about it and help it become real (Telier et al., 2011, p. 15).

Accordingly, we teach the students that each reflective action brings their idea more into being, making their object of design real. By iteratively reflecting on their object of design, the students slowly transform it from possible to real. This transformation hinges on the representations of the object – the imaginaries (drawings, stories, prototypes) – which become co-actors in the enacting of their idea (Neubauer, 2022, p. 90).

2.1 Track 2: Reopening method

With 2nd year students we teach and research design methods. In this studio class, we explore a range of aspects in the design process, mainly focusing around the question of how to design for the intangible. Our method of research in this studio is inspired by Frayling’s approach of gathering
materials for design (Frayling, 1993, p. 5). We will briefly summarise the past semester work we did with the students, as it opened a part of the research and learning process in an unexpected way.

The brief was to design a sustainable clothing product. In this track, we went beyond investigating the use of design imaginaries, but explored the method of making the design imaginary, which was a story map (Patton, 2014). Design practitioners from industry practice joined us to tell us about their methods in practice. We had workshops around how to design for service, how to create a shared design space through mapping, and how to design for opportunities and ventures. With these reflective activities going on in parallel, we practically went to work and used story mapping to build a map (Patton, 2014). The map embodied the knowledge we developed in collecting and organising information on production, retail, and use practices of clothing. The story map was the imaginary we had created, and the story mapping process was the method of designing.

Mapping is a method to externalise relationships (Kalbach, 2016). In story mapping, ethnographic knowledge is collated from many different groups of users and stakeholders (Patton, 2014). In mapping, an overview is created, of these diverse experiences (preface). The mapping activity is guided by rules of how to visualise actions, materials, and people (pp.1-35). The process of mapping serves as the negotiation process of integrating experiences that may differ, or even conflict. The integrating activity of mapping, while following the rules of how to map, is supposed to align collaborators and create the shared understanding that is needed in a project. The method of mapping creates and negotiates the imaginary that then embodies the shared design knowledge. How crucial this is, is also reiterated by frameworks such as transition design, which point out the importance of including transdisciplinary knowledge in the design method, in the light of the complexity of today’s design challenges (Kossoff, Irwin, & Willis, 2016).

We explored the method of mapping with the students. However, in the course of the project we discovered that our method consisted not only of story mapping, but it contained also other rules and constraints. These rules and constraints were made up of a time schedule of workshops and studio time containing tasks with deadlines. As the students critically explored story mapping, they began questioning its usefulness, because it seemed laborious, and they were not certain of its value in helping them create good ideas for a clothing product. This engagement with the method was expected by us, the teachers, and it was a planned part of the learning. It was crucial to convey that different methods produce materially different information, and thus fundamentally impact on designs. But soon another challenge emerged. The students also challenged our organisation and time management of the studio class, because they struggled to meet deadlines and to complete tasks. It was not clear to them how the workshops with external practitioners tied in with the organisation of the studio time. They were not clear how much studio time was remaining, on what days it was scheduled, how long each would last, and what tasks were to be completed when. Due to the outbreak of the Coronavirus, our studio classes took place online, and the digital environment added uncertainty and unfamiliarity. Dates, times and virtual spaces had turned out to be an invisible constraint that created discomfort for the students. We realised that time and digital space were an instrumental part of the method of designing (Neubauer & Wecht, 2021). These created material conditions that enforced certain ways of working. It took some time to uncover this source of discomfort. The constraints had been implicit – noticeable but invisible.

The initial imaginary we had created in this studio class was the story map of the clothing life cycle, through the method of mapping. But the method was required to respond to the local conditions that emerged as problematic for some (Schiffer, 2020). With the new constraints appearing (the time and space constraints), we extended the story map with another map – a map of our studio schedule. We mapped an overview of our ways of working, including the time and place conditions that the students had made us aware of. This opening up of our method of working made visible the parts that were not
visible before. We used the method of mapping also to negotiate the design method and process itself. Through creating this extended map, the process map, we regained visibility, a shared understanding, and agreement with the students over the tasks and timeframes before us. This second map demonstrated to us the agency of mapping – that it provides a space for negotiation. It did that even better than as if we had not experienced first-hand how a method does not work (for everyone); how the method’s configuration can be made visible, and how it can be opened and reconfigured. The mapping method showed us here truly its material capacity: making invisible constraints visible, bringing them out in the open, giving everyone a chance to negotiate its quality. The unexpected turn of events, that students raised their concerns with the method used (in particular, those parts of the method that had been invisible) had turned out to be a great asset in teaching and researching method and how it may be critically examined. We were able to visualise and reflect on our method and improve it collaboratively, so it worked for everyone involved, and so we could get on with producing the knowledge needed for our design task at hand.

For a team to be able to reflect on itself, to ‘radically rethink’ its strategy if something is not working well, is a key literacy (McGrath, 2013). We use reflection in this studio class to question and open our way of designing. The method of designing in the studio was here opened for scrutiny, investigation, and improvement because it was not working for the students. The mapping helped us make constraints explicit and negotiable. Reflecting on the method enabled us to adjust the parameters and negotiate agreement. In this studio class, students learn to see methods, examine them, and open them if needed.

2.4 Track 3: Reconfiguring designing

The activity of research in this track with 3rd year students takes place as (how Frayling defined) research through design (1993, p. 5). In this studio class we explore and design the design methods themselves (e.g., templates and design kits) with which we make design imaginaries. We do this through looking at our own design practices of designing, using the categories ‘physical materials’, ‘digital materials’, ‘physical space and time’ and ‘virtual space and time’. By examining our own material conditions of design, and those of younger student cohorts, we attempt to improve and reconfigure our conditions of design.
In the research project, we began to practice new forms of designing, as well as creating artefacts that embody these new forms of designing, such as the reflective template (used in the 1st year studio), a design materials kit, and a design process diagram bringing together our insights about methods. We have described these artefacts in more detail in a conference paper (Neubauer & Wecht, 2020b). We kicked off the term by introducing the research project Reconfiguring Artefacts, introducing the idea that it plays a role in ‘designerly ways of knowing’ (Cross, 1982). By looking at the example of Phillipe Starck and the Juicy Salif lemon squeezer (Lloyd & Snelders, 2003), where Starck describes to have been influenced by familiar materials from his childhood, or from the place where he was eating during the first drafts of the design, we examined how our personal, situated material relations influence the design solutions we come to develop. We also explored practice-oriented concepts of knowledge (Gherardi, 2012, 2017; Gherardi & Nicolini, 2006; Orlikowski, 2007, 2010; Suchman, 2002, 2007) and how the creation of knowledge in practice-based design research takes place through a performative process of ‘make-it-to-see’ (Vaughan, 2017, p. 35).

Defining the aim of the project – exploring and innovating our process of design – brought us to a lively debate about whether designing can be described as a process at all, or as a method, a set of practices, an approach, a strategy, or a posture or mindset. The debate broached the big question, in what way design thinking can be systematised. These questions are crucial: how, if not in a systematised way, are we able to teach and learn design thinking?

To illuminate different approaches to theorising design, we invited guest design researchers to work with us on design fiction, as well as on embodied cognition and how material artefacts help us ‘know’ (Neubauer & Wecht, 2020a). In this 3rd year cohort, we explored various ways how designing can be conceptualised. Utilising the concept of reflectivity in design, following Schön (1983), we developed the reflective template, which we gave to 1st year students to work with, and explored how useful it was to them in organising their activity. The template (a means to designing imaginaries), was from our viewpoint an imaginary in itself. It represented what we envisaged designing to be: reflective. This is the core of the three-dimensionality of the design process, which is recursive in its own development. In this track we do not only design something, but we design our own ways of designing while designing. We had opened the method (‘What is designing?’) and designed the process (a reflective template). What was for beginners an asset and a guide was for us advanced designers an object of research and design.

In the course of our work in the 3rd year studio, we staged interventions in our own practices. We observed our own practice and attempted to prototype new practices, using concepts of how practices emerge, break apart or change in changing relations (Shove, Pantzar, & Watson, 2012). We observed the relations of our practice, and through changing the material relations, we tried to reconfigure our practices. One intervention explored distributed/local space by transporting us back to the same lecture room at university during a distributed studio class, giving us all the same background image when talking in our video meeting software (see Figure 3). During another intervention we were supplied with a design materials kit, requesting us to prototype our experience. Another intervention invited us to ‘reset’ our local work environment in order to restart work in a refreshed way; to take a break, open a window, fetch a glass of water and taste it. This intervention inspired a reference to artist Marina Abramović and her instruction of water drinking, and how that is to be done in an embodied way (Louisiana Channel, 2013). On an ongoing basis we reflected on these interventions, in conversation during the studio class and workshops, on our research website, and with conference contributions (Neubauer & Wecht, 2020b, 2021; Dorothé Smit, Neubauer, & Fuchsberger, 2021).
In the following text we are going to explain in detail, how our design practice itself became the object of design – the thing we were designing – and how it was explored, opened and changed. We reflected on our current studio practice: that remote studio classes took place on Microsoft Teams, with everyone sitting in their own workspace. For all of us, this was an unfamiliar situation, as we were usually located in the same room at the University. Everybody was in their own workspace, in a different location of the world, in different spatial contexts. When we came together in Microsoft Teams for design studio class, this produced a different background for everybody. One intervention sought to attune us better for collaboration, to bring us closer together. The students’ attention turned to these different backgrounds, materially placing us in different locations. The meeting on Microsoft Teams being the current method of practice, the students looked for ways to improve this method. The different backgrounds are part of the material relations of the method. Intervening in these material relations (and thus in the method) the students tried to ‘bring us into the same workspace’ by giving everyone the same video background. The intervention did of course not bring us physically into the same space, but it created an experience of seeing everyone in the same space. We tried out how this experience impacted on us and on our method of designing. This is an example on how we reflected and acted on the methods of design, changing and improving our design practice through it.
We bring together designing as a ‘reflecting on action’, as well as a ‘reflecting on method’, and we turn it into a three-dimensional tool that simultaneously does reflect on action while it does reflect on the method of action. We discovered that design practice is capable of adapting and reconfiguring both – the object of design as well as its method of working on the object. The ‘curriculum by design’ conceptualises design thinking as three-dimensionally active; a process that does not only act towards the world but also towards itself, renewing and adapting itself through the reflections and actions of the practitioners.

In this studio class, in this track of research, all tracks come together and make up the three-dimensional body of design thinking. With this work, we respond to a big challenge that we see for design thinking: How can designing be conceptualized, something that is traditionally done by a designer in the studio – and extrapolate it for teams to be used in a project? There are many design processes, some of them very successful. They guide design thinkers to reflect on the world with empathy, and on the experiences of people in order to improve them. However, these processes do not emphasize the need to reflect on its methods and to design these methods. It is a well-known scientific paradox that simply through investigation, the object of investigation is changed through the methods of investigating (Law, 2004). Design, which is the tool of change, utilises this nature of investigative action; it turns this bug of science into a feature. However, it is crucial to also carefully design the methods of change. The design process we have outlined reflects on issues and acts on these issues in order to improve them, and while it does that, it also reflects on its methods of action, which it is able to adapt in the process (see figure 4).

3 Summary: A curriculum by design

The ‘curriculum by design’ embodies a reflective approach that is aware of materiality. For example, it is aware of its methods of producing design imaginaries, which it is able to adapt. While it reflects on the conditions of design work, its design practices are reconfigured in turn. Through the framework of configuring artefacts the imaginaries that materialise design ideas become visible and tracible, as well as the methods that produce the imaginaries, allowing for the reconfiguration of its methods.

In track 1 we teach design as the reflective action that brings into being the objects of design. We use the theoretical framing of imaginaries, which is based on the concept that material-semiotic artefacts
can be used to configure material relations (Suchman, 2007). The students learn to reflect and iterate, to query their concept, to develop imaginaries, and through these to re-knot material-idea relations, and to bring into being their object of design. Based on Barad’s ‘intra-actions’ as the enacting of relations to form matter (Barad, 1998), we teach and theorise designing as the enacting of relations in order to materialise ideas.

In track 2, we teach method and its significance on the materialising of an idea. Methods shape objects of design and of research (Law, 2004). As we experienced first-hand with the students challenging our method, method impacts on design situations and its agency needs to be made visible. The mechanism of reflecting on method creates a situation that remains open to adapting and solving issues in design practice.

In track 3 we turn the principles of reflective action onto design practice itself, which turns design into a tool that is capable of acting towards the world, as well as adapting and reconfiguring its own local parameters of practice.

**Figure 20.** The three-dimensional approach to design thinking

With these three tracks of teaching and researching design, we develop a curriculum of design thinking. Simultaneously we contribute to the research of design by providing a conceptualisation of its capacity. We also seek to further the practice of design by pointing to the importance of its method and the need to remain flexible, or even highlight method as a core design material that can optimise design as a tool.

The educational design studio is a site of developing knowledge, of learning, and of practicing design (Tovey, 2015). Through the three tracks of teaching and researching, we create a new curriculum of design; a curriculum that is sensitive to, and makes visible, design thinking as a three-dimensional approach. The outcome is design as a tool that provides awareness of its methods, and that is, while changing the conditions of the world, capable of redesigning itself as a method; being in reflective conversation with itself. Through the configuring artefacts framework, the agency of design thinking can be understood to not only change the conditions of the world, but to also change its own conditions. In this, we line up with the argument that new forms of design are required, which have inspired other design frameworks, such as transition design (Terry, Tonkinwise, & Kossoff, 2015), or autonomous design (Escobar, 2018). We conclude that design is a powerful tool that can change the material and ideal conditions of the world, but that it needs to remain open towards its own impact and the material and ideal conditions of design practice.
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7 Expanding architectural design
The impact of outsourcing and collaboration on the use of intuition and deliberation: A study of site analysis in the context of architectural design

Diana Osmólska and Alan Lewis
University of Manchester, diana.osmolska@manchester.ac.uk, alan.lewis@manchester.ac.uk

Abstract. This study utilises dual-processing theory to explore the impact of outsourcing and collaboration on the use of intuition and deliberation during site analysis. At site analysis stage, information is gathered, synthesised, and applied by architects to test the feasibility of proposed construction projects. Architects might collaborate with different internal or external players or outsource information-gathering tasks. 21 semi-structured interviews were conducted with architects and architectural assistants. The findings show that while collaboration can prompt deliberation, it can also lead to the use of intuition when supported by collective confidence, in turn causing errors to be overlooked. Outsourcing facilitated efficiency and reduced complex reasoning associated with difficult problems, providing an appealing and sometimes problematic method of working. This study expands design thinking by exploring site analysis, a non-design activity essential to the design process.

Keywords: Architectural Design, Collaboration, Design Cognition, Dual Processing Theory, Outsourcing

1 Introduction

There is evidence that architects use intuition in their work, particularly in the design process (Akin, 1986, 1990; Canter, 1974; Lawson, 2004b; Schön, 1991), but also in site analysis (Burns & Kahn, 2005; Darke, 1979; Leoto & Lizarralde, 2019; Lewis, 2017; Rohde et al., 2020). Previous studies have focused on individual designers’ use of intuition. However, architectural design and site analysis are not practised individually (Imrie & Street, 2011). A project involves external consultants, internal team members, regulators and Local Planning Authorities who all affect outcomes (Sinclair, 2020). This is especially apparent during site analysis, where information from multiple sources is gathered, synthesised and applied to test the feasibility of proposed construction projects. Collaboration and outsourcing are essential to site analysis, yet how they impact architects’ thinking has received little attention.

During site analysis, a proposed development is assessed to determine its viability in a particular location. The process includes evaluating existing conditions and exploring design options (LaGro Jr, 2013). It is during those initial stages that ideas are generated which can shape the entire project (Darke, 1979; Lawson, 2004a). It is also during site analysis when there is the greatest potential for optimisation of the project (Kovacic & Zoller, 2015; Rohde et al., 2020). Such optimisation can happen through architects’ detailed analysis, outsourced information, or collaboration. The decisions taken during those stages can influence up to 80% of the project’s environmental and operational costs (Bogenstätter, 2000) and have off-site impact on biodiversity, flooding and traffic (LaGro Jr, 2013).

Arguably, the site-analysis literature provides an inaccurate description of architects’ processes, implying the use of linear procedures, in which information is collected and synthesised before design can begin (for example LaGro Jr (2013) or Sinclair (2020)). The design-studies literature, however,
suggests that architects often start by forming design solutions, which are then evaluated as information is gathered (Akin, 1990; Darke, 1979; Lawson, 2006; Schön, 1991). Such studies have focused on architectural design, but much could be learned by considering the related activity of site analysis. Specifically, there is scope for exploration of the impact of solution-focused approaches on how architects gather and synthesise information, tasks intrinsic to site analysis. In this way, studying architects’ use of intuition in site analysis expands design thinking to encompass processes of information gathering and evaluation, that is, non-design activities which are integral to design. Those activities are particularly important as they affect design-quality and performance, as noted above.

We have an understanding that expert architects work using pattern recognition, where they automatically recall past-situations based on their experience and design habits, and apply those to current situations (Akin, 1986, 1990; Canter, 1974; Lawson, 2004b). If, however, we acknowledge the co-productive nature of architectural practice, our current understanding of architects’ intuitive processes can change. This may open new fields of discussion and expand current understanding of design thinking. To explore the use of intuition and deliberation in a collaborative environment, this paper will draw on dual processing theory [DPT]. DPT recognises two types of thinking, Type 1 which is automatic and intuitive, and Type 2 which is deliberate and slow (Evans & Stanovich, 2013). The concept of fast and slow thinking is widespread both in philosophical and psychological writing (Frankish & Evans, 2009) and has been applied in multiple fields of study such as economics (Kahneman, 2011; Rand et al., 2012), medicine (Brink et al., 2019; Brush et al., 2017) or judicial practices (Wissler et al., 2012).

DPT assumes that we are all born with essential Type 1 abilities and develop others through learning. A prolonged use of a technique can allow an individual to become an expert and perform it intuitively. An example of such phenomena in architectural practice was described by Lewis (2017), who discussed how his interviewees could look at an architectural drawing, and intuitively judge whether a proposed building would have adequate daylight. However, not all intuitions are based on expertise (Evans & Stanovich, 2013), because Type 1 is constantly “on” generating ideas and suggestions (Kahneman, 2011). Hence, intuition can be used even if there is not enough skill to support the accuracy of judgments (Stanovich, 2018).

Type 2 is associated with complex decisions and problems. It requires concentration for optimal performance, for example when calculating 126x17 (unless you are an expert in mental arithmetic), because it is bound by the working memory and its capacity. Type 2 is used for rationalisation of intuitions, hypothetical thinking, argumentation, safety and reduction of errors (De Neys, 2017; Evans, 2019). Deliberation needs motivation, relevant knowledge, and cognitive capacity to perform optimally.

The way both thinking-types combine is that Type 1 provides Type 2 with information. Type 2 tends to approve these suggestions immediately, especially when there is an ingrained feeling of rightness, which is a characteristic of Type 1 (Ackerman and Thompson, 2017; Thompson et al., 2011). Alternatively, Type 2 justifies suggested intuitions or deliberates and reasons for alternative solutions (Evans, 2019).

To look beyond intuition and deliberation as aspects which affect an individual, Hemmatian and Sloman (2020) discussed how outsourcing and collaboration can be explored through DPT. The process of outsourcing might be linked to the use of intuition, as it hinges on information one does not possess, but which can be relied on, and supplied by another more informed individual (Hemmatian & Sloman, 2020). In those situations, Type 2 processes can become outsourced to reduce effort and complexity. It is possible to confuse outsourced information with individual knowledge and in turn, overestimate one’s understanding of the process. Just knowing that there is access available to experts who understand a particular process is enough to provide a non-expert with the confidence needed to proceed with a particular task (Barbey et al., 2021; Hemmatian & Sloman, 2020; Rabb et al., 2019).
Possibly, architects become dependent on other experts as a result of outsourcing, for its convenience and reduced effort.

Collaboration can encourage deliberation especially when there is a common goal (Barbey et al., 2021; Hemmatian & Sloman, 2020). This is not to say that intuition cannot emerge and be prompted by collaboration, but it is possible that deliberation takes more of an active role in collaboration. This could be due to the need for clarity and understanding between team-members, which lends itself to a more structured process of working and explaining. In collaborations, however, members of the same team can also share a common language and sense of understanding (Lloyd, 2000; Lloyd & Busby, 2001), potentially reducing the need for deliberation.

By studying collaboration and outsourcing, this paper will explore the involvement of different co-operators and their extended effect on site analysis processes and, in turn, design. Also, considering how architects think, when working in co-production, will enhance our understanding of practice processes.

2 Background

2.1 Site analysis

The current literature suggests that site analysis involves following instructions, theories, set standards and guidelines on how to analyse a site successfully (De Chiara & Koppelman, 1984; LaGro Jr, 2013; Lynch & Hack, 1984; Makstutis, 2018; Rubenstein, 1987; Tait, 2018). It incorporates scientific methods to predict, for example daylight (Mavromatidis et al., 2014), sunlight (Nault et al., 2015), ventilation levels (Ko et al., 2018) or multiple physical properties at the same time (Leidi & Schlüter, 2013). Site analysis processes described in the current literature are arguably Type-2 dependent, that is, they assume the use of deliberation.

There is a possibility that site analysis also involves the use of intuition, which is yet to be acknowledged in the site-analysis literature. The literature on design expertise suggests that architects utilise automatic pattern recognition (Akin, 1986, 1990; Canter, 1974; Lawson, 2004b). Researchers who discussed architects’ site analysis process (Darke, 1979; Lewis, 2017) and scientific methods for site analysis (Rohde et al., 2020) also indicated reliance on intuition, although without specifically outlining how intuition was used.

Despite the cruciality of site analysis in building development, it has received little attention until now. There is a potential for this research to influence the current site analysis and design literature.

2.2 Collaboration

There have been studies on collaboration on forms of design outside architectural practice, that suggest disagreement and challenging of ideas can lead to more careful analysis of solutions (Stempfle & Badke-Schaub, 2002). Moreover, collaboration can prompt a team to explore more factors before a decision is made. In collaboration, the knowledge of a team is larger than that of any individual (Ottosson, 2003). There are suggestions outside the area of design that groups perform to the standard of their best member (Moshman, 1998). The design-studies literature also acknowledges how critical networks are in the transfer of knowledge and their application in action (Cross et al., 2006; Lloyd & Busby, 2001; Luck, 2007; Schön, 1991). As suggested by Hemmatian & Sloman (2020) DPT can provide the means to explore those networks.

Current literature also indicates how verbalisation of ideas, collective problem solving (Cross et al., 1996; Ding & Ng, 2010; Gill et al., 2000; Lawson, 2006; Murphy, 2005) and pitching ideas to a team (Lloyd & Busby, 2001) can lead to the use of deliberation. It is not necessarily the case, however, that collaboration always leads to deliberation. For example, storytelling can act as a form of discourse
within a design team. Stories can begin to shape ideas during design processes (Lloyd, 2000; Lloyd & Busby, 2001). Designers’ use of storytelling can be accompanied by “selective interpretation” (Brereton et al., 1996), where the story being told is based on incomplete knowledge of a situation. This could be linked to Type 1’s need for coherence which is privileged over the need to full and accurate information (Kahneman, 2011).

The research on collaboration and working in practice is still limited (Ding & Ng, 2010). It focuses primarily on team meetings or project discussions. In architectural practice, other players are involved. For example, site analysis would include the client (and the client’s advisors), lead designer (who gathers input from each team member), principal designer (managing health and safety), designers (architect, landscape-architect, interior designer), engineers (civil, structural, mechanical and electrical [M&E], fire and others) and other specialists (such as cost, acoustic or daylight consultants) (Sinclair, 2020). There is a need for research that explores architects’ thinking processes when working with those professionals towards a shared goal.

2.3 Outsourcing

The concept of outsourcing was defined by Hemmatian and Sloman in the field of cognitive science as information “one does not know oneself but assumes that someone else (whose identity may be unknown) can supply” (Hemmatian & Sloman, 2020:103). Hemmatian and Sloman in their description of outsourcing mostly present examples of non-professionals utilising knowledge from an expert. However, it is possible the implications of outsourcing change when it is used between professionals. Such changes might impact on how outsourcing is defined.

Research outside of the area of design suggests that people might believe they know more than they do, by attributing outsourced knowledge as their own (Ward, 2021). This raises questions regarding who takes the credit for the outsourced actions (Barbey et al., 2021).

By recognising that architects work with multiple players, there is an indirect acceptance that those actors provide information. An architect needs to consider the data from all those actors to shape a project, even when not in the position of a lead consultant. Outsourcing can also happen between colleagues working for the same company. Although current design-studies literature explores collaboration, there is little discussion of implications of outsourcing on how professionals work. This research will begin to fill that gap, by exploring how outsourced information is applied, when it is used, its links to intuition and how it differs from collaboration.

3 Research Aims

This paper explores how outsourcing and collaboration impacts on the use of intuition and deliberation within site analysis, focusing on the following questions: is collaboration more likely to result in deliberation or intuition? And similarly, is outsourcing more likely to result in the use of deliberation or intuition?

4 Methods

4.1 Participants

To investigate the research aims, the article draws on semi-structured interviews with practising architects and architectural assistants. For the purposes of this study 21 participants were interviewed. Participants varied in their experience, positions within the company, types of work undertaken and practice sizes. The researchers decided to have a varied representation of practitioners undertaking site
analysis in their daily practice to explore differences between their approaches. Interviews were conducted until researchers decided the data had reached saturation. Purposive sampling was used, with potential participants identified through architectural-practices’ websites (Etikan et al., 2016). Additional participants were recruited through snowball sampling (Biernacki & Waldorf, 1981). All of the participants were employed in the UK and undertook site analysis in their work. Participation in the study was voluntary. Table 1 provides more specific participant detail.

All interviews were included in the analysis of data. Longer interviews were richer in contextual detail, but shorter interviews allowed researchers to have a broader understanding of what is happening in practice, and to reach saturation.

Table 1. Participants’ information

<table>
<thead>
<tr>
<th>Interviewee number</th>
<th>Experience (years qualified as an architect [Q] or years without qualifying [WQ])</th>
<th>Position within the company</th>
<th>Type of work undertaken</th>
<th>Practice size</th>
<th>Length of the interview (min)</th>
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</thead>
<tbody>
<tr>
<td>A1</td>
<td>15 Q</td>
<td>Senior Architect</td>
<td>Healthcare</td>
<td>Large</td>
<td>94</td>
</tr>
<tr>
<td>A2</td>
<td>3 Q + 11 WQ</td>
<td>Architect</td>
<td>Healthcare, Education</td>
<td>Large</td>
<td>32</td>
</tr>
<tr>
<td>A3</td>
<td>3 WQ</td>
<td>Arch-Assistant</td>
<td>Inhouse healthcare team</td>
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<td>19</td>
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<tr>
<td>A4</td>
<td>26 Q</td>
<td>Director</td>
<td>Residential, commercial</td>
<td>Medium</td>
<td>80</td>
</tr>
<tr>
<td>A5</td>
<td>24 Q</td>
<td>Director</td>
<td>Residential, commercial</td>
<td>Small</td>
<td>62</td>
</tr>
<tr>
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<td>Mixed</td>
<td>Large</td>
<td>64</td>
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<td>Mixed</td>
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<td>48</td>
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<tr>
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<td>Director</td>
<td>Education, mixed</td>
<td>Medium</td>
<td>39</td>
</tr>
<tr>
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<td>Architect</td>
<td>Mixed</td>
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<td>Small [solo practitioner]</td>
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<td>Residential/conversion</td>
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<td>Medium</td>
<td>32</td>
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<td>Residential, Commercial</td>
<td>Small [solo practitioner]</td>
<td>95</td>
</tr>
<tr>
<td>A15</td>
<td>22 Q</td>
<td>Director</td>
<td>Conversion, Education</td>
<td>Small [solo practitioner]</td>
<td>69</td>
</tr>
<tr>
<td>A16</td>
<td>16 Q</td>
<td>Director</td>
<td>Residential</td>
<td>Medium</td>
<td>99</td>
</tr>
<tr>
<td>A17</td>
<td>10 Q</td>
<td>Director</td>
<td>Mixed</td>
<td>Small [solo practitioner]</td>
<td>50</td>
</tr>
<tr>
<td>A18</td>
<td>1 WQ</td>
<td>Arch-Assistant</td>
<td>Large mixed projects</td>
<td>Large</td>
<td>53</td>
</tr>
<tr>
<td>A19</td>
<td>17 Q</td>
<td>Regional Director</td>
<td>Mixed</td>
<td>Large</td>
<td>51</td>
</tr>
<tr>
<td>A20</td>
<td>10 WQ + 0.5 Q</td>
<td>Architect</td>
<td>Mixed</td>
<td>Medium</td>
<td>47 + 92</td>
</tr>
<tr>
<td>A21</td>
<td>5 Q</td>
<td>Senior Architect</td>
<td>Large mixed projects</td>
<td>Large (Star practice)</td>
<td>109</td>
</tr>
</tbody>
</table>
4.2 Data Collection

The interview questions were intended to facilitate the researchers in understanding the site analysis process. The questions were open-ended and focused on asking architects to explain from the beginning how they go about analysing a site. Prior to each interview, interviewees were asked to be prepared to discuss a specific past project. When it was necessary to gain more detail about a particular response or process a closed question was asked. However, those were generally avoided to allow interviewees to describe site analysis processes in their own words (Fisher & Geiselman, 1992). It was possible that due to “desire for esteem” (Proctor, 2006) participants would present themselves and their processes in the best possible ways, not necessarily in line with their actual ways of working or thinking. Hence, the researchers decided to build a rapport with the interviewees (Fielding, 1993; Phoenix, 1994). The interviewing researcher had experience of working in architectural studio. This allowed a familiarity bond to be built with the interviewees, restricting participants’ feelings of being examined or under threat, and allowing the interviews to proceed more openly. The interviewing researcher was careful to not let their preconceptions based on their architectural-experience lead the interview (Chew-Graham et al., 2002). As interviewees were expected to present themselves in the best possible light, statements which showed interviewees’ culpability in making errors were judged to be reasonably accurate. Additionally, to overcome the limitation of architects’ self-presentation, the interviewer sometimes followed open-ended question with questions that required explicit answers.

All interviews were conducted by one researcher via telephone or video link (Zoom). During the interviews some participants shared their screens to talk through plans, drawings, diagrams, presentations, competition submissions and planning application documents such as full or outline design and access statements.

This research was conducted during COVID-19 pandemic, where there was a need to adapt from face-to-face interviews to accommodate for the restrictions in place (Chew-Graham, 2020). Research suggests that interviewing via zoom or telephone carries similar strengths, such as convenience and accessibility (Block & Erskine, 2012; Gray et al., 2020), however unlike telephone conversation, video link can allow for a personal connection between the researcher and interviewees. However, participants might decide not to turn their camera on during their video-link interview, but rapport can still be built through commonality of life during pandemic, reducing some of the weaknesses associated with distance-interviews. Compared to video-link interviews, telephone interview can be conducted on-the-move, potentially prompting more honest and automatic answers, however, with less depth.

The interviews were digitally audio-recorded and transcribed verbatim. This study was approved by the University of Manchester Research Ethics Committee.

4.3 Data Analysis

Inductive thematic analysis was undertaken. Although, the researchers had a pre-existing theoretical understanding of intuition through DPT, they did not anticipate the focus on collaboration and outsourcing; rather, this interest was prompted by the data, combined with an awareness of recent design-studies literature (Braun & Clarke, 2006).

Transcripts were analysed using NVivo 12 software. The themes were identified, by considering the extent to which aspects of the data captured “something important to the… research question[s]” (Braun & Clarke, 2006:82). The analysis, therefore, while inductive, was also informed by relevant literature. As Braun & Clarke have observed, “Researchers cannot free themselves of their theoretical and epistemological commitments, and data are not coded in an epistemological vacuum” (2006:84).
The use of deliberation or intuition cannot be directly observed, hence researchers had to make assumptions based on the interviews and transcripts. Sometimes it was possible to infer the use of intuition or deliberation from a specific quote, which was then provided in the findings section. On other occasions, the use of intuition or deliberation was only apparent through a number of interview questions and the flow of the conversation. For example, as requested, an interviewee would talk-through their project and only towards the end, or by being prompted by an emerging question, an aspect discussed earlier would reveal itself as intuitive or deliberate. Due to complexity of those situations, the researchers decided to paraphrase the key aspects to capture and explain the phenomena. When findings were paraphrased and reported, their prevalence in particular transcripts was noted.

5 Collaboration in architectural practice

Site analysis within the interviews was described as a collaborative process involving internal and sometimes external collaborators. The interviewees collaborated with clients [A1,16], contractors [A2,3] and users [A1]; with fellow architects and assistants [A10,2,20,21,6,14,19,4,9,15]; with consultants where there was an opportunity to involve them in the project at an early stage [A10,3,16,5,15] and planners only when there was a shared goal [A10].

A1’s report can be used as an example of how such collaboration happened in practice. A1 discussed how when working on a new cancer centre, a retired head of radiotherapy helped to develop the brief and program with her extensive experience. A1 also involved other clinical staff and specialists to gain feedback on the project’s proposed occupancy, purpose, dimensions, spatial connections and hierarchy. Then it was A1’s role to synthesise information to explore design options. The proposals were then tested and reviewed, as A1 explains how “I must have done a half a dozen presentations leading up to submitting the planning application to keep the Trust updated and the team updated with the progress of the design…” (A1). The design proposals formed part of testing the feasibility of the site.

The process described by A1, where the information is gathered and repetitively communicated through involvement of different experts is similar to what normative literature outlines for programming stages (LaGro Jr, 2013; Maxwell & Brown, 1993; Tusler et al., 1993), suggesting a deliberate process.

5.1 Architects’ desire for collaboration

The interviews with solo-practising architects particularly stood out, as they emphasised how much they missed practice-based exchange of ideas [A17,10,15], potentially because they could compare their experience with when they worked at a multi-person office [A17]. The contrast could allow them to realise how collaboration can prompt discussions which do not occur when an individual is working alone (Wallace & Ahmed, 2003) in turn, improving proposals through deliberation (Mercier & Sperber, 2011; Trouche et al., 2014). This led one architect to “set up a network of smaller businesses in [his city]” made of construction industry specialists. They want to use the network as “sounding board for free advice” and “do design reviews for each other and potentially check stuff over” (A10).

Other interviewees also discussed how they appreciated forms of collaboration. A21, reported how his practice operates on pin-up bases, where they show-case their work every morning to the project team, and begin discussing and elaborating on ideas. A4 and A19 discussed having project presentations across the office to gain feedback.
The reliance on others in collaboration can be desirable for architects as it can allow them to work more efficiently. For example, A9 utilised the collaborative setting to work quickly on multiple things at a time, potentially intuitively. He could work in such a way because he “…[relied] on the other staff in the office to pick up the detail...”, this was achievable due to common goals set in collaboration.

5.2 Joint problem solving

Collaborative problem-solving appeared to involve deliberation. Interviewees discussed how when mistakes emerged, the team tended to come together to jointly solve those. The mistake acted like a common goal which drove the team together. For example, A9 discusses how when they neglected to consider topography at the beginning of analysis, and developed an infeasible proposal “everyone panicked and had to do a lot of work very quickly...and just working very, very, very hard in the panic...So it wasn't it wasn't a disaster by any means, but ... It was a pretty scary two weeks...” A similar situation was described by A6, A1 and A10, where the team had to come together to resolve site analysis issues they initially neglected to consider. Sometimes a problem emerged because of a particular design concept chosen for the project or due to site constraints. That problem then became the focus of deliberation, an area where collaborative effort was placed to resolve the issue. For example, A20’s project was near a motorway, and as a result the design team had to consider the pollution, how to dampen the sound, ventilate the building and the cost of the project. A16 wanted to discharge service water into a river which was protected at certain times of the year. Those problems led to careful considerations and involvement of specialists. However, by resolving these problems, architects brought improvement to the area of problem-focus. Resolving a problem is not equal to the betterment of the design as a whole (Chakrabarti, 2003). In that respect, placing effort in one area, does not result in deliberate reasoning on other aspects of the project. Additionally, after effort has been placed, practitioners might be less willing to engage in Type 2 for the next challenge, because effort is tiring (Baumeister et al., 2018; Vohs et al., 2014). There were no apparent reports within the transcripts of architects undergoing a complex process of resolving a problem, followed by another problem, or multiple problems at once, in relation to site analysis.

5.3 Negotiation as a result of collaboration

Although not directly considered as a form of collaboration, negotiation, where discussion is aimed at reaching an agreement between the parties involved, emerged as a theme when working in collaboration within site analysis [A16,9,15,1,2,21]. Based on reasoning literature we can assume that deliberation is responsible for the development of arguments and persuasion, which are present in negotiation (De Neys, 2017; Mercier & Sperber, 2011). Interviewees reportedly developed strategies to persuade other collaborators of their ideas. For example, A16 described how when working with a developer and surveyor he intentionally “set the bar high [for the project] so they have something to cut. Almost like giving them a chance so they feel like they have something to do” (A16). The process might have also involved hypothetical thinking, a feature of Type 2, where different possibilities and their consequences were explored prior to being shown to the collaborator (Evans, 2020; Evans, 2019).

There are often meetings arranged with the local planners to discuss larger projects prior to submitting planning applications (in the UK proposed buildings require planning permission before construction can begin). Those meetings are another example of where collaboration led to negotiation. For example, an interviewee explained how they prepared aspects to propose during the meeting to “sweeten the deal” (A9) for the planners to accept their design proposals and overlook certain factors
of site analysis that are not to the expected standard. A9 provides an example of such deal, where they are “providing this amount of funding for this, which they [planners] really want, and you’re gonna be ...redoing the public realm around the site... and you’ll be providing X amount more workspace, which is important, in their strategic plan..., maybe they can overlook the rights [to light] issue if it’s not a major concern.” Other forms of negotiation emerged when architects had to communicate with Government funding bodies, Historic England, or Conservation Officers [A16 and 15]. For example, A16 describes how “Conservation Officers [...] want a building...] to look old.” This is an illustration of a site constraint, where the design of a new building might be constrained by the need to make it resemble adjacent historic buildings.

5.4 Individual thinking in a team setting

When introducing the concept of collaboration, A1 was used as an example for his work with external actors. However, in the interview, A1 downplayed the importance of internal collaboration. Similarly, A15 emphasised his own role, where he was the Lead Architect on a project. This could be linked to taking such collaboration for granted, or architect’s ego when presenting his project. Alternatively, it is due to the hierarchical set-up of an office, as one interviewee compares his experience to “…other offices I worked in, the decision making is very hierarchical. So, it comes from the director, director thinks something, and everyone just does it…” (A21). Another interviewee discussed how when the Lead Architect wanted to develop an idea, the support or comments from fellow team-members did not affect the design [A20]. In those situations, potentially the Lead Architect wants to have autocracy in decisions on design and the feasibility of a proposed building on a specific site. However, individuals who are thinking on their own will not be able to benefit from collaboration (Mercier & Sperber, 2011).

5.5 Collaborative overlooking

Although collaboration can lead to further deliberation, there were reports of collaborative overlooking of certain site analysis aspects. This phenomenon can be attributed to intuition, based on Kahneman's (2011:85) explanation of Type 1 characteristic “What you see is all there is (WYSIATI)”. WYSIATI implies that Type 1 creates a story from the information an individual can see. In those circumstances the quality and quantity of evidence supporting a particular story does not matter. Instead, it is the quality of the story that engenders confidence in an individual. For the sake of a coherent story, an individual might fail to recognise that critical evidence is missing. Arguably, it is not just subjective confidence that such stories can facilitate, they can also foster collective confidence. The interviewees A1, 2, 6, 9, 10 and 13 believed what they saw as a team, in their project-stories, was all there was. They confidently proceeded with their projects, until they realised, they were collaboratively overlooking missing crucial evidence. The development of such stories was also discussed within A20 and 21’s interviews but without mention of overlooking of evidence.

The following quote from A1 provides an example of the phenomena within a team setting:

“A1: We did a health centre in [City] in 2018... it was ready to submit for planning at stage 3. And later on in the day, the client sent through the underground utilities information, which showed a high voltage electricity cable running right under the building, which meant that actually to divert that would cost the client 150,000 pounds. So, it blew the budget out of the water straightaway. [...] Researcher: is there a reason why the client didn't send it earlier on?
A1: I think it was a mistake. I think that the architects ...have... just... basically forgotten. [And] the project manager forgot about it. ...And it wasn't until I think it was a planning requirement as part of the submission that they wanted to see underground information.”
In this case, there was a collective acceptance of the project, its story and progression, which reduced the need to deliberate or look for additional information. A1’s team had meetings, negotiations and discussions with the client, planners, and other collaborators. The project was ready to be submitted for planning, hence, site analysis was completed, and the design was coming to an end as well. However, it was not until A1’s team was prompted by an external cue, in needing to supply information, that they realised they were missing critical evidence. The project had to be re-worked once they realised their mistake, which led to delays, loss of time and fees.

6 Outsourcing

There were instances of outsourcing in the interview data, which aligned with Hemmatian and Sloman’s (2020) definition. For example, the interviewees outsourced internally through relying on information from architectural assistants, and in-house experts, data gatherers and analysts. External outsourcing was also prominent, where the data was provided by external consultants. In the description of findings below, however, the definition is extended to include outsourcing of decisions, where decisions are made by another individual.

6.1 Outsourcing effort for efficiency

Type 2 processes are dependent on cognitive resources (De Neys, 2017). Overall, overworking in forms of cognitive, emotional, or physical effort can result in greater reliance on Type 1. After we expend energy we have a tendency to save what is left (Baumeister et al., 2018; Kahneman, 2011; Vohs et al., 2014). Hence, the interviewees appeared to outsource some site-analysis-related effort, to facilitate their deliberation in other places. For example, architectural assistants can become outsourced to produce site analysis for the project lead, as described by A16: “...I didn’t have time to sit there and do it... I say, “Here you go,” to one of the Part 1s (architectural assistants) [you do it]...” (A16).

Similarly, instead of researching different aspects of a site, A19 described how they outsourced knowledge from fellow-office-architects with specific areas of expertise. Those architects could utilise their knowledge to very quickly provide information to be incorporated into site analysis. The process differs from collaboration as it does not involve engaging in constructive discussions.

Some practices reportedly employed staff who specialise in specific data gathering methods for their site analysis. For example, A13’s practice employs a data analyst, A19 has a team who works with GIS and A21’s practice has a research department which uses scientific methods to provide information to the design team, a workspace department which focuses on developing information about the future of the site and project, and a sustainability team. The material is then provided to the design team and utilised in the project.

Interviewees [A13,16,19,21] explained utilising outsourced information through forms of feeling of rightness. If there was a low feeling of rightness, deliberation would be engaged, and the particular area of information would be investigated, but otherwise it was intuitively accepted and applied to the project (Thompson, 2009; Thompson et al., 2011; Thompson & Morsanyi, 2012).

6.2 Information stored elsewhere

Sometimes an in-house expert can develop and share information to aid site analysis, such as a guide to planning applications, or compile certain regulations for ease-of-use. The members of the office might begin to utilise such information, but they can also assume they know more than they do. The actual knowledge and its in-depth implications are retained by the expert who supplied the information. It is also possible for the knowledge to be shared across other experts who understand the
information provided. Utilising such aids can be attributed to outsourcing, and be based on intuition (Rabb et al., 2019; Sloman & Rabb, 2016). For example, A2 reported how they have access to “these spreadsheets [with] all of those calculations [for example for occupancy and spatial areas which] ...you don't need to be doing, because someone's already done them and they are tried and tested”.

Other examples described by the interviewees include pre-made documents and templates which contain ways of presenting site analysis, or examples of how to construct certain analytical diagrams or calculations [A1,20]. Those could then be applied to projects “...from page to page. It was like, access, then it was sun path, then it was noise, potential noise, then it was... protected trees and greenery areas around... and then your little massing studies at the end” (A20). A similar approach reportedly was taken with housing standards, where a “variance of stuff we used before” (A16) is outsourced to form new proposals. Another example was described by A11, where her practice developed a style which had to be applied when working on projects.

6.3 Outsourcing to reduce complexity

Some Type 2 processes can be outsourced to reduce complexity. Interviewees commonly avoided complex analysis by outsourcing it [A1,3,5,6,7,9,11,13,14,17,18,19,20]. Hence, if they needed to understand an aspect of a site, instead of utilising prescriptive or scientific methods they could rely on an expert specialised in the area of enquiry to deliver the knowledge (Hemmatian & Sloman, 2020). This approach appears to reflect an attitude in which external consultants are responsible for providing technical knowledge, while the role of an “architect is to actually bring in the right partners at the right time” (A19) [similarly A2] (also discussed in Jamieson et al., 2011). As observed above, however, architects might not only be outsourcing the analytical aspects of site analysis, but also consultants’ understanding. For example, A17 discussed how he had “a specialist involved to do those types of calculations” but A17 “didn't understand the numbers”. Other interviewees also reported being unable to fully understand the reports [A3,7,13,14,17,18,19,20]. An example of such phenomena can be seen in the following conversation:

“Researcher: Did you do any calculations to make sure that there's enough light?
A1: We didn't, no, because we knew that the volume of light coming from this atrium would be sufficient through what the M&E guys told us. ... Likewise, natural lighting, artificial lighting and ventilation in-take and extract and a lot of other things utility, services is all the M&E consultant, we design the space and help deliver the brief.

Researcher: Does what M&E consultant ...inputs in, does that change the design quite often?
A1: Not really.” (A1) [similar conversation happened with A7]

It should be noted that in the above quote, the information given by the consultant did not lead to collaboration. The interviewee was also not involved in any analytical work prior to consultant’s provision of information. This could be linked to interviewees’ desire to reduce cognitive load and their arguably “lazy” Type 2, which prefers not to engage in a topic where lack of expertise might lead to increased effort and energy. Arguably there was no application of the findings to the project either, as the design was not affected (Baumeister et al., 2018; Hemmatian & Sloman, 2020; Kahneman, 2011; Vohs et al., 2014).

Sometimes to reduce complexity and consultancy costs, interviewees described how they did not engage in analytical aspects, such as “daylight analysis” (A18). They would only conduct such analysis if asked to do so by a planner in the submission process [A18,11]. However, at that stage it can be too late to adjust the design to apply the information. Similarly, some interviewees reported how consultants’ reports needed to be done, as a ‘tick-the-box-exercise’, with no intention to synthesise such information into the project [A6,9], hence supporting the argument that reports did not affect the design.
Other interviewees discussed how they looked for pointers within report’s summary pages, to highlight any aspects which needed considering [A1,7,13]. Possibly in practice, information is accepted and set aside, unless there is a cue which triggers a low feeling of rightness and prompts deliberation.

When there was data which needed applying, interviewees looked for specific instructions they could swiftly employ. For example, if the report said there is “arsenic in the ground, so you need to have a capping layer of 600 mm of new topsoil”, the interviewee “would be like fine, okay, so the ground levels of the site need to come up by 600 mm...” (A5). Type 2 might be involved in reading and comprehending the report; arguably Type 2 is always present in some form when reading and formulating a response. The DPT literature assumes that Type 2 is always “on” but in a low effort mode (De Neys, 2017; Kahneman, 2011). However, the instructions of what needs to be done were outsourced and applied.

Another perspective on outsourcing is when the external consultant is content to oversee and guide the architect through the process to reduce the complexity of their task at a later stage. As A15 explains: “[the environmental, M&E and structural engineer] want me to give them the right zones of space, so that when they are on the project at the building regs stage, they've got enough space to do what they need to do. They've learned over the past three years that if they don't help me early on, it's really difficult for them at the next stage because I haven't given them enough space...” (A15). However, such process of inter-reliance was achieved over-time.

Not all interviewees relied on consultants for information. A21 reported how it is important for him to use analytical software which can help shape the design. That way as the design progresses, he can make sure the proposal is optimised, for example the proposal makes use of the orientation on site. Additionally, the software can highlight any parts which need further attention. By contrast, consultants’ reports can be utilised for precise information, after the design has been set. A21’s approach aligns with some of the scientific methods discussed earlier.

6.4 Outsourcing decisions

Sometimes, planners were outsourced by architects as design validators. For example, “I think if... it went to planning, and you received an approval straightaway. Then yeah, it's a good sign that you've done all your job correctly. And you've done the analysis, and it kind of justified the design process” (A13) [also reported by A11, A6 and A10]. In those situations, possibly architects were substituting difficult questions such as whether the analysis was satisfactory, with easier ones, such as whether the planners liked the scheme. Substitution, where one question is answered instead of another, is a feature of Type 1 thinking (Kahneman, 2011:97). Substitution was also used to outsource what needs to be incorporated into site analysis based on “what the planners want” (A8) [also A18 and A8]. Reportedly once planning consent has been granted less consideration could be placed on site analysis. For example, A6 discussed how nearby buildings “are being overshadowed by us” but “because this ...already been ...[through]... planning, it is going to get done, so, it's fine” (A6). The importance of decisions associated with site analysis diminished, implying that the initial process of site analysis was reliant on outsourced planners’ needs. Overall, there is less need to engage in Type 2 when the decisions are insignificant (Evans, 2019).

The process of structuring and aligning a project to suit planners’ needs can reportedly fail, when there is a change of staff, as explained by A16:

“We had many discussions with one planner, and then he left, another came, and they said this completely does not suit the requirements and it does not work for them, it does not make sense, the aesthetic does not match what we are after.” (A16).
Potentially, the reason why there is minimal collaboration between the planners and architects is because they are working to a different set of goals for the project and the wider built environment. If the goals aligned, it could become “a team-based thing, rather than... the architect’s game” as A14 reports, who has experience of working in collaboration with local authorities and planners. Reportedly such collaboration is rather uncommon. However, it could lead to some benefits discussed in the previous section, such as joint discussion and improvement of ideas. Difficult decisions can also be outsourced by architects to their clients. Hence, analysis would be resolved, when the client is satisfied [A1,19].

7 Discussion

By switching the focus from design processes to information gathering, which is central to site analysis, we can open new perspectives on design thinking. Specifically, exploring how collaboration and outsourcing are used in site analysis reveals their impact on intuition and deliberation.

7.1 Extending the frontiers of design thinking through the study of site analysis

Previous studies of design indicate that designers, including architects, often start by generating and evaluating potential solutions, rather than gathering and synthesising information before commencing design (Akin, 1990; Darke, 1979; Lawson, 2006; Schön, 1991). According to these studies, information-gathering and design happen simultaneously. Such studies, however, have focused on design; less attention has been paid to the ways in which designers collect information. This study expands design thinking by focusing on site analysis, a design-related activity which centres on the gathering and synthesis of information. Moreover, it considers information-gathering processes through the lens of DPT, which provides insights, especially in relation to architects’ use of Type 1 thinking, with its capacity to overlook information. Looking at site analysis through the lens of DPT challenges some accepted ideas around design expertise. In the current literature, much emphasis is placed on the ways in which designers, including architects, develop and deploy expertise in design processes (Akin, 1986, 1990; Canter, 1974; Lawson, 2004b; Schön, 1991). Specifically, there is a perception that architects learn over time, allowing them to intuitively recall situations by meaningful chunks when prompted by cues. However, it appears that architects can also take the default act of applying information without conscious reflection. Unlike pattern-recognition the information is not based on consolidated knowledge (Akin & Akin, 1996). This raises the possibility that vital information will be overlooked in decisions on design or on the feasibility of a building on a given site. The implications of overlooking information are apparent from the literature on post-occupancy, which highlights the severity of problems caused by design errors (Stevenson, 2019).

7.2 Co-production in Architecture

Collaboration and outsourcing are essential to the information-gathering processes involved in site analysis. By investigating these, this study broadens our current understanding of collaboration (Cross et al., 2006; Ding & Ng, 2010; Gill et al., 2000; Goldschmidt, 1996; Lawson, 2006; Lloyd & Busby, 2001; Luck, 2007; Murphy, 2005; Ottosson, 2003; Schön, 1991; Stempfle & Badke-Schaub, 2002) by highlighting instances where team-work prompted deliberation or intuition. Current literature indicates that in collaboration, differences and challenges (Stempfle & Badke-Schaub, 2002) and forms of negotiation (Bereton et al., 1996; Lloyd & McDonnell, 2009; McDonnell, 2009) can be present, and those can lead to more deliberate ways of working, which was echoed in this study’s findings.
A novel and critical finding is how intuition can be present in a team setting in the form of collaborative overlooking. This happens when missing critical evidence is overlooked for the sake of a coherent story about a project. Such, selective interpretation was also reported by Brereton et al., (1996). However, this study’s findings indicate that those stories engendered confidence which was shared across the team. Arguably, this Type 1 characteristic, usually attributed to individuals’ use of intuition (Kahneman, 2011), can manifest in team-based settings. This shared sense of confidence can undermine the benefits associated with collaboration, such as the challenging of ideas, which prompts deliberation.

Although there have been previous studies on collaboration in design, there have been far fewer studies on outsourcing. Within site analysis literature (LaGro Jr, 2013; Makstutis, 2018) there is an assumption that architects receive information from external parties but the process behind its application is not discussed. A key finding was that architects rely on outsourcing for efficiency and to reduce complexity. Due to outsourcing, architects can feel as if they have all the necessary information, if they receive reports on key issues. However, the automatic nature of outsourcing may mean that architects do not necessarily understand the reports or have read their content. Hence, they can have a misplaced sense of confidence. The findings indicate that outsourcing led to the use of deliberation only when the information received was accompanied by a low feeling of rightness. However, if the information is beyond architects’ understanding, it might not be possible for them to recognise its relevance, and in turn, have an associated feeling of rightness, to engage Type 2 (Stanovich, 2018).

A related issue is some architects’ apparent inability to understand consultants’ reports. Potentially, because architects know they can avoid understanding complex structures by outsourcing them, they need never gain competence in the task in question (Hemmatian & Sloman, 2020). Furthermore, reflecting on consultants’ reports would require architects to expend a considerable amount of energy (Baumeister et al., 2018; Vohs et al., 2014), especially if there is lack of competence in the area (Dreyfus & Dreyfus, 2005). However, this might be unfeasible in an environment where architects are under pressure to produce high quality outputs within a limited time (Jamieson et al., 2011; Nelson, 2017; Serginson et al., 2013; Sinclair & Ashkanasy, 2016).

This study also begins to explore co-production and its effect on the design produced. Information delivered from an outsourced external actor, or fellow office staff member, did not appear to affect the design, unless there was an issue which emerged and needed resolving. The contribution of outsourced actors was mostly uncredited. There is an understanding that architects work collaboratively (Goldschmidt, 1996; Imrie & Street, 2011), which was shown in the findings, however, the lead-architects also wanted to portray themselves as the sole authors.

### 7.3 Limitations and further work

Semi-structured interviews are post-rationalised reports of events. Trying to obtain data on intuition or deliberation through interviews is difficult, especially since it is dependent on interviewees’ recollection of the event. Brief events which occurred some time ago can be forgotten (Ericsson & Simon, 1984; Paletz et al., 2011). Hence, further research is needed to explore key questions emerging from this research. For example, ethnographic work on initial and post-completion stages of a project would be beneficial to explore implications of architects’ decisions, and experimental research on architects’ competencies would show the basis of expertise in architects’ intuitive judgments.
8 Conclusion

Through studying site analysis, and the integral activities of collaboration and outsourcing, this paper expands design thinking. Investigating design-related information gathering processes yields new insights into how architects work, specifically on architects’ use of intuition beyond pattern recognition.

The findings indicate that collaboration is more likely to result in deliberation when there is a desire between team-members to work together, when faced with a difficult problem which needs resolving, and when it leads to negotiation. Intuition, however, might be present in collaboration, particularly where shared narratives cause the overlooking of information, which in turn can lead to re-works. Outsourcing allowed for efficiency and reduced projects’ complexity but seemed more likely to lead to the use of intuition. In the interview data, deliberation was prompted during outsourcing only when there was a common goal between the information supplier and architect, or when outsourced information led to architects’ low feeling of rightness. The prominence of outsourcing in this study raises questions regarding the type and level of expertise that architects require in order to gather and synthesise information, in undertaking site analysis.

References


Considering architects and clients’ interactions through the Design Thinking framework

Audrey Mertens, Yaprak Hamarat and Catherine Elsen
Université de Liège, audrey.mertens@uliege.be, yaprak.hamarat@uliege.be, catherine.elsen@uliege.be

Abstract. As the quality of the relationship between designers and users highly contributes to the success of the design process, involving users in the design process is more than ever crucial to the project. This paper argues that Design Thinking could help architectural routines evolve regarding the interactions between end-users and architects. Though the Design Thinking principles may serve as an inspirational framework, we claim they still need to be adapted to architects’ needs and fields’ constraints. This paper focuses on the Belgian housing design field, specifically questioning the posture architects tend to have towards their end-users through 5 narratives collected from on-field practitioners. The aim is to establish a parallel between day-to-day architectural practice and Design Thinking as a mindset and as a process, as to delineate the essential points architects might benefit from and as to question the role that end-users could furthermore play throughout housing design processes.

Keywords: architectural practice, Design Thinking principles, housing design, user involvement

1 Context of the research project

1.1 Background of the research project

This research is part of a wider research project aiming to provide a better understanding of how architects and end-users interact nowadays, and to suggest ways to renew these interactional models. As the intertwined relationship between designers and end-users constitutes a crucial part of the design process, involving users in the design process is more than ever essential to the project success (Lawson, 2005; Esteyez & Léglise, 2015; Sarkar & Gero, 2017; Arboleda, 2020). Recently researchers have put into question the traditional model of architectural design, seen as the result of a sole Master’sartful persuasion (Prost & Chaslin, 2014). This model has been said to be completely outdated and no longer practicable (Siva & London, 2011; Albrecht, 1988; Macaire, 2009; McDonnell & Lloyd, 2014). As an alternative, this paper leans towards the Design Thinking framework as an inspiration to help architectural routines evolve when it comes to users and architects’ interactions, while still being adapted to architects’ needs and field constraints.

1.2 Belgian context

Considering the architectural practice, we specifically focus on housing in Belgium (in Wallonia & Brussels), where any construction work affecting the envelope or structure of a building requires an architect in charge. In the process of digging into existing interactional models, one of the first steps consists of getting a better grasp of architects’ actual organizations and current practices. One of the most well-known Belgian association for consumer protection (“Test-Achats”) has shown that amongst 1330 respondents who built their personal homes between 2000 and 2013, only half felt satisfied with their architect(s) at the end of the process. Almost half of the participants moreover
expressed having experienced stress and 27% confessed having suffered from irritability and anxiety throughout the process (Nauwelaers & Rossini, 2014). Another questionnaire broadcasted in Belgium showed that the client is among the « top 5 factors » that make architects’ jobs more difficult on an everyday basis (Stals et al., 2018). This friction occurring in the housing design process between architects and end-users highlights the need to further question the social interactions underlying the design process, as these interactions seem to be a source of dissatisfaction.

2 Architectural design through the design thinking framework (a thematic literature review)

End-user low satisfaction levels constitute a key issue nowadays in architectural design (Siva & London, 2011). Discounting the importance of alarming reports, architectural design indeed missed several opportunities to systematize user-centered and participatory approaches, therefore lagging behind other design fields (Bacqué et al., 2011; Van der Linden et al., 2019a). If housing architecture is a branch of the design practices, we question the influx of Design Thinking in that scale of practice.

We will develop this connection through two levels: conceptual and pragmatic. Firstly, we touch upon the principles of Design Thinking as a reflective approach (section 2.1.). Secondly, we tackle its use as a process and a set of tools for architects (section 2.2). This framework will be used as a lens to look into our empirical data, as to later frame how it might support user centeredness in architectural practice.

2.1 Might design thinking be a mindset… for architects?

As Brenner and Uebernickel put it, “innovation is made by humans for humans” (2016, p.8). This human-centered premise is presented as one of the fundamentals triggering all Design Thinking principles. Another fundamental aspect would be combining both divergent thinking – following unconventional paths – and convergent thinking to eventually grasp the details and stakes of the most promising path (Cooper, 2008; Brenner & Uebernickel, 2016). Those lines of thinking, by nature, require experimenting and iterating, prototyping, failing, implementing and enhancing prototypes, looping with this process until the output meets most expectations in a satisfactory manner. Of course, some architects can already be referred to as design thinkers in that regard, but one has to observe that most of those concepts are not systematically and/or explicitly taught in architecture schools, nor implemented in most architectural offices (Nishimura et al., 2017). Looking into architectural practices, another question arises: whose insights and user-centered data might drive such iterative processes in architecture, be they applied? Architectural offices functioning with design teams (instead of an individual architect working on his/her own project) might already be closer to the Design Thinking mindset, in the sense that during collective ideation, processes get challenged by other designers, all of them working together with creative confidence and optimism (Brown, 2009).

Nevertheless, in the architectural field, more often than not we see architects operating in the close, tiny, mono-disciplinary microcosms of their firms. This is especially true in Belgium, where research has shown that most architects work in structures of less than 10 employees, 42,7% of surveyed architects (N=572) even working alone, or with just one colleague (Stals et al., 2017). Historically and structurally speaking, architects thus do not tend to exit their microcosms and cultivate empathy towards end-users, at least not as often as designers from other design disciplines. Attention has been brought to this issue repeatedly (Tribout, 2012; McDonnell & Lloyd, 2014) and, as a consequence, participatory practices slowly gained more interest from architects, especially in public spaces’ design or building projects driven by the public sector (Biau et al., 2012; Zetlaoui-Léger, 2013). If such citizens’ input, needs and expectations are nowadays considered as enriching these divergent-
convergent processes, it is not clear if such participatory practices might also percolate smaller scale projects, such as housing projects.

2.2 Might design thinking act as a process, a toolbox… for architects?

The fragmented nature of the architectural design field, as underlined by Jacob (2016), can be challenging to analyze. Based on Lawson (2005), Jacob provides a brief model of the architectural process, arguing that during the first step called “formulating”, architects have to define, identify, understand, frame and explore highly complex, intricated and ill-structured design problems. Emphasis is put on the fact that architects, while navigating such problem space, should generate stories to reframe the issues from different points of view and perspectives. In this case, we argue that being in contact with the key actors eventually populating the artefact being designed, e.g., the future end-users, might help open up some relevant perspectives, that architects while working between themselves might otherwise not open to. From where we stand, this first phase might well be the cornerstone, with the involvement of end-users profoundly changing the whole story. This aspect of Jacob’s model that we defend is closer to matching Brenner and Uebernickel’s (2016) “need finding” step (Figure 1).

In his second step, Jacob (2016) delineates the “representation phase”, when architects externalize their ideas and thoughts to represent the problematic through models or drawings, among other visual supports depending on the nature of the outcome. If we compare Jacob’s model to Brenner and Uebernickel’s (2016), this step also overlaps the “need finding” step mentioned earlier (Figure 1). This is the moment where architects create externalized, mediating supports and could further include other actors into the architectural conversation. In Jacob’s third and final step, architects come up with one or more solutions - also referred to as “moving” by Lawson (2005) - in a form of divergent/convergent process, which connects well with design thinking principles of ideating, prototyping and testing (Figure 1). Still according to Jacob (2016), designers should integrate objective/technical and subjective/aesthetic judgments in making choices and be able to reflect in action, and also be able to reflect on how they go about the design process itself, for example by keeping sketchbooks or collecting artifacts reflecting what they consider to be good design to learn from when considering future designs. Reflecting on Lawson and Jacobs’s process descriptions, we realize those do not fall very far from Brenner and Uebernickel’s Design Thinking description (2016). For both authors, the sequence of steps from “formulating” to “moving” rarely follows a linear logic (Lawson, 2005), but is rather continuous and iterative. However, whilst keeping Lawson’s and Jacob’s hypothesis and developments in mind, we will base our comparative analyze on Brenner and Uebernickel’s model (Figure 1).

If the five steps forecasted in Figure 1 are typically implemented to aim for judicious innovation through Design Thinking, it is still unclear at this point how (or if) those five steps might be transposed or interpreted in the small scale of housing architecture practices, or if any of the tools Brenner and Uebernickel have popularized with their 2016 book – i.e. Stakeholder Maps, Empathy Maps, 5-whys, AEIOU-Method, Personas, Observation and Storytelling – are taken upon by architects in the Belgium housing context. Several researches have indeed shown that, in small scale architectural practices, most architects rarely go beyond early conversational interactions to reach out to users’ needs and expectations (Norouzi et al., 2015; Van der Linden et al., 2017).
2.3 Focus

In this paper, we specifically question the posture architects tend to have towards their end-users and we use Design Thinking as a framework through which we study these architectural practices. We first want to summarize the process and meeting points of architects and end-users during small-scale housing projects. We question the architects’ postures toward the end-users and look for success stories in these relationships. Finally, we look for the patterns depicted by the interviewed architects in regard of the Design Thinking principles, steps and tools raised here above.

3 Research methodology

After building a theoretical understanding of our use of the Design Thinking model through international scientific literature, we put our focus on Belgian practices through empirical inquiry. We broadcasted a questionnaire through the Belgian Architects’ Association, as to invite all Walloon and Brussels architects affiliated to this Association to take part in this study. We then conducted five semi-structured, in-depth interviews.

On that basis, we consider the data through the lens of abductive analysis (Timmermans & Tavory, 2012): with Brenner and Uebelnickel’s principles as a comparative model, we analyze and compare the phenomenon described by architects in terms of design methods and we let the data express unexpected trends, adding specific and original depth to the model regarding our field (e.g., housing architecture in the Walloon Context).

3.1 Online survey and profile of the participants

The recruitment questionnaire, aiming to profile different significant groups of architects active in the housing sector, got 96 respondents. Questions touched upon their location in Belgium, their experience, education, the scale of their agency, their level of responsibility, the percentage of housing projects overall, the type of clients they usually deal with (private individuals and families/investors…), if they feel impacted in their daily practice by their relationships with their clients, and eventually how often they interact with them. We grouped the respondents in view of their answers, and we selected an architect amongst each main group to conduct an in-depth interview and collect qualitative data on the actual day-to-day practices regarding the interactions with their clients.
added the profile of another architect who had not participated in the survey but was interviewed in the same conditions than the others. This last profile was a pragmatic choice yielded by an opportunity: a senior architect in contact with our research lab agreed to participate in the interviews even though he had not responded to the questionnaire. This allowed us to include the profile of someone who was not amongst the architects innately drawn to this problematic (and spontaneously taking part in the survey), i.e., someone who was not necessarily predisposed to volunteer and participate in our research, but rather did it give favorable circumstances.

In this paper, we thus focus and analyze interviews of five architects (two female, three male), situated in three different provinces (Brussel [2], Liege [2], Luxembourg [1]) and who mainly practice residential architecture. Only one is fully dedicated to individual clients with a single-family housing project, while others also work for residential projects carried by institutions (e.g., social housing and co-op housing), self-builders or real estate’s investors. They have various professional experiences (less than six years [1], between 10-14 years [2], more than 25 years [2]). Only one of the participants is trained as an architectural engineer and four others are architects, one with a collective housing specialty. On a daily basis, they work in an environment welcoming between 3 and 14 collaborators, except for one of them who works alone. All of them hold leadership positions, three for their own companies and two for third parties. With the exception of one of them (for whom we could not collect data through the survey), the others declared that the relation with the client influences a lot their motivation and the quality of their daily life at work. To conclude, we identified that the way these architects meet their clients during the early design phases of architectural project is quite different, notably in terms of frequency. While one of them declares meeting the client only twice, others meet between three and five times, and another can meet with them up to eight times before reaching the building permit phase.

3.2 Semi-structured in-depth interview & analysis

These interviews aim to collect rich qualitative data on architects' relations with their clients, who are also the end-users of the building being designed, since we are here looking at housing projects cases. The objective is to understand multiple interactions that intertwine different issues related to communication, architectural culture, money management and time, among others. This complex situation, called a "wicked problem" by Horst W. J. Rittel (see [Buchanan, 1992] for a genealogy of the concept of design thinking), requires a global understanding of the phenomenon and a co-construction of some shared sense between the researcher and the interviewee (Imbert, 2010; Denzin & Lincoln, 2011). Therefore, a conversational place is necessary for architects to develop their point of view when it comes to the role given to the end-users throughout the architectural practice.

Semi-structured interviews are nowadays recognized for their added value when researching architectural or design processes. For example, four Japan-based designers were interviewed to study “their perception of Western and Japanese people’s behavior in co-design workshops” (Taoka et al., 2021, p.2), while 20 interviews were realized to identify “perceptions, sources and tools, as well as perceived barriers and motivations for inclusive design” in Flemish architectural practice (Van der Linden et al., 2016, p.33). Holopainen (2010) studied a service design project in order to understand how designers and architects design their services, with which particularities. Part of a broader ethnographic approach, they conducted eight scheduled, semi-structured interviews to “provide[d] a more structured way of discovering the opinions of the informants” (Holopainen, 2010, p.602). As we see in these examples, even though such interviews should be completed with other methodological approaches to deeply understand architects’ practices (see 5. Limits and Perspectives), semi-structured interviews allow to reveal architects’ perspectives, at least in an exploratory approach.
Through general and specific questions, both on residential architecture and relations with clients, the semi-structured interviews created a reflexive conversation and revealed the experiences, opinions, feelings, and particular situations experienced by the architects during their careers. A set of 20 questions organized into six thematic categories thus guided the conversation on the specific topic of interactions between architects and end-users, while leaving the possibility for the participants to explore other subjects more freely when relevant and when the allocated time allowed. In brief, five one-to-one recorded semi-structured interviews were realized through Zoom (3), in the interviewee house (1), or hosted at a university office (1) and lasted between one and two hours. We focused only on discursive content on basis of a written transcription of all of the audio recordings (h=8:58:57). After such a transcription, we did a comparative analysis of the interview data, using an abductive approach. To do so, we used our research topics operationalized through the questions asked to interviewees. We annotated common and singular patterns meaningful to our research object, i.e., interactions between architects and end-users. We aim to reveal the plurality of the data without generalizing it (Beaud & Weber, 2010; Dodier & Baszanger, 1997). To this end, we differentiate the interviewees from one another using pseudonyms to preserve their anonymity. We compared these results to the Design Thinking framework, thus revealing similarities and differences between architectural practices and design thinking and discussing the added aspects of the architect’s narrative to enrich the reference model. Firstly, we conduct analysis using a collective lens, pointing out the big overlaps in the interviewees’ narratives that echo the Design Thinking model. Then we zoom into an individual lens and match specific excerpts corresponding or diverging from the model to illustrate differences and surprising specificities as expressed through our interviews.

4 Findings & discussion

Looking into the data, we first focus on some insightful practices and comments raised during the interviews. Then, we delineate the similarities and gaps between the Design Thinking framework and the practices depicted by the interviewed practitioners. In most narratives, we tried to grasp the elements that caused frictions, or on the opposite were actually working really well. Thus, we acknowledge that the following anecdotes are not representative of all interactions that may occur between end-users and architects, but these examples can serve as a basis for further reflection on the variety of practices. We also want to drive the reader’s attention to the fact that some of these short stories are anecdotal in the interviewee’s practice, whilst some other narratives are more customary and thus representative of this single interviewee’s routines.

4.1 Overlapping positions

The five interviewed architects told us stories about their practices when encountering clients that would reach out to them for their housing project. These narratives allow us to create a summary timeline on the most frequent meeting points occurring between architects and clients throughout the design phase of the project (at least in their contexts). This sequence of steps is a compilation of the main steps described by these five participants, practicing architecture in Belgium in offices employing less than 20 collaborators. The process described includes a first contact phase between the user and the architect, when they both “test each other” in order to decide whether or not they are going to be working together. The second phase, sometimes already forming in parallel with the first phase, is about creating or adjusting a brief, firstly through physical or virtual meetings and conversations, secondly by presenting reference images and/or bringing along the first sketches and drafts of the architect’s ideas ("sketch", “esquisse” in French). When the architects sense there is a
good enough grasp on the user’s needs and expectations, they define and detail the layouts and enter the phase they call preliminary project or pre-project (“avant-projet” in French). Finally, when the architects consider all the variables as set, they undertake the building permit documentation, which is mandatory for any work on the building’s envelope or structure, delineating a rather fixed version of the project (“dossier de permis” in French). Of course, this sequence appears as rarely linear, and does not do justice to the messiness and the complexity of an actual design process. This simplification is displayed as a support for the reader’s comprehension of the main steps that are discussed in the rest of this paper.

One of the main strains mentioned by every interviewed architect, apart from the usually tight budget to hold, is the little time they have for all day-to-day responsibilities. They are in charge of usually small teams of co-workers, and do not have all the support staff they would dream of as to make more time for meta-cognitive thinking. This could be an explanation for the architects’ lack of hindsight on their practices and lack of reflection when it comes to enhancing their interactions with their clients in general. This is a key point that has to be kept in mind for any future recommendations.

Another explanation that could be explored is also brought up by several interviewees. Indeed, Ken, Charly and Richard raise the question of the architectural educational background compared to the actual practice. Whereas handling these complex social interactions require huge amounts of social skills from the architect’s part, all three of them mention that being an architect sometimes feels like having to be a psychologist, while never receiving any training in such matter. Architectural training often focuses on the form, function and techniques of the end-product design (e.g., the building, the public space…) but lacks coaching on the overall process of designing, especially in terms of social interactions with colleagues (Calixte, 2021) but also with clients. If empathy is often presented as key to a relevant design (Heylighen & Dong, 2019), these architects regret not having an actual psychology course. Whether this might have been recently implemented in architectural trainings around Belgium should be looked into; yet we wonder: would it be possible to accompany senior architects with further continued training to bridge this gap, in order to enhance their current practices, whilst still fitting their tight schedule? As the leader of his architectural firm, Ken does mention that he called an expert in psychology to give all of his associates a course on collaborating and working as a team. This kind of courses could be a great inspiration to adapt a format of classes tackling the psychology behind interactions with users.

Overall, they all seem to be generally in favor of user-centered design in their discourse, but still often depict a vision of the “wise” architect facing the “naive” end-users. Richard, while emphasizing the importance of being at the user’s service, still adopts a paternalistic position, explicitly saying he knows what to do for the good of the occupants, that he “offers” his high-quality viewpoints and “help them take a step back to re-examine their needs”. Whilst this hindsight coaching is non-rebuttably welcome and rich, we advocate that any user should be considered as the main “expert” when it comes to their needs, desires and uses.

Richard does mention the difference between designing for private mono-family housing (with very specific, individual choices), and larger scale housing when the design is thought to be suiting “everyone”. In that regard, he says he enjoys larger projects, public housing for instance, but still designs some residential projects from time to time. Lola also expresses her preference for clients who let themselves be taken by the hand, who listen to what she suggests, without challenging her too much. Still regarding user expertise, Charly addresses the difference of confidence she might put in a user, depending on whether such a user holds certain skills, background or knowledge in construction-related topics. She values clients that come with certain craftsmanship skills and show themselves to be open to debate and exchange with her. This again expresses a certain reluctance to seriously considering every single end-user’s input as expertise. All five of the interviewees state that they refuse clients who arrive with ready-made plans to be signed, but we were not able to collect
information on whether those layouts were copied or stolen from another project, or if some or all of the mentioned cases might have actually been drafted by the clients themselves. However, this still highlights the reluctance these architects express about not being the initiator of the design process and design concept.

4.2 Individual excerpts and anecdotes

Another possible explanation for this reluctance to accept ready-made layouts is brought up by Ken during his interview:

“You don't expect to get the gift [of recognition] but to get it, to feel a real thank you and that your work was appreciated, that is clearly the reason I’m in this business. (...) I could earn more, and stress less [in another job] but I would like it less because I wouldn’t have the fulfillment that my job brings me. Recognition is part of that. The fulfillment is to be able to please, to bring projects to life for the people trusting us, bringing our touch to it for people to live in”.

From his point of view, the actual passion in his job comes from the fact that he is able to create and gift the project and get full recognition for it; in that regard, we can understand the reluctance he shows when it comes to sharing credit on any design ideation process. However, couldn’t he get the recognition he craves by including the end-users more and thus co-creating together with them an even more relevant project, fitting their wishes and needs? The shift in authorship touches a delicate cultural preconception, stating that only the artist is the creator of an art piece he/she offers to the world.

For Leo, the ideal mission for an architect could be summarized as designing living spaces that allow people to blossom. In contrast with this utopia, he says, is the reality of the architect’s task: to respect and apply norms, regulations and to take responsibility when things go wrong. On the one hand, he puts the user’s wellbeing as the main target, but then on the other hand, it seems like the practice and real-life constraints keep him from actually fulfilling this goal. He also mentions the complexity of communicating with people who do not have an architectural background nor sensitivity to the design culture. According to him, people do not have sufficient general skills in terms of reading a blueprint or harmonizing elements and materials. Again, the architect is placed as the expert.

When specifically asked about their thoughts on participation practices, in general, all the interviewees pause for a short while. Whilst Ken is not quite sure what participation means, and while Lola shuts down the conversation saying firmly “it's good to listen to all the people whose lives will be impacted by the project”, Richard praises it for public projects, but would not go there for smaller scale houses. However, he does detail a participation process he was involved in, in the context of a school project, where all the potential future users were invited to a consultation committee and were invited to speak. They visited the site, room by room, noting down everything that was said, listening to and reframing the debates between stakeholders. He also mentions some work groups with teachers and maintenance staff, of children needs being collected, and even the presentation of a model to the children as to get feedback in an iterative process. The design was then presented to the parents and another feedback loop was implemented to take into account their comments and opinions.

His enthusiasm in narrating this memorable project surely contrasts with his reluctance in including the end-user in the very first steps of the design process when it comes to private housing for instance. Once again, the cultural architectural background of these architects does not include any sort of training in participatory approaches and co-creation methods, which might explain such reluctance.

Regarding Lola’s case, even though she did not manifest a particular interest in per-say participation, she does have an interesting posture when it comes to client-communication. She qualifies her mission prima facie as to have to put all of what she has learned to ensure the comfort and wellbeing.
of the occupants. She prefers private housing projects and puts a great emphasis on a human connection with her clients, introducing herself not only as an architect but reminding that she is a human being, a woman, a mother too. She wants her clients to be able to empathize with her and tells them "We are going to live together for a few months" before signing the contract. She also mentions what she calls her “feedback methods”:

"I sent a card every (...) I take a picture of one of the year's projects and send it as a postcard to each client at the end of the year, to tell them ‘Hi, I'm still here. I hope all is well’(...) I'll publish out images from previous projects. I make a post on Instagram, (...) saying: Here it's already been that many months since the project was finished, or things like that. And [feedback] works through replies to those kinds of posts or replies to stories for me. (...) I've also had clients call me (...) they give me a nice little comment. Or a client who was pregnant at the same time as me, who wrote to me when her baby was born. Yes, little things like that, but always positive (...) without wanting to sound pretentious. And I also think it is because I'm filtering my clients.”

However, she still admits that two of her stories are not that easygoing. She addresses her vision on what went wrong in these relationships:

“It happened two times, and the two times the clients were people who came to me, not because they were convinced that what I was doing was great, or that it was what they wanted. No, they came because they needed an architect, already had been kicked out by another one. And because somebody had told them that they knew somebody… that was me. And I was kind of as a last resort.”

Leo also has a success story hidden in an anecdote recalled in his interview, that could be taken as an inspiration for similar cases. In this project, he was in charge of redesigning a small house where his clients experienced difficulties in the daily use. He suggested setting up a small "simple" solution, like a prototype, to test what it could be like to partition the living room, and thus created a small entrance hall with a wardrobe. Eventually, the prototype met the expectations of the end-users so well that it was sustained, and the project did not need to be taken further since the issue had been solved. This can be seen as a smart and effective application of the prototyping principle in a small-scale housing architecture context.

Another isolated success story happened in Richard’s career, about 20 years ago. He could not recall who initiated this method, but for a specific client, he had to narrate the space. He did have blueprints and sketches but did not take them out at first. Instead, he did some storytelling, he interpreted a daily journey taking place in the designed spaces. This scenario of life, staging the space in the tale while involving the listener, was a success says Richard, a great moment shared with his client, who then became and has since stayed a friend of his. The project did not evolve much afterwards, from what he recalls, as if this was a crucial step when the end-user could project himself into the immaterial design at this time and was content with what he heard. Unfortunately, this was a one-time experience for Richard, thus nothing indicates that this could be an unfailing method to follow. However, the fact that this experience had a positive outcome can be interpreted as a positive signal to test this method further.

4.3 Patterns of design thinking in architectural practices

Putting together these five narratives and all of the stories of project within, we delineate the practices that can be considered as complete or incomplete steps of a Design Thinking-like process, discussing potential add-ons specific to our field (e.g., housing architectural practices in Wallonia).

4.3.1 Need finding & synthesizing. The collection of user data is very variable, and as mentioned earlier, can even vary for a same architect depending on the client he/she meets. As harsh as this elitist way of doing may seem, some architects did confess this practice: depending on the budget of the
client and the scale of the project, the architect will bring a different approach to the user’s needs, such as higher attention to detail, visiting their homes and ensuring a better client support overall.

Every architect interviewed did use reference images, most of them with a procedure encouraging clients to come up with images they really like and images they dislike and having them explain why. This photo elicitation-like technique (Clark et al., 2013) has proven to be really effective in bringing up reactions and insightful information about the wishes of the client.

Ken also has an original method for collecting precious information. He asks the clients to have a notebook or a large piece of paper that will lie on the kitchen counter or anywhere in the current living space to note down whatever comes to their minds regarding the project, even the smallest thing, even if they think it might seem ridiculous or irrelevant. This allows him to collect some more detailed and intimate information, but also trains the clients to actually think and write down what they really need. Although this method sounds really promising, it relies first on the discipline and rigorousness that the clients put into writing things down, but also on their ability to reflect on what they do and what they need. Although this method might miss the actual information that could be observed in action (Zahle, 2012), it still can be a great start to collect further information on uses, expectations, needs and desires of the clients.

Charlie’s method is more conventional and consists of a questionnaire of preferences that she sends to her new clients to collect broad information for the project.

Lola had the opportunity to meet with clients initiating new ways of presenting themselves. In one case, it was a family and they had prepared a slide presentation to present all the members of the family, their usages of the rooms, their needs and expectations. “They premade the job for me”, she recalls. In the second case, a couple handed her a mood board for the project, which she also welcomed warmly. Although these two cases could be a coincidence, they might also be evidence that the sense of humanity she brings to her communication practices is paying off, as the clients feel freer to share intimate information with her. On another level, this could be another thread to pull on for a shift in the relationship: a thread that could not be pulled by architects, but for once could be pulled by the clients; a way to empower and encourage them to take the lead on unraveling their habits and uses to their architect. As we see it, we conclude that there is no apparent consensus on the methods or tools to collect user data, nor to constitute a brief in small scale housing projects. Everyone seems to do things in their own way.

4.3.2 Ideating. Sometimes, it seems that the architects will skip right to the ideation step, collecting only some basic information on the brief and then hurtling to come up with sketches and drafts already. We might want to hear the user’s side of this story in order to frame if this might be perceived as an issue.

This ideation step is not so well documented in the interviewees’ narrative and still seems to be cultivated as the mystery of artistic creation. Ken does mention that he often goes to reference books for inspirational images, that can also serve later on to communicate with the client.

Only one thing appears quite clearly in the architects’ narratives, and somehow goes against the conclusions of our thematic literature review: none of them mention ideas brought by the users when it comes to the design of volumes, layouts, organization, light... Sometimes, they mention that the clients should chose some of the materials, at best, or sometimes just the interior finishing or some of the equipment, but do not really seem ready to let go with, nor share their creative processes.

4.3.3 Prototyping. As previously mentioned, some actual tools come in handy when it comes to giving end-users a sense of the future project. Mood boards are often brought up as a useful way to “draft a vision of the space” quite early in the design process. Leo preaches for physical scale-models but recognizes that it is slowly fading out of the architects’ common practices, as they have less and less time and budget to work with nowadays. He also mentions Virtual Reality (VR) headsets that can allow end-users to virtually move around a model of the project. However, this kind of technology is
not supported by Richard. These are interesting tools, he says, but the time to invest in regard to what we want to show is not yet profitable for small projects. If the model is there and well-built for construction or design purposes, it is a blessing to be able to show it to the client as a plus. But if the model is not accomplished enough, it can be detrimental to the project. Building the model is very time consuming and not every architect is trained to model virtually their drawings. Richard and Charlie agree that to be able to showcase a sensory aspect of the chosen materiality, it is easier to work with a still image of an outlook that can be further worked with rendering mode. Lola also creates these kinds of sensory previews but uses a collage method to style her prospective views on the project. She adds a layer to the use of these images by suggesting taking the end-users to the room or place that is modelled, in order to better visualize the changes and discuss the designs on actual site.

She also did once some “pretotyping” with tape and cardboard on site to help end-users get a better sense of the spaces delineated in the project. She is also interested in VR and augmented reality, which would allow clients to virtually walk through the project but insists, just as Richard, on the lack of time to make such models, as well as the lack of funds for this kind of equipment. She also worries that it might lead people to think that you can “easily” move an element while not realizing all of the consequences implied by small changes and thus not realizing how long it can take to actually implement these small kinds of changes.

4.3.4 Testing & redefining. All of the techniques described here above are supposed to be implemented at some point between the “sketch” phase and the end of the “preliminary project” phase. As a design project is rarely a linear process but rather an iterative, messy process (Brenner & Uebernickel, 2016; Jacob, 2016), often when the client is consulted, there is an update and a change to apply. In this case, it might be important to highlight the fact that it is often not per se a test, but rather the architect reaching out to ask for some validation from their clients. Architects are inclined to accept the changes requested by their clients up to a certain point. Indeed, one of the interviewees insists on the fact that challenging the first drafts is common and clients are welcomed to do so. But as the architect’s time is very precious and counted, the interviewed architects have a policy of accepting up to 4 or 5 modifications throughout the “sketch” and “preliminary project” phases and will often even try to aim for a maximum of 3 major modifications.

To that end, Ken and Richard for instance present 2 rough sketches at the very beginning of the project, in order to rule out the unfollowed paths without having to explore them further. This resonates with Brenner’s “fail often and early” principle (2016, p.8).

4.3.5 Issues with feedbacks. The first four design thinking steps can be somehow referred to, or at least reinterpreted through the architects’ narratives. Commonly emphasizing the importance of empathy and pointing to the iterative process of working through variants of the project, the definition and ideation steps yet vary the most from one profile to the other.

The fifth step however seems to be the most critical. While listening to architects depicting their practices, what stood out the most is the limited feedback of the user on the project being designed, and even more the lack of user’s feedback on the overall collaboration process. Indeed, none of the interviewed profiles had an actual feedback method in place to grasp the possible difficulties or dissatisfactions their clients might have experienced during the design and construction process. This particular issue resonates with the Design Thinking framework, where feedback is an essential step to understand and improve both the output and the process.

In the architectural field, the post occupancy evaluation (POE) literature generally tackles this feedback issue. While indeed being addressed (see for instance: Love, 2000; Ng et al., 2011), this study sheds light on the fact that evaluation still appears to be rarely applied in practice, thus revealing a gap between the scientific and the architects’ worlds, at least in view of the cases studied. Furthermore, we argue that POE methods undertake the satisfaction issue behind time, after the harm
is already done. Even if it brings valuable information for architects to enhance their ongoing practices, the unsatisfied end-users are left with their frustrations and maintenance issues. We advocate in favor of a shift in architectural practice, and for an evaluation and feedback loop as soon as in the early phases of the design process, to aim for better end-user's satisfaction upstream rather than downstream. In that regard, we also want to drive the attention on the loop of “sketch” (“esquisse” in French), “preliminary project” (“avant-projet”) and “consultation of the clients/end-user” described by the interviewed architects in regard of their design processes and emphasize the need for an actual user input during these phases, rather than just allowing them a light comment or validation.

5 Limitations and future research

If the research points out possibilities for improvement when it comes to architects and end-users’ interactions, five qualitative in-depth interviews cannot lead to generalities nor imply representativeness of all Belgian architects. However, the paper still highlights that Design Thinking seems to be hardly diffusing in housing architectural practices, which raises the question of how architectural practices could benefit from broader inspiration from other design practices. Even though interviews are limited to the "self-reporting issue" (Van der Linden et al., 2016); are restrained to the gap between reflexivity and practice (Boltanski & Thevenot, 1991); remain limited to what architects say they are doing or think they are doing and are influenced by what architects are open to share with the researcher vs. what they really do in practice, they remain a powerful exploratory method to study a professional community. Interviews reveal "the shared vocabulary, attitudes, and values of architects”, as well as their relations to users (Van der Linden et al., 2016). Worth to mention, this study is part of a broader set of interviews (n=15) which will be soon completed and will be nurtured by observations conducted with an ethnographic approach. Therefore, such interviews constitute an excellent basis to build a solid step-by-step research method to tackle this complex topic of users' place in architectural practice. The complementarity between exploratory questionnaires, interviews and observations in the field is crucial to understand this specific research object (Van der Linden et al., 2016). Moreover, this research is part of a broader research program, including a study on participatory approaches developed in the design field (service, social, graphic, product). The aim is to understand contemporary architectural practices while identifying and adapting strategies developed in design to improve interactions between architects and end-users. During autumn 2021, we conduct interviews with designers, begin observations with architects, and design upcoming workshops. Then, in winter 2022, we shift to participatory activities through workshops, develop prototypes and probes, and experiment deeply the levers and obstacles for a more collaborative approach between architects and end-users.

6 Conclusions

Through in-depth interviews, we addressed the main social encounters architects describe when describing the design phases of some of their small-scale housing projects. Then this paper outlined some pain points and success stories extracted from those processes. Finally, we delineated and discussed some patterns depicted by the interviewed architects in regard of the Design Thinking principles, steps and tools raised here above, highlighting the (lack of) feedback processes at stake in these narratives. We advocate that an improvement in the interactions between end-users and architects is possible and argue for an architectural practice learning further from the Design Thinking principles. Moreover, we stand in favor of further involving users into the design process, the quality of the relationship between designers and users still constituting a key issue in architecture. Such an
involvement and such a shift in the architect’s posture towards the end-user seems to be encountering resistances in the architects’ practices and has to be tackled keeping in mind the architects’ real-life constraints such as budgets and timing. It nevertheless remains more than ever crucial to the success of any architectural project.

References


8 Design thinking training
The effect of the place: From physical space to virtual environment in the design thinking learning process

Can Güvenir\textsuperscript{a}, Hatice Hümanur Bağlı\textsuperscript{b} and Hande Yıldız Çekindir\textsuperscript{c}

\textsuperscript{a}Istanbul Technical University & Yaşar University, Turkey, \texttt{can@canguvenir.com}
\textsuperscript{b}Marmara University, Turkey, \texttt{hbagli@marmara.edu.tr}
\textsuperscript{c}Izmir University of Economics & Izmir Design Factory, Turkey, \texttt{handeyildizcekindir@gmail.com}

Abstract. In Design Thinking education, interaction is an important factor to increase motivation and collaboration. However, this term is diversified through the several interaction models such as people-people, people-process, people-place. The place is one of the important factors for DT and there is a lack of knowledge about learner motivations depending on the place in digitized learning processes. Therefore, this paper compares the applications of a DT learning process in higher education applied on diverse places. We aim to discover the effects of the place factor on the learner's motivation, interaction, and collaboration in the DT process and to explore potential differences related to the place while focusing on the virtual environment and using the reflective writing method through the online questionnaires, feedbacks and observations of the students and facilitators. Today, in the digitized world it is necessary to discuss the advantages and disadvantages of space interaction.

Keywords: Design Thinking, Higher Education, Interaction Models, Virtual Environment

1 Introduction

Interaction, in its most general sense, is the exchange of information, opinions or feelings between two or more people and creates an impact on all parties involved (Brown, 2001). Moore (1989) stated that interaction is very important in education and revealed three types of interaction in the design of distance education: learner-learner, learner-content and learner-instructor. According to Moore (1989), in teacher interaction, the instructor “aims to stimulate or at least maintain the student’s interest in what is to be taught, motivating the student to learn to increase and maintain student interest” (p.2). Moore (1989) defines learner-content interaction as “the process of interacting intellectually with content that results in changes in the learner's understanding, the learner's perspective, or the cognitive structures of the learner's mind” (p.2). Moore (1989) defines learner-learner interaction as “interaction between a learner and other learners, alone or in group settings, with or without the real-time presence of an instructor” (p.4). Besides these types of interaction, students interact not only with the source of the content, but also with the environment in which they reach the content. Although Hillman, Willis, and Gunawardena (1994) suggested that the fourth type of interaction, the learner-interface interaction, was unique to online courses in the 1990s, it is increasingly observed in face-to-face learning environments as well. Learner-interface interaction is the manipulation process of various tools to achieve a task that enables learners to access information by using their senses to record information in sensory systems (Martin, Parker & Deale, 2012). Dewey (1938) defined the classroom layout as an interface that affects the learning outcomes of the course.
It seems that the essence of interaction is the learner. If the medium of action is the teacher or the student, the medium of the message is interaction, thus making interaction a topic worth exploring in any educational setting, including the distance learning setting.

Design Thinking (DT) may be considered as a great tool to be used in the teaching/learning process to develop twenty-first century skills. (Luka, 2014) This mindset has been used across several disciplines to tackle with the world-wide challenges for decades due to its comprehensive approach. Also, an increasing number of universities opened up design thinking institutes to help students acquire creative problem-solving and collaboration skills that are hardly encouraged by traditional schooling. (von Thienen et al., 2017) The Design Thinking approach has an iterative process consisting of basic five steps: empathize, define, ideate, prototype, and test. The process has divergent phases for creating choices and convergent phases for making choices. Students from different disciplines develop solutions to real-life problems by using a certain set of processes and methods. In this process, learning is created through reflection. Thanks to its application-oriented structure, it is aimed that the participants will be able to define this mindset and DT process by themselves and apply the methods to their personal and professional lives at the end of the process. This mindset is based on the three pillars that are called “3Ps” -people, process, and place-. The “people” are represented by cross-functional, multidisciplinary teams; the “process” is an iterative innovation process that builds up its momentum around collaborative creativity; the “place” refers to a variable space that invites and allows for creative teamwork (Schwemmle et al., 2017). In this mindset, there are several interactions between these three pillars such as people-people interaction, people-process interaction, people-place interaction, and process-place interaction.

Design Thinking comprises three core elements (Figure 1), flexible space, teamwork and the design process into a systemic approach on problem solving. In that, it is not only a process of learning, but a whole mindset and atmosphere (Scheer et al., 2012). When we consider the place factor in the process, it is important for students to use it as a reflection tool in their own practice processes, to make the processes visible and to establish cause-effect relationships of the decisions made in the process. At this point, it is important to understand the difference between space and place before moving on to the concept of place in Design Thinking. Tuan (1977) distinguished between space and place by suggesting, “What begins as undifferentiated space becomes place as we get to know it better and endow it with value” (p.6) Hence, spaces become “places” as they become imbued with meaning through lived experience (Tuan, 1977). In that paper’s case, people live this experience through the DT process in diverse places such as physical and virtual environments. While in the physical environment, students interact with the physical place and the tools; in the virtual environments, this interaction takes place with the interface.

Figure 1. Core elements of Design Thinking. Elias Barrasch 2012, In Scheer, Noweski, & Meinel, (2012)
The place is one of the important factors for DT and there is a lack of knowledge about learner interactions depending on the place in digitized learning processes. Therefore, this paper compares the applications of one-semester interdisciplinary DT learning process in higher education on the university campus, co-working space, and virtual environment. We aim to discover the effects of the place factor in the DT process on the learner and to explore potential differences related to the place.

2 Case study: One-semester interdisciplinary DT course

Design Thinking courses often ask cohorts of students from a variety of disciplines to solve real, complex problems using a human-centered design approach (Wrigley et al., 2018). As a learning approach in higher education, this paper presents a case study conducted in an interdisciplinary Design Thinking course that is designed and applied by İzmir Design Factory which is a newly established design, education, and research center to fulfill the qualified workforce need and project needs with high added of the local stakeholders to strengthen competition in the global market through the local and international partnerships. The course brings together students from different universities in the local area for interdisciplinary project work through collaboration with different industries. The course has adapted the Design Thinking mindset in terms of people, place, and process approach. While ‘people’ - students, facilitators, instructor, research assistant, partners, mentors- and ‘process’ -non-linear Design Thinking process- has been stable during the course, ‘place’ is different as physical and virtual environments. The one-semester interdisciplinary Design Thinking learning process in higher education, designed as a part of an EU funded project has been applied in three different places: university campus, coworking space, and virtual environment. The course process started on the university campus and continued in a local co-working space to experience the Design thinking process in a more creative environment rather than the regular space for education. In the pandemic period, it turned into completely digital, and the learners completed the process using different online platforms.

2.1. People of DT Course

The characters of the process as people of the 3P approach of Design Thinking are diverse and the motivations diversify between these different characters. Students are undergraduate students in 3rd-4th grade who have basic information about their field and can practice with people from different disciplines. Facilitators are who guides and observes the students during the course process. Instructor is the one that prepares the learning process, plans the overall framework and flow, and contributes to the learning by making students think about their experiences. Research assistant is the person who supports the instructor in preparing and managing the process and collects the data accumulated in the process. Partners are open-minded institutions, companies, non-governmental organizations or SMEs that can support students in the project, focus on process rather than project outputs, and want to experience the Design Thinking process. Mentors are experts in their field who can be consulted about our project process, guides with their experience and knowledge.

2.2. Process of DT Course

When we came to the second “P” that is “Design Thinking process”, it is an iterative learning process consisting of understanding, observation, problem definition, ideation, prototype, and test. During the Design Thinking course process, the students started the semester with a training project that is a three-week process consisting of insight, ideation and implementation phases to understand the basic DT process before starting a real project and it was held in Yaşar University campus physically and worked on the campus problems. After the training project, participants started their project with desk
research in the scope of the partner project brief. The different groups worked on the diverse projects that were given by three SMEs and two international corporate companies. While they were using a local co-working space in Izmir at the first week of the project, with the effect of the global pandemic the course environment has turned completely online. In the ongoing process, in order to increase their insights, they have met with the partner companies and SMEs to understand their needs, motivations, and expectations as online and they also carried out online interviews with users at the scope of the user research. When they collected all the data, they synthesized it using various Design Thinking methods and defined the problem. Students who converge the thinking process with problem definition, they got to the ideation phase through the divergent thinking, and they chose the idea that was deemed worthy of implementation as a solution proposal. After the prototyping phase to concrete the idea as a problem solution, the prototypes were tested through the user’s involvement once again in the online DT process. Students who completed their partner projects shared their presentation videos and project reports with partners, users and other characters in the process and received feedback on their project ideas for further development. The routine interdisciplinary teamwork with the team facilitator during the course process enabled team interaction which is important in order to learn from each other as learner-learner and/or learner-instructor interaction. After the teamwork this interaction was reinforced by in-team and facilitator reflection. In addition, getting the opinions of different experts and listening to their experiences in order to guide the course process and facilitate project management has created a new field of interaction such as mentor-learner interaction. In these meetings held with people from different fields of expertise every week, the students talked about the project process, and they gained practical knowledge and found answers to their questions. Throughout the process, students interacted not only with people but also with physical and virtual environments. The next chapter focuses on the learner-place and even the learner-interface interaction in the DT course process.

3 Diverse Places in DT Course Process

Place is one of the most important factors that have an impact on motivation, collaboration and interaction in the learning process. Therefore, emphasis has been placed on the use of different physical and virtual environments together during the Design Thinking Course. During the term, students have worked in three different places. In the first three weeks, students who completed their training projects at Yaşar University campus, used a local co-working space for teamwork in the partner project. Mentor meetings have also started at Yaşar University campus. Due to the 2020 pandemic, teamwork and mentor meetings were transferred to online and the course period was completed in this way. In this way, students experienced the virtual environment as well as the physical space throughout the process.
When we examine the physical spaces used in the process, there are some differences between university campus and coworking space. While the class at university campus is more structured with seating arrangements through the whiteboard, tables and chairs; the local coworking space has a more flexible atmosphere for teamwork. Students carried out teamwork with modular furniture like movable whiteboard, wheel tables, screen for presentation in a common area without wall boundaries through more social interaction rather than a regular class (Figure 2).

While the worksheets prepared by the instructor were used in which the course was conducted in the physical environment, various digital platforms were used to keep distance education and teamwork more efficiently when switching to online due to the pandemic. Virtual environment works, which were held simultaneously with physical work from the beginning of the DT course process, were limited with access to the course content and submissions at the first stage of the course. In the second half of the course, with the effect of the pandemic, the course was completely transferred to the virtual environment and online platforms that will provide the most efficient way to pass the process have been determined.
The digital platforms used during the course are Google Drive, where the submission templates, videos, course guide are shared with students and submissions are made, which provides file storage, synchronization service; Mail system, that provides communication during the course and where announcements are made; Zoom, where teamwork and mentor meetings take place to communicate actively and synchronously; Mural and Miro, which are digital workspaces for visual collaboration where teamwork is carried out simultaneously and team members can access the work at any time; Google Forms, a questionnaire management application to receive both the opinions of the students and their facilitators on the course process and the appreciations to each other at the end of the course and project. While the students share their submissions so that each other can see and comment during the process on Google Drive, they interact both with the characters as other students, facilitators, instructor, and the interface. After the class work consisting of warm-up and introduction given by the instructor, the students who perform teamwork at the breakout rooms return to the main room at the end of the day and share their reflections with the class on Zoom. Mural and Miro as other interactive platforms used in the process, students carry out their project by using the virtual post-its and other tools to work collaboratively so that each participant at the process has access to the works in that way. The following section outlines the data collection and analysis processes of the research.

4 Methodology

To understand effects of place factor on the learner motivation and virtual DT learning process potentials for interaction and collaboration, we conducted a qualitative research study with the students who participated in a one-semester interdisciplinary DT course by applying questionnaire study as reflective writing method during and at the end of the course process and getting feedbacks during the semester as end-of-class reflection. This research has included people who experienced a one-semester interdisciplinary Design Thinking course. 51 students from 13 different disciplines - industrial design, visual communication design, animation, industrial engineering, architecture, software engineering, energy engineering, interior architecture, business administration, English language and literature, psychology, advertising, graphic design- in three local universities and 7 facilitators from different backgrounds -design, psychology, advertising, entrepreneurship and academicianship- who guide the students during the teamwork in the course process have formed the study group.

4.1. Data collection: Reflective writing

Reflective writing method is a method developed for analyzing cognitive and affective outputs in design education by Gelmez (2016). Reflective writings have recently appeared under different names in the design research literature, which theoretically is based on Schön’s reflective practice. This different usage might be occurring due to the objective and context of the writing task. (Gelmez & Bagli, 2018) This method is based on the writing-to-learn approaches to support and empower students’ learning process.

The methodology questions, which are affective, cognitive and meta-cognitive level, seven open-ended questions, planned by the research of Gelmez (2016) (Table 2). The method implementation planned to collect the individual reflections on the Design Thinking projects that participants experienced during their Design Thinking learning journey. In the process, we conducted an online questionnaire with students twice, at the end of two projects. The questionnaire consisted of seven main questions based on the affective, cognitive and meta-cognitive levels asking: (1) What are my feelings and thoughts about the project? (2) What did I learn?; (3) How did the daily programme contribute to my learning process?; (4) What couldn’t I understand? Why not? (5) How has my
understanding about Design Thinking changed?; (6) What is the link between the things that I have learned in the process and the things that I knew before the course?; and (7) What would I want to change if the project was repeated? Why? When the DT course has been shifted to online with the effect of the pandemic in the process, we added one more question that is (8) What are your thoughts on continuing the course online? We also collected data in the process through intermediary questionnaires which consist of the question of “What are your thoughts on transition of the course to an online environment?” and through the feedback at the end of each course day. During and after their experience in the DT course, the students wrote down their reflections, thoughts and wishes through these question sets.

Table 2. Reflective writing method questions

<table>
<thead>
<tr>
<th>Reflective Writing Method Questions</th>
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<tbody>
<tr>
<td>Q1-What are my feelings and thoughts about the project?</td>
<td>(Affection and cognition)</td>
</tr>
<tr>
<td>Q2-What did I learn?</td>
<td>(Cognition)</td>
</tr>
<tr>
<td>Q3-How did the daily activities contribute to my learning process?</td>
<td></td>
</tr>
<tr>
<td>Q4-What couldn’t I understand? Why?</td>
<td></td>
</tr>
<tr>
<td>Q5-How has my understanding about Design Thinking changed?</td>
<td>(Metacognition)</td>
</tr>
<tr>
<td>Q6-What is the link between the things that I have learned in the process and the things that I knew before the course?</td>
<td></td>
</tr>
<tr>
<td>Q7-What would I want to change if the project was repeated? Why?</td>
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</tbody>
</table>

4.2. Analysis

Reflections of students who experienced the Design Thinking process in diverse places such as university campus, co-working space, and virtual environment as digital platforms used for different functions that are collaboration, feedback, live events, documentation, and communication shows diversity. While some of the students prefer to be in physical places, university campus and co-working space where the course is applied at the beginning of the semester, for DT process learning and think the interaction between people in the process is higher than virtual space, some of them argue that online platforms are more effective in their learning process when they shifted the environment with the effect of the pandemic. A small part of the students does not notice the difference between these two types of places.

Most of the students agree that the use of a digital platform increases the interaction between teammates, student-instructor, and student-facilitator by eliminating the distance. Even those who defend the physical environment think that this process should be supported by online platforms.
The students focus on the adaptation and efficiency based on different causes like face-to-face communication, technical problems, and time management. The reflections of the students who prefer the physical places rather than the virtual environment as follows:

+ I'm so sorry we went online. Because we may experience technical problems from time to time… I mostly have sound problems… This means extra waste of time for us.
+ As a person whose visual intelligence works heavily, the environment affects my focus a lot. So, I had a huge efficiency drop. I do not believe that online studies can provide the same efficiency as face-to-face with today's technology.
+ In general, our work achieves its purpose, but I would rather be face-to-face. Because in this way, I was getting more efficiency from our work.

The reflections of the students who prefer the virtual environment are:

+ This project was my first work online. In this regard, I can say that it taught me to adapt to online studies.
+ While not encountering any problems or troubles in the online environment, on the contrary, it is quite pleasant that it is so efficient and planned.
+ I liked online lessons more because it supports less resource use than physical togetherness.
+ It can be useful to continue online because it is an advantage to adapt to the new era.
+ Place can distract people, but when you are at the computer for a certain period of time, time is used more efficiently.

The students focus on interaction, online platforms, collaboration, team up, communication, creativity and some of them add their suggestions about their interaction with the place. Who prefer the physical environment stated that the following sentences:

+ There's a big difference between looking at a screen and breathing the same air as teammates under the same conditions.
+ Perhaps, instead of providing the resources, process and studies piecemeal through different applications, providing them through an online platform such as a single website could reflect the big picture better.
+ It's proof that a community was built in this transition, showing how well we can handle challenges and unexpected situations. But I don't think that means it should last like this.
+ Frankly, I think that whatever the conditions are, as long as the necessary reason and motivation for doing a job are provided together, that job will come out in the best way.

The reflections of the students who prefer the virtual environment are:

+ Platforms like Miro support online usage, which is a big plus.
+ Despite some technical problems, we are able to teach our classes and get our mentor training every week through Zoom. The Mural board, which we use alongside Zoom, completes the missing visuals in the online section in a fun way.
+ I learned how to be a team, albeit from a distance.
+ I think having it online was also invaluable at some points because it made it easier for teams to meet outside of school.

According to the verbal and written feedback received at the end of the lesson from the facilitators who experienced the process with them as well as the students, the effects of three different places - university campus, co-working space, virtual environment - on motivation, interaction and collaboration were examined. The facilitators emphasized that for the three different places used in the process: the university campus environment was insufficient, the co-working space was a motivating environment for students, and the use of different tools together in the online environment as a virtual space created an interactive working environment. The facilitators' specific reflections and suggestions about these three different places are as follows:

The University Campus;
Fiziksel mekandaki imkanlar yetersiz, kullanılan materyaller geliştirilebilir. Kullanılan materyaller öğrenciler için daha motive edici hale gelebilir. Movement space is limited. The time spent in the airless environment should be reduced. It seems important to create coffee breaks between lectures in order to improve bilateral dialogue and get to know each other more.

The Co-working Space;
- A new venue excited students as a motivating environment with good study materials.
- The place felt unusual, modern and spacious.
- With the impressiveness of the place, the students became more eager to do projects.
- Team spirit increased with the effect of the co-working space.
- The implementation stage was lively and fun.
- Having a whiteboard for each group also improved the working opportunity.

Virtual Environment;
- The combined use of online tools provides an interactive working environment.
- Despite being remote, communication was good, I can even say that there was more focus…
- Students have adopted the new environment, and participation rate is high.
- As we learn the systems, we will use them better. There may be improvements for students to be active and participatory online.
- According to the feedback from the students, the lesson was very interactive without even realizing how the time passed.
- Although it was the first time we met online, everyone adapted quickly.
- When we do not come together physically, we have difficulty in managing time together as facilitators for our teams.
- The lack of interference in the breakout rooms made it more comfortable. It allowed me to have more interaction with students…
- There is time pressure in the online environment. The time management in digital can be developed by experiencing.
- We have difficulties in the use of technology, we learn something new every lesson for the digital tools.
- It was very efficient for the teams to visit each other in the breakout rooms and comment and give ideas about the project as an outside eye.
- Focusing on the screen provided concentration.
- Motivation increases every week by using digital tools better.
- Using multiple platforms can be challenging

Additionally, according to reflections of students and observations of facilitators, although the simultaneous use of different digital platforms throughout the process sometimes causes confusion, it has made a positive contribution to interaction by increasing the sense of the responsibility over students and facilitators and has kept the process dynamic.

5 Conclusion
In general, although interaction is defined as the exchange of information, opinions or feelings between people, it can be diversified not just between people but also with process and place. Design Thinking as one of the accepted approaches to develop twenty-first century skills in teaching/learning process, with the effect of the pandemic the distance Design Thinking education has increased all over the world. Most of the universities that have DT courses transform their process from physical to virtual by using diverse digital tools. As a result, people-interface interaction as well as people-people and people-process interaction has become worth examining. Studies on the interaction as one
of the core factors in education and conducting separate and related studies on different types of interactions will make an important contribution to the field.

This paper investigates the effects of different places on the efficiency of the process and the learner-interface interaction through facilitators’ observation and reflection as well as students’ reflection and feedback during the DT learning process. According to the research, while some of the students want to interact with the physical environment to increase their motivation and collaboration through face-to-face communication; the others prefer to interact with the virtual environment through diverse digital tools because of easy to meet, more effective collaboration and teamwork. Motivation, adaptation, efficiency, interaction, online platforms, collaboration, team up, communication, creativity are common topics both for the physical and virtual learning environment.

Through the comparison of applications in diverse places which are physical and virtual, we need to explore how a virtual environment as a place can be linked to people and process in order to increase motivation, interaction, and collaboration. In this research, we just gathered reflections from a small study group; however, a holistic approach and detailed research are needed. The qualitative research methods were used in this study. Using quantitative methods as complementary to to find the details about the relationship between their experiences in the process and place factor, especially the virtual environment, that affects both people and process in the DT course might provide more comprehensive results. Today, it is necessary to discuss the advantages and disadvantages of space interaction, which has been moved to digital due to the pandemic, and what it can offer to the learning experience and the student. Moreover, this study may allow for an application in a wider context as a digital platform for distance collaboration with other stakeholders for further studies.

6 References
Identifying inconveniences in daily life: A problem finding prompt to foster non-designers’ engagement in design thinking training

Renato Antonio Bertãoa, Chris Heeseok Jungb and Jaewoo Jooa
aKookmin University, South Korea, islandes@me.com, designmarketinglab@gmail.com
bCreative Thinking Facilitator, LG Academy, South Korea, hsjung@lgacademy.com

Abstract. In general, companies use training programs to implement design thinking’s creative problem-solving methodology and encourage employees to embrace it. However, as design thinking involves different mindsets and practices, employees face barriers when joining training initiatives and experience challenges related to its implementation in organizational structures. This explanatory case study introduces a design thinking boot camp developed by LG Corporation and examines its unique approach applied to the initial phase of the design thinking methodology—namely, problem finding via empathetic observation. The boot camp aimed at helping employees develop the skills to identify customer inconveniences that may require design thinking’s problem-solving attitude. This paper delves into a preceding activity designed to increase the awareness of design thinking methodology via immersion in customer issues and strategies to promote participant engagement in training.

Keywords: boot camp, design thinking, LG Corporation, problem finding, training.

1 Introduction

Over the past decades, design thinking has been promoted as an approach that can drive innovation in various industries (Brown, 2008). While its practices in business environments are often praised, implementing it also faces multiple challenges. In addition to the organizational obstacles that accompany the adoption of such a creative problem-solving methodology (Kupp et al., 2017; Micheli et al., 2018), employees tend to resist embracing its principles and attitude. An often-cited barrier in both corporate and individual contexts (Dunne, 2018; Seidel & Fixson, 2016) is the lack of understanding of the design thinking process. These obstacles frequently work in tandem and lead initiatives to fail.

Organizations have sought to help employees overcome adoption obstacles but involving corporate staff in design thinking processes requires using a set of strategies. Therefore, Human Resource Development (HRD) and Research & Development (R & D) managers tend to resort to training to introduce design thinking in organizational structures and engage employees in its practices. Interestingly, despite being highly common in corporate environments, design thinking training programs are little discussed in the academic context. Although the literature has addressed the planning and format of such initiatives (Inns, 2013; Liedtka et al., 2017), research into specific approaches for overcoming the barriers these initiatives encounter needs expansion.

Scholars have already identified different factors that constrain the implementation of design thinking at the organizational and individual levels. Regarding this latter aspect, Butler & Roberto (2018) highlighted the role of cognitive obstacles in training programs. In order to address the barriers employees need to overcome to embrace design thinking, we conducted a case study to understand
how a global corporation developed its training program. Our research aims to contribute to the literature by identifying strategies to involve non-designers in a design thinking boot camp and further encourage its adoption to boost performance. For the sake of this research, we refer to a non-designer as a corporate employee who is a novice in design thinking and seeks to embrace its mindset and practices.

Our research examines a program developed for R & D personnel, junior engineers working in distinct companies of LG Corporation, a South Korean conglomerate that conducts business in several industries. We obtained a dataset from the HRD division, the so-called LG Academy. It is about the boot camp initiative aiming to help non-designers with multidisciplinary backgrounds tackle customer problems through design thinking. The qualitative dataset consisted of information concerning the training context (planning and development), the participants, and their creative outcomes. We utilized an explanatory case study approach (Yin, 2003) to unveil relationships among the training program’s strategies and components. In particular, we paid attention to its pre-training activity (Liedtka et al., 2017), the pre-boot camp. Further, we delved into a pre-assigned task that asked participants to develop empathetic activities to identify customer inconveniences.

Although wicked problems (Buchanan, 1992) are often deemed the target of design thinking, all sorts of problems have been addressed in design thinking endeavors. In such a context, more attention tends to be given to defining or framing problems (Paton & Dorst, 2011) than to finding problems. Our case study explores how a design thinking training initiative addressed the latter approach. In the pre-boot camp, non-designers employed observation strategies to identify inconveniences in ordinary people’s daily lives, thereby diagnosing customer problems and developing problem-finding skills. This training strategy aimed to help LG Corporation’s employees foster field observation abilities as well as acquire a customer orientation perspective, which could boost their R & D performance.

The pre-boot camp blueprint we introduce provides insights on how to train non-designers to tackle customer problems in their business contexts. The LG Academy case study offers a fresh perspective regarding empathy and problem finding when developing design thinking training initiatives in corporate environments. It should be particularly useful for R & D divisions seeking ways to innovate more effectively. In addition, in the context of design thinking training, the findings of this study suggest that a pre-boot camp is a feasible strategy a company can use to develop in-depth empathetic observation activities effectively. Furthermore, this case study unveils down-to-earth approaches for non-designers who need to be immersed in customer issues and make sense of design thinking in the organization.

2 Theoretical background

2.1 Design thinking barriers

Corporations have applied design thinking approaches in their efforts to innovate products and services, but initiatives tend to be constrained by barriers at two levels: first, organizational-level barriers, which encompass a variety of factors including corporate culture (Carlgren et al., 2016); and second, individual-level barriers related to employees’ comprehension of design thinking principles and practices (Seidel & Fixson, 2016). Prior research has identified several obstacles to adopting design thinking within organizations, and some scholars further examined the barriers that affect individuals throughout the process. In the following paragraphs, we explore the design thinking challenges that an employee faces in the process of organizational implementation and in educational circumstances. We focus on research about in-company projects, academic programs, and training initiatives.
In the corporate context, Carlgren et al. (2016), Micheli & Perks (2016), and Rosenberg et al. (2016) all showed that existing practices, climates, and cultures constrain design thinking initiatives. The disconnection between its processes and business operations (Dunne, 2018; Kupp et al., 2017) is evidenced by the difficulty of implementing the outcomes [ideas] (Carlgren et al., 2016). In such conditions, design thinking clashes with the fear of failure mindset often observed in corporations (Rosenberg et al., 2016). The lack of [corporate] understanding of design thinking (Dunne, 2018; Sobel & Groeger, 2013) as well as the difficulty of proving its value (Carlgren et al., 2016; Rosenberg et al., 2016), constitute another barrier. Moreover, helping employees acquire the skillset to run design thinking processes (Carlgren et al., 2016; Hölzle & Rhinow, 2019) turns out to be a barrier that affects both organizations and individuals. As a result, employees hardly ever make sense of how adopting design thinking as a creative problem-solving approach can benefit their daily activities in organizations.

A common strategy companies adopt to overcome these organizational barriers is to train staff in design thinking methodology and tools via in-company activities or university-level educational programs. In examining their design thinking academic initiatives, Butler & Roberto (2018) identified cognitive obstacles that may hinder novices’ participation in design thinking practices. Examples of the obstacles they identified include individual biases in empathetic observation and fixation during ideation sessions. The naïve thoughts and behaviors towards the design thinking process revealed in Siegel & Stolterman (2008) corroborated these findings. Meanwhile, Seidel & Fixson's (2013) contribution to this topic lies in their identification of the obstacles multidisciplinary teams face when adopting design thinking.

However, novice’s barriers to design thinking are related not only to their cognition but also to their behavior when asked to interact in training initiatives. By exploring the specific context of in-company workshops or boot camps, Seidel & Fixson (2016) suggest that a lack of understanding of design thinking dynamics, particularly its mindsets and tools, challenges non-designers. Rekonen & Hassi (2018) expanded these findings in the training context, adding cognitive issues such as overlooking and reduced focus and behavioral issues such as resistance during corporate training.

Organizations often implement design thinking to encourage their employees to adopt a creative attitude; nonetheless, researchers have made few suggestions regarding how to overcome the barriers that companies and individuals encounter in these efforts. Although still in its early stages, current research in the context of academic education and in-company training offers insights into employees’ obstacles. However, literature on design thinking training needs further development to suggest how to overcome the barriers and promote non-designers’ engagement in design thinking initiatives within organizations.

2.2 Design thinking training and sensemaking

Design thinking workshops or boot camps aim primarily to help employees develop skills related to tools and mindsets that might improve their creative problem-solving performance. When developing training programs in organizational contexts, initiatives often replicate previously established models. The d.school - Hasso Plattner Institute of Design at Stanford is widely known for design thinking education, and most training programs tend to use it as a benchmark.

However, in general, corporations and design thinking program planners and developers fail to consider the aforementioned individual barriers, ignoring participants as fundamental stakeholders. Delving into the d.school model, Royalty (2018) recommended that planners consider audience and team—in addition to challenge, practice, and creativity—as central elements in design thinking initiatives. Exploring the organizational environment, Inns (2013) also recommended developing training in linked learning systems that encompass people, processes, and places.
Meanwhile, Liedtka et al. (2017) proposed a comprehensive framework to help overcome the barriers that arise in teaching design thinking to non-designers. One of the most significant features of this framework was the addition of a phase that preceded the on-site activity. Indeed, the implementation of a preliminary activity addresses Seidel & Fixson’s (2016) contention that time constraints in design thinking training can lead novices to fail to effectively learn design thinking methods. Inns (2013) suggested that the development of training programs should pay attention to pre-workshop and post-workshop components.

In addition to the structural and operational aspects of training development, the issues participants encounter in corporate initiatives need special attention. Rekonen & Hassi (2018) pointed out resistance to iterating the design process as a bottleneck that hinders novices’ adoption of design thinking mindsets during boot camps. Also, based on workshop observations, Tarja & Heli (2013) explored how non-designers make sense of design methods in their organizational contexts. Rauth & Nabergoj (2016) claimed that sensemaking could foster idea development across organizational levels. In a similar vein, Kurtmollaiev et al. (2018) focused on the effect of design thinking training on participants’ managerial capabilities.

Considering the structural and individual factors scholars have identified, we speculate that sensemaking likely plays a crucial role in helping novices overcome barriers in training programs. Kolko (2010, p. 18) defined sensemaking as “an action-oriented process that people automatically go through in order to integrate experiences into their understanding of the world around them.” When non-designers are introduced to design thinking, they struggle to understand it because its mindset is novel, ambiguous, and confusing. In addition, its processes and practices are not expected in organizational contexts. According to Maitlis & Christianson (2014), people tend to resort to sensemaking in such conditions.

2.3 Problem finding in design thinking

The literature frequently emphasizes design thinking as a problem-solving approach that can be used mainly to tackle wicked problems (Buchanan, 1992). To solve problems creatively, design thinking initiatives resort mostly to empathetic observation and problem definition in the early stages. However, nowadays, design thinking is also leveraged to address problems that are not necessarily wicked. Therefore, it is not surprising to find that much discussion about design thinking focuses on problem definition rather than problem finding. Indeed, even seminal design thinking models lean in this direction. According to the d.school - Hasso Plattner Institute of Design at Stanford’s (2016) project guide, empathy and ethnographic tools and methods facilitate the observation of problems that can subsequently be framed using a set of problem definition tools. In this sense, framing and reframing a problem is a core strategy (Dorst, 2011; Paton & Dorst, 2011) and skill (Beckman & Barry, 2015) for design thinkers.

Design thinking-related fields offer several perspectives on problem finding. For design practitioners as industrial designers, who sometimes refer to it as problem identification (Lawson, 2005), problem-finding activities comprise the initial stages of problem-solving processes. Meanwhile, despite some variation in scope, opportunity identification (Koen et al., 2001) is considered an equivalent term in innovation and New Product Development (NPD) contexts. However, problem finding has a slightly different meaning in established design thinking models. The IDEO’s (2015) methodology seems to view the problem as already identified; its design thinking practice focuses on framing the challenge. Although the d.school - Hasso Plattner Institute of Design at Stanford (2016) defines problem-finding as discovering meaningful opportunities, its process and tools focus on examining problems rather than identifying them from scratch. This framing perspective on problem finding, i.e., framing an
already identified problem, recurs in design thinking education research (Beckman et al., 2010; Laferriere et al., 2019). Researchers in creative education fields have explored problem finding in-depth. Dillon (1982) developed a conceptual scheme that organizes dimensions of problem finding into three levels. On the first level (existent), people recognize problems based on available evidence. On the second level (emergent), people probe the data to discover implicit problems. On the third level, people build (potential) problems out of incipient elements. This framework aligns with Melles et al.'s (2015, p. 192) definition of problem finding as a process “that engages with the world around to discover needs and insights that might drive the innovation of products, services or systems of various scales and complexities.” In fact, Dillon's (1982) third level of problem finding, i.e., potential problems, tends to receive less attention in design thinking initiatives due to the emphasis they place on framing on the first two levels, i.e., existent and emergent problems.

The following section examines a particular approach to finding potential problems, introducing the case study of LG Academy’s design thinking training program.

3 Case description

3.1 The LG Academy design thinking training

Although global perceptions of the LG brand mostly relate to electronics and products for daily life, LG Corporation is a relevant player in other areas. In South Korea, its affiliates employ a multi-industry perspective, developing business in industries such as chemicals, communications, healthcare, construction, and services, among others. LG Academy serves as the corporate leadership center, offering educational programs for affiliate employees and regularly providing training in creative problem-solving.

In 2017, the LG Academy began running a regular design thinking program after exploring the topic in previous innovation-related initiatives. By benchmarking its approach against that of d.school - Hasso Plattner Institute of Design at Stanford (2016) and considering several corporate requirements and constraints, it created a customized training focusing on LG affiliates’ R & D engineers. The program’s primary goal was to help employees acquire a customer-oriented perspective and enable them to solve business problems using design thinking tools and methods. In the short run, it aimed to provide R & D personnel tools that would improve their individual performance. In the long run, it sought to nurture collaborative opportunities among LG companies.

In total, the three editions of the boot camp involved 68 junior engineers working in R & D departments at LG affiliates operating in the electronics (59%), chemical (18%), and home appliance (15%) industries, among others. The majority of participants were male (78%) staff that had not previously heard of design thinking (60%). A survey administered before the program showed that participants’ expectations encompassed developing new skills to work on R & D (65%) with a customer orientation (43%) by employing creative thinking (44%) and creative problem-solving (41%) methods and tools.

One of the unique characteristics of the LG Academy design thinking initiative was that it divided the program into two stages: a pre-boot camp and a design thinking boot camp. The former focused on remotely guided activities that served as preparation for the on-site boot camp, which was run by expert design thinking facilitators. Although the program also encompassed innovative customization approaches to design thinking training, the pre-boot camp strategy is a relevant aspect of the overall initiative because it allowed empathetic observation to the field and, therefore, the primary focus of this study.

The next two subsections describe the pre-boot camp activities designed to help participants immerse themselves in customer problems and identify problems worth tackling during the boot camp. We also...
present the findings obtained from individual observations reported in this initial stage of the design thinking training program.

### 3.2 The Pre-boot camp

The pre-boot camp was a month-long activity comprising four phases with remotely conducted individual assignments (Figure 1). The first phase aimed to provide R & D engineers with information about design thinking (Prior learning). The second and the last phases allowed each participant to practice empathetic observation of users (Inconvenience identification and Customer research). An in-between phase (Sharing and connection) focused on sharing observation findings and on forming teams for the on-site training using online tools.

#### Figure 1. Structure and process of the LG Academy’s design thinking pre-boot camp. Source: LG Academy (2019)

**3.2.1 (A) Prior learning.** In this phase, a microlearning exercise required participants to watch six short videos (three minutes each) introducing design thinking principles and processes. Also, they were encouraged to read magazine and online articles about topics related to user experience, new product development, innovation, and creativity throughout the pre-boot camp period.

**3.2.2 (B) Inconvenience identification.** In this core phase, participants individually contributed to identifying potential problems that could be tackled during the design thinking boot camp. First, they were asked to spend a week observing and identifying the inconveniences ordinary people face. Next, they elaborated the findings of the empathetic observations into descriptive problem statements following the guidelines presented in Table 1. Finally, they uploaded the statements onto the intra-platform used by LG employees.

**3.2.3 (C) Sharing and connection.** When accessing the online platform, participants were required to vote for one inconvenience that they were interested in solving during the boot camp. In order to ease training dynamics, those who proposed the inconveniences that received the most votes were promoted to team leader positions and managed team formation.

**3.2.4 (D) Customer research.** Participants conducted a second round of empathetic activities regarding the inconveniences their teams would address during boot camp. Following LG Academy instructions, they were asked to immerse themselves in the inconveniences through new rounds of observations and interviews with customers. Again, participants shared the findings online to further use during the on-site activity.

### 3.3 Core assignment

While planning the design thinking program, the LG Academy team came up with the pre-boot camp solution to overcome time constraints and, most importantly, to facilitate participants’ immersion in potential customer problems. Among the assignments, a very structured one was created to offer R & D personnel an initial opportunity to exercise empathy and identify topics for the design thinking boot
camp. Named "Identifying inconveniences in daily life," the core assignment (Table 1) based on field observation strategies already adopted by design consultancies as IDEO and encompassed five steps.

**Table 1. Assignment guidelines for identifying people’s inconveniences**

<table>
<thead>
<tr>
<th>Assignment</th>
<th>IDENTIFYING INCONVENIENCES IN DAILY LIFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Select a person [customer]</td>
<td>Choose a family member, friend, colleague, etc.</td>
</tr>
<tr>
<td>II. Select a circumstance</td>
<td>Choose one of the following situations</td>
</tr>
<tr>
<td>A. Home</td>
<td>Cleaning, storage &amp; organization, cooking, childcare &amp; education, sleeping, relaxation &amp; hobby, etc.</td>
</tr>
<tr>
<td>B. Workplace</td>
<td>Meeting, communication, work environment, using PC, etc. (exclude particular company content)</td>
</tr>
<tr>
<td>C. Other</td>
<td>Grocery shopping, using public transportation, etc. (any situation frequently experienced in daily life)</td>
</tr>
<tr>
<td>III. Do observation</td>
<td>Discover inconveniences the customer encounters in daily life and select one</td>
</tr>
<tr>
<td>IV. Prepare a statement</td>
<td>Briefly describe the inconvenience following the format and example</td>
</tr>
<tr>
<td>1. Who</td>
<td>My wife, a working mom,</td>
</tr>
<tr>
<td>2. What situation</td>
<td>when feeding our two-year-old daughter,</td>
</tr>
<tr>
<td>3. What action</td>
<td>has to take the baby food out the refrigerator.</td>
</tr>
<tr>
<td>4. Inconvenience experienced</td>
<td>Every time she has to take out all the food containers located deep inside,</td>
</tr>
<tr>
<td>5. Negative emotion</td>
<td>she gets annoyed.</td>
</tr>
<tr>
<td>V. Share your findings</td>
<td>Upload your statement using the app</td>
</tr>
</tbody>
</table>

Source: LG Academy (2019)

First, participants were required to select a family member, friend, or colleague who might be a customer [of a new or improved product]. Second, they had to choose a circumstance where the selected person might be situated, such as home, workplace, or other. Third, they were instructed to observe the person in different moments and identify inconveniences s/he faced in ordinary life. Also, in analyzing the empathetic observation findings, they had to choose one inconvenience [problem] to propose as a topic to tackle during the design thinking boot camp. Fourth, to help participants organize their findings and share the inconveniences with others, LG Academy facilitators provided a structured template to compose descriptive statements that included the following information: (1) who, (2) what situation, (3) what action, (4) inconvenience experienced, and (5) negative emotion. In the last step of the assignment, they shared the individual statements with other participants via a mobile app. Table 1 shows the general guidelines for the assignment and an example.

The four phases of LG Academy’s pre-boot camp were carefully designed to help R & D personnel absorb the gist of design thinking remotely and individually. Collectively, the phases aimed to promote individual engagement in the training as well as in the empathetic observation stage of the design thinking process, and the "Identifying inconveniences in daily life" assignment was the crux of the training employing several strategies to achieve these goals. Note that the assignment emulated the identification of inconveniences that [prospective LG] customers face when dealing with a wide variety of products and services. It focused on daily interactions with devices because the majority of the participants worked in the electronic and home appliance industries.

As a core activity whose findings served as the basis for selecting the problems to be solved in the boot camp, the “Identifying inconveniences in daily life” assignment was structured to enable participants to collect consistent information for the development of the training initiative. A statement describing the inconvenience was the expected individual outcome. Indeed, the LG
Academy customized the 5W1H (who, what, where, why, how) method to guide individuals in composing their problem statements.

Since most R & D engineers should observe people while performing daily duties in their workplaces or personal lives, they were asked to select an ordinary person to whom they had easy access (see Table 1, item II). To help them narrow down the context of the person’s inconvenience, participants were required to define a specific circumstance for observation. This approach aimed to help them carry out the assignment and understand the person’s behavior by focusing on the environment where s/he felt uncomfortable.

In fact, the LG Academy devised a process for empathetic observation in the core assignment. Besides identifying the people [(1) who] were facing the inconveniences, participants contextualized the inconveniences from different perspectives. They were asked to observe not only the specific circumstances [(2) what situation] but also the activities [(3) what action] that evidenced the problems [(4) inconvenience experienced]. In general, ordinary people react with bad feelings [(5) negative emotions] when they experience discomfort. Rather than asking about the thoughts or rational opinions people might have in such conditions, the participants described their emotional reactions at this stage of the observation task. After addressing these five factors, the R & D personnel succinctly summarized their findings in the problem statements. Cumulatively, this process immersed them in the inconveniences of the people they observed.

Out of the 68 inconveniences the participants submitted following the “Identifying inconveniences in daily life” assignment, 11 were selected via individual votes as the topics the teams would tackle during the three editions of the LG Academy boot camp (Table 2). More inconveniences were chosen in the first edition due to a slight change in the training program’s operation. In the second and third editions, fewer inconveniences were selected because pairs of competing teams tackled each inconvenience. Also, as shown in Table 2, in these editions, facilitators summarized the scopes of the problems to guide participants in the second round of empathetic observation [Customer research], the last assignment.

Overall, the pre-boot camp introduced participants to a problem-finding tool (Table 1) based on empathetic observation. Furthermore, the outcomes of this preceding activity (Table 2) provided the directions to the on-site boot camp. The next section examines the pre-training strategy and development that supported LG Academy’s program goals.
Table 2. Selected problem statements from the LG Academy

<table>
<thead>
<tr>
<th>Pre-boot camp</th>
<th>PROBLEM STATEMENT (selected inconveniences based on participants' vote)</th>
<th>PROBLEM SCOPE *</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>When ordinary people buy things at a mart and try to use a cart, they have no coins because of the increased use of credit cards these days. It's inconvenient because they can't use the cart right away and have to ask the clerk or carry a coin with them.</td>
<td>NA</td>
</tr>
<tr>
<td>B</td>
<td>A man in his late 20s who lives alone tries to do laundry that he has been putting off a week. When he takes out the clothes, they stink because he has left them too long. He's offended and does the laundry again or, if he doesn't have time, wears stinky clothes to work.</td>
<td>NA</td>
</tr>
<tr>
<td>C</td>
<td>My sister is often late for work because it takes too long to wash and dry her hair in the morning. If she washes her hair before going to bed, she can shorten the drying time in the morning, but her hair sticks out everywhere. She ends up in a situation where she needs to dry her hair again. Eventually, she just goes out with her hair rough.</td>
<td>NA</td>
</tr>
<tr>
<td>Edition 1</td>
<td>D</td>
<td>A person holding a bag and an umbrella tries to get in her car on a rainy day. When she opens the door to get in, she folds her umbrella and gets wet, and the water from the umbrella makes the seat wet. It annoys her.</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>A 37-year-old man living alone arranges furniture. When he tries to put the furniture where he wants it, a power outlet gets in the way. He has no choice but to rearrange the furniture. Since his room structure is different from the original plan, he has to live under stress.</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>My friend likes to use a cell phone. When his phone battery is almost dead, he uses a power bank. He experiences inconvenience because he has to carry his cell phone and the power bank connected by cable in his hand. He's irritated and doesn't want to use his cellphone anymore.</td>
</tr>
<tr>
<td>Edition 2</td>
<td>A</td>
<td>Whenever I, or my husband, get ready for work in the morning, we try to find clothes, but it's hard to think of where they are because the clothes are messy. In the end, I dress as usual.</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>When my wife tries to take bowls or food down from high shelves, she has to stand on something to take out the stuff deep in the shelf. So she usually puts the dishes on a lower shelf, which is inefficient.</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>When my wife bathes the children, it takes a long time because she has to check the water's temperature and depth. And when the children are left alone, there's a danger of accident, so she feels nervous.</td>
</tr>
<tr>
<td>Edition 3</td>
<td>A</td>
<td>Whenever I try to find a car in the parking lot, I have to memorize the column and floor number. It's inconvenient. I think about how to solve it.</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>On the weekend, I was at the supermarket to buy some daily goods. The moment where I had to make a quick U-turn, I found myself stuck with a heavy cart that had a broken wheel that made the trouble even worse. It gave me thinking that if it were only my wife with such a cart, it would have been a real hard-time for her while buying too many things.</td>
</tr>
</tbody>
</table>

* In the first edition of the training program, LG Academy facilitators did not summarize the problem scope.

Source: LG Academy (2019)

4 Discussion

It [the design thinking training program] was good because the way we solved the problem was different from what we have been doing. In the past, I said ‘customer-oriented,’ but I now realize I actually solved only superficial problems. I think this is why the problem keeps coming back. (Extract of the evaluation of the LG Academy design thinking program from one participant).
In corporate environments, employees seek to solve business problems by targeting customer issues related to products and services; however, if they lack the skill to understand customers, they may fail to achieve this goal. Also, such failures often result from targeting the wrong customer problem or choosing a process that proves ineffective in solving it. Lawson (2005) emphasized that practices in the design domain are more oriented to identifying problems than to solving them. Indeed, a common discourse among design practitioners claims that successful design outcomes stem from proper problem identification. Design thinking emphasizes this orientation by providing a set of tools and a systematic process that make it easier for non-designers to elaborate problems when employing creative problem-solving in business contexts. Its human-centered attitude and focus on empathetic observation are crucial to defining problems in ways that lead to innovative solutions.

Note that design thinking training programs rarely provide clear problems to be solved. Instead, participants are presented with an initial problem scope that they later explore using ethnographic tools and methods and then frame in the problem definition phase. Although problem scoping may overlap with problem framing in design literature (Dorst, 2011), we follow Atman et al.'s (2007) and refer to problem scope as an introductory statement about a problem’s nature and boundaries. Liedtka et al. (2017) corroborated this approach, pointing out that scoping a problem is crucial to starting the design thinking process. Table 2 shows some examples based on the pre-boot camp participants' problem statements. They reveal that the R＆D engineers helped scope the problems. Thus, our case study presents an approach that has been less frequently adopted in design thinking practices: searching for problems without an initial scope, i.e., the earliest stage of the problem finding process. In this sense, the ‘Identifying inconveniences in daily life’ assignment, through its guidelines (Table 1), was a fundamental problem-finding tool.

Adopting the perspective proposed by Dillon (1982), we suggest that most design thinking training programs focus on the existent and emergent levels of problem finding. One rationale for this strategy is that—within corporate contexts—time and money for training programs constrain participants’ empathetic immersion. Nevertheless, even lacking ideal conditions in terms of observation activities and field research, participants can work on existent or emergent problems and then successfully exercise creative problem-solving tasks because design thinking by itself nudges participants to focus on framing (Beckman & Barry, 2015; Dorst, 2011). However, if a corporate initiative aims to work with potential problems (Dillon, 1982), participants need to dive deep into customer/user issues to reach incipient elements. In such conditions, training programs should use a different strategy and structure. As Liedtka et al. (2017) pointed out, effectively identifying opportunities and project scopes may require the addition of a preliminary activity.

The pre-boot camp developed by LG Academy, particularly the core “Identifying inconveniences in daily life” assignment, can be considered a driver for finding potential problems that are relevant for training purposes. Although the activity was completed individually and remotely, it enabled the design thinking training participants to truly immerse themselves in customer/user issues. The problem statements produced by the R＆D engineers not only describe inconveniences but also establish scopes for the on-site creative problem-solving sessions. Table 2 shows the diverse problem statements and scopes participants developed by individually observing people’s inconveniences. Although they do not contain all the required elements of a design brief, they could be viewed as a draft of the outcome Liedtka et al. (2017) expect from activities preceding design thinking training. We claim this elaborated problem-finding strategy introduced in the pre-boot camp is expected to further support participants in tackling business problems at the workplace.

Conversely, we can also view the “Identifying inconveniences in daily life” assignment and its problem statement outcome as a persona outline. The LG Academy did not introduce persona to participants in any of the pre-boot camp activities. However, the structure suggested for the problem statement (Table 1, item IV) facilitates the visualization of a customer’s/user’s identity and
characteristics. Based on the assumption that emotions play a crucial role in customers’ purchase decisions (Bettman et al., 1998), the training initiative’s focus on psychological reactions—negative feelings associated with inconveniences—was strategic, aiming to familiarize participants with customer issues. Also, exploring embodied emotional characteristics during observation activities is critical to identifying problems from an ethnographic perspective. The use of these approaches in the design thinking training strategy mainly provided LG’s R & D employees with means to delve into customers’ attitudes.

The “Identifying inconveniences in daily life” assignment was central to the training plan because it sparked the design thinking program. Its outcomes—the problem statement and the problem scope—provided a direction for the subsequent activities in the pre-boot camp, namely the “Sharing and connection” and the “Customer research.” In the latter one, the second round of focused observation was conducted. Indeed, through the preceding activities developed remotely, participants experienced a fundamental aspect of design thinking practice—empathetic observation—and generated comprehensive material for subsequent exploration in the boot camp.

Here, we contend that the pre-boot camp strategy developed by the LG Academy suggests a new avenue for design thinking training initiatives in corporations. Conventional on-site endeavors tend to avoid developing observations from scratch—or even emulate it—and often forego immersion opportunities due to time and money constraints. As Seidel & Fixson (2016) pointed out, unrealistic time constraints may undermine effective learning. The LG Academy training program blueprint enabled R & D engineers to complete a sequence of pre-training activities and experience the essence of design thinking practice, thus improving the boot camp’s dynamics and timing considerably.

I could get a rough idea of what this training was about through the pre-assignment. I solved problems with my team members, and I’m really proud of it. From now on, if I encounter a new problem in my workplace, I will apply what I learned from this design thinking training to solve it. (…). (Extract from one participant’s evaluation of the LG Academy’s design thinking program).

HRD departments usually offer a plethora of training related to creative problem-solving (e.g., TRIZ). However, design thinking is comprehensive and balances problem finding and problem-solving in its processes. Assuming employees in corporate environments are results-oriented, we suggest that design thinking training—rather than focusing on framing to solve problems—also pay particular attention to problem finding in their efforts to foster adoption of this approach to innovation. Therefore, a very elaborate training strategy is needed to help participants during the process. What we learned from the LG Academy design thinking pre-boot camp’s strategy is that training initiatives explore relevance and sensemaking to promote participant engagement.

4.1 Relevance

Two significant challenges in any training program are motivating participants to immerse in the activities and fostering them to apply the tools and processes at the corporate level. Our close examination of the LG Academy design thinking initiative shows that its blueprint encompassed tactics to boost non-designers’ engagement in design thinking practices. One example in this regard is the emphasis the initiative placed on empowering participants—exemplified by the active role pre-boot camp participants took in identifying topics to tackle during the on-site activity. Although the instructions for the “Identifying inconveniences in daily life” assignment suggested that participants adopt a business perspective and eventually align it to LG Corporation’s industries, they were not required to do so. Instead, participants were free to fulfill the assignment as they saw fit. Furthermore, team formation was based on individual interests.
To make design thinking relevant for training participants, we suggest that initiatives focus on individuals’ aspirations to boost professional performance. Previous studies have pointed out that some individual barriers to design thinking adoption involve cognitive factors (Butler & Roberto, 2018), primarily the lack of understanding of the design thinking mindset and practices (Seidel & Fixson, 2016). This indicates that the training itself cannot easily overcome cognitive barriers. Assuming that relevance permeates cognitive processes (Sperber & Wilson, 1995), focusing on design thinking’s applicability is one possible way to promote engagement. Although this may seem self-evident, it needs to be nurtured in training. In general, non-designers do not perceive design thinking practices as relevant to their daily activities in corporations. However, as evidenced by the pre-boot camp strategy, the LG Academy training program invested heavily in problem-finding and helped R & D personnel immerse themselves in potential customer issues. Thus, participants learned how to prospect problems, a skill they were previously shown to lack while developing R & D activities.

The pre-boot camp (Figure 1) was designed to expose participants to customer issues in two particular moments. First, the “Identifying inconveniences in daily life” assignment gave the R & D engineers an opportunity to initiate contact with customers. Its guidelines for observation and the problem statement (Table 1) provided them with practical tools they could subsequently use in their workplaces. Second, the additional step of the empathetic observation strategy—when the “Customer research” was developed through a new round of observation followed by interviews—helped participants strengthen their newly acquired customer-oriented skills. As Carlsgren et al. (2016) and Hölzle & Rhinow (2019) pointed out, developing design thinking skills is challenging not only for employees themselves but also for the companies implementing such practices. The target audience of the LG Academy program, engineers, tend to have a pragmatic orientation and value new R & D perspectives mostly when linked to tools that facilitate the delivery of professional outcomes. Providing them with a useful tool kit is a fundamental strategy for making design thinking relevant in training circumstances and organizational environments.

4.2 Sensemaking

As a process that helps achieve order from confusion and chaos (Maitlis & Christianson, 2014), sensemaking is crucial to understanding organizational practices. Since design thinking challenges corporate structures, cultures (Carlsgren et al., 2016; Micheli & Perks, 2016; Rosenberg et al., 2016), and businesses (Dunne, 2018; Kupp et al., 2017), employees need guidance about how to integrate it into their daily practices. To adopt a design thinking mindset and methodology, they need to make sense of design thinking practices within their organizations. The LG Academy initiative invested in strategies to facilitate individual sensemaking (Cristofaro, 2021) instead of addressing sensemaking across organizational structures (Rauth & Nabergoj, 2016). The training program targeted R & D engineers who were eager to acquire innovation skills because they lacked the customer-oriented mindsets and tools to effectively deliver commercially profitable outcomes. Since the design thinking training initiative was customized to this audience and emphasized customer issues, it embodied sensemaking.

By implementing the pre-boot camp strategy, the LG Academy training carried out activities that helped individuals make sense of design thinking in the corporation. The “Inconvenience identification” and “Customer research” phases introduced participants to a structured and self-conducted way to incorporate design thinking into their R & D tasks. In particular, in organizational environments that do not encourage collaborations among teams, such an approach may release the burden for non-designers to adopt design thinking. In a broad context, the inconvenience identification activity also nurtured sensemaking by linking ordinary people’s discomforts to potential business opportunities—a key concern for the R & D personnel. In this regard, the customized
solution to the empathetic observation in the LG Academy design thinking training methodology may also be understood as a problem-finding tool that helps non-designers working in corporations. Focusing on problem-finding in the pre-boot camp stage certainly did not allow participants to tackle organizational barriers to design thinking; however, it supplied them with feasible means to navigate the corporate context by embedding a design thinking approach into their practices.

5 Concluding remarks
An extensive body of design thinking research has developed in recent years. However, design thinking training is overlooked. Relying on an explanatory case study, we present a perspective on the subject, focusing on a preliminary training phase. While previous studies have discussed this step (Liedtka et al., 2017), its application has not been elaborated. The LG Academy initiative, especially its pre-boot camp activity, provides a blueprint for training programs and some strategies to cope with barriers non-designers face when introduced to design thinking practices. Interestingly, the pre-boot camp we examined focused on problem finding—a central aspect of the design domain that has received less attention than problem framing in design thinking training initiatives. After reviewing the pre-boot camp’s empathetic observation activities and its core problem-finding assignment, we found that such preliminary activities comprise a sound solution for training programs even when conducted remotely and autonomously by participants. In addition, the LG Academy initiative addressed relevance as a means of tackling non-designers’ cognitive barriers. The training program helped participants understand the value and application of design thinking tools in their workplaces by concentrating on customer-orientated tools. In doing so, individuals made sense of design thinking.

We acknowledge that this training strategy cannot be easily replicated because LG Corporation is a conglomerate developing business in several industries, and its R & D employees have particular needs. However, this case study provides several clues about how to develop design thinking training programs in corporate contexts, even for implementation initiatives. By delving into training, our study also reveals research avenues for scholars interested in the topic of non-designers’ engagement in the design thinking process.

Academic research about corporate training initiatives is often constrained because data is not comprehensive. Our research is not an exception in this regard; we were unable to access post-training information concerning how non-designers put into practice their new skill sets. Although this context impacted the extent of the case study, we argue our work maps current practices in the industry, particularly within global corporations seeking to implement design thinking.

From the practitioner’s perspective, this case study sheds new light on a structured approach to problem-finding in corporate-level design thinking training. While the LG Academy program did not address problem finding, it employed a problem finding perspective in the initial stage of design thinking’s empathetic observation phase. This strategy aimed to facilitate corporate staff eager for customer orientation to engage in the training and to enable them to employ such an orientation in their workplaces. Ultimately, this approach provides a direction for overcoming individual and organizational barriers and fostering the further implementation of design thinking initiatives in corporations.

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References


9  Empathic design beyond the mainstream
Empathy goggles - The advantages of a physical empathy exercise when teaching design process and group work

Petra Ahde-Deal and Mette Laier Henriksen
Copenhagen School of Design and Technology, peth@kea.dk, mlah@kea.dk

Abstract. In this paper we will address the impact of empathy when designing for blind and partially sighted people and discuss our experiences on how to engage students in an eye-opening physical empathy exercise when entering a new project. We will also explore the impact of using an empathy experience in group work and in the design process. One way to get to know the users, is to visit their everyday life and to try to experience their joys and frustrations. We transformed ski goggles into empathy goggles with several eye deceases and blindness. The task was to produce a prototype of wearables for a concept inspired by blind and partially sighted people that would help them in their everyday life, yet which would also be of interest for anyone to use. Our ambition was to teach empathy to better understand the everyday life of the end users of this interesting, yet vulnerable user group.

Keywords: blind and partially sighted people, empathy, design thinking, pedagogy, wearables

1 Introduction

“Social and emotional skills, such as empathy and respect for others, are becoming essential as classrooms and workplaces become more diverse” (OECD, 2019). This paper discusses empathy in teamwork and understanding the users in a design process. We will address the impact of empathy when designing with blind and partially sighted people and discuss our experiences on how to engage students in an eye-opening physical empathy exercise when starting a new project. We will also explore the impact of using an empathy exercise in group work and in the design process.

We will discuss this topic in the light of the different skill sets needed by future design professionals and base it on the future skill sets defined by UNESCO and OECD to give strength to our argumentation (Care et al., 2019; OECD, 2019). We can see that the design profession is in transition. We cannot see a strong future for the traditional solo designer as a profession. On the other hand, we see the future of the design professional as very hybrid, the designer of the future will have many transversal skills and will be able to navigate in the complex entity of creating new products, systems, and services. We strongly believe in design education and therefore do not suggest that ordinary people become designers but rather to utilize them as experts in the design process. In our opinion, design work is true teamwork that requires many approaches, methods and tools. And as Ricardo Sosa we also believe “that advancing knowledge and transforming practice in the teaching of empathy and creativity are key to equip people to ask powerful questions, generate innovative ideas, and make more responsible and sophisticated decisions in everyday life.” (Sosa, 2019)
2 Wearables class

We will illustrate our argument with teaching examples from two classes called Wearables at the BA Jewellery, Technology and Business programme at KEA - Copenhagen School of Design and Technology (later KEA) held in 2020. In these classes our jewellery students not only studied the vulnerable user group, partially sighted and blind people, but also designed together with them and produced products following universal design principles which would improve anyone’s everyday life (Story, 2011).

The classes were conducted in collaboration with the Danish Institute for the Blind and Partially Sighted (IBOS) as they had approached us with a wish of improving the design of assistive aids and tools provided for blind and visually partially sighted. IBOS is a knowledge- and rehabilitation center in the field of vision impairment (IBOS, 2020).

Our consultant at IBOS, Birgit Christensen, told us that many assistive aids for this target group is very expensive as it is a small market, and at the same time the appearance, sound and quality of the materials used are often poor, as the producers of the products believe it is only the function that is important. Many blind and partially sighted feel isolated and secluded from everyday life as they are provided with these technical aids to replace human contact. The assistive aids are supposed to help them, but many have a really loud, annoying sound which makes it stigmatizing to use out in public and they are made of materials that feel cheap, uncomfortable, and fragile. Often when they need to use an assistive aid they cannot find it, it doesn’t work, they cannot change the battery themselves or read the manual to fix it, so instead of helping the user it makes them frustrated and feeling more secluded (observation notes).

We found this case very fitting for our pedagogical aim to learn to teach the importance of empathy in the design process as it adds an engaging aspect to the wearables classes when the user has a real need, and not just a want for another technical gadget. We also had a focus on teaching the students to work in interdisciplinary groups to give them readiness to empathise not only with the users but also with group members from other courses at KEA.

Our definition of users is inspired by Kenneth Balfelt’s definition of user participation: “The users are not architects and vice versa. However, users are experts on the context and on their own needs.” (Balfelt, 2019, p 79) Our blind and partially sighted participants are not laypersons, but experts in their everyday life as non-seeing people and users of aids for the partially sighted. They therefore constitute an invaluable source of information and inspiration for our students.

We define wearables “as a novel multi-domain field which incorporates electronics embedded into objects worn on the body.” Our “aim of the Wearables class has been to encourage students to broaden the design space in this field. In our programme, we believe (…) there are fundamental similarities between the electronics and jewellery domains. Both are dealing with extreme detailing, high precision, size constraints and precious conductive metals.” (Ahde-Deal & Henriksen, 2019).

3 Methodological discourse on empathy in design

In this paper we focus on the aspects of utilizing empathy in the design process and our work is mostly built on empathizing with the users. Empathy is a very well-studied aspect in design research, user inspired design and in many defined design processes. In this paper we follow the Design thinking process (Brown, 2009) as it is the main design process we teach at KEA. To better understand the importance of empathy in the design process we have looked for help from prior scholars’ work who are building on the discourse of designing with empathic inspiration from the users (Kumar, 2013; Koskinen, 2003; Mattelmäki, 2006; Brandt, 2011). We also wanted the students to learn to take users into the design process by learning from the users’ empathic actions and
behaviors (Koskinen et al., 2011; Redström, 2017). In our teaching cases the students have applied different ethnographic design research methods involving the users.

Several scholars propose that the use of empathy in design should not be merely “to be like someone”, especially when it comes to designing for people with disabilities and designers simulating their disability. Instead, we should aim towards exploring how “to be with someone” (Bennett & Rosner, 2019) and support the designers’ ability to design with others within an empathic sociability (Devecchi & Guerrini, 2017). Empathic sociability is defined by Richard Sosa as “a sense of empathy that connects to creativity as the capacity to change with others.” (Sosa, 2019 p.2). It was important for us to involve the aspect of designing together with the users to the curriculum at this stage. Empathy is an essential aspect in applying co-experience in the design process and when involving the users in the actual design work (Battarbee, 2004; Sanders & Stappers, 2013, Kumar, 2013).

4 Empathy

Imagine having lunch without seeing what you are eating or with whom you are having your lunch. Having your senses cut down to sound, smell, taste and touch. That is the everyday of the research participants in these teaching cases.

In the spring 2020 class, we had additional students from the KEA Bachelor programme Product Development and Integrative Technology PTI (later technical students) and in the autumn 2020 class, we had the jewellery students working together with technical experts. In both classes, the task was to produce a prototype of wearables for a concept inspired by blind and partially sighted people that would help them socialise more in their everyday life, and which would also be of interest for anyone to use.

Our ambition was to teach empathy to better understand the everyday life of the end users in this interesting, yet vulnerable user group. One way to get to know the users is to visit their everyday life and to try to experience their joys and frustrations. We let the students get as close to the users’ everyday life as possible by making the students prepare a Make tools session (Sanders & Stappers,
2013) and a Wardrobe interview with the blind and partially sighted experts in their homes (Klep & Bjerck, 2014) and by getting the students to collaborate with the users throughout the projects. These ethnographic design research approaches were used to gain empathy in our teaching cases, to help the students understand the importance of learning from and with the users. (Møller, 2019, Fletcher & Klepp, 2017). We succeeded in the best possible way, conforming with the COVID-19 regulations and recommendations.

Let’s go back to the lunch. On the very first day of their classes, the students were divided into groups to work together on the project. We wanted them to feel how it is when your sight is limited, and therefore, we designed an empathy exercise. Together with our class design expert, Miss Blindspot, partially sighted Danish blogger (Nahnsen, 2020), we prepared 30 pairs of ski goggles to represent different levels of visual impairment with black tape, black paint marker and glue. The goggles simulate different medically defined eye diseases and conditions, from being completely blind to being able to see partially.

![Figure 2. A group of students right after receiving the goggles. The person with the pink cane is wearing goggles that prevent any seeing, the others simulate conditions such as blindspots, tunnel vision and partial sight due to brain damage.](image)

We distributed the goggles amongst the students once they were introduced to their new group members, they did not know prior to this class. They were put in groups of five. In each group, there was one totally blind person with a cane and one assistant who was able to see normally. The rest wore goggles with different conditions. They wore the goggles for one hour while having lunch together and navigating around campus. According to Miss Blindspot, for the students to better empathise with the partially sighted people, it was important to give the students an opportunity to experience and engage in social activities involving many skills.

Bennet & Rosner argue that empathy, which is built through immersion “may steer designers toward narrow and inaccurate conceptions of disability experiences.” Several scholars believe that building empathy in design cannot be based on empathy alone, other competencies need to be present, as compassion, humility and noticing. One technique Bennet & Rosner lists as important is “codesign
exercises in which designers enlist disabled people as partners” (Bennett & Rosner, 2019 p.4). We applied this to the class through the Make tools sessions (Sanders & Stappers, 2013) and Wardrobe interviews (Klepp & Bjerck, 2014).

Figure 3. Miss Blindspot has customized her canes to fit to her outfits and moods

Figure 4. Students out for lunch in the autumn class. (pictures from students’ final presentation)

Although it was evident that with the empathy goggles exercise, the students would not entirely understand the everyday of a partially sighted or blind person, they were able to better connect with them through the experience. As the student Pauline says, “…of course we are never going to feel like they feel, but I think it is good to just have a glimpse of how it feels. And if it was just this and we wouldn’t be in any contact with people with the impairment, it for sure wouldn’t be enough, but I think it is a good starting point, a good way to make us think.” (Interview 1, autumn). They were also able to create a consensus in their groups from the start of their collaboration with this joint extraordinary experience.
During the empathy exercise, Pauline had felt that her personality changed a bit, as she felt isolated and unable to speak to people because she couldn’t see what was happening. Her group ended up picking “this subject that was about breaking social barriers and how you can feel isolated while having the impairment, so it (the introduction with Miss Blindspot and the empathy exercise) kind of guided us towards that direction.” (Interview 1, autumn).

Figure 5. Student project, autumn class. Hey There!: A small piece of silver jewellery with a wooden ball with a button containing the electronics. You can hang it in your necklace, your keyring or carry in your pocket.

Each group was connected with one user. They were well prepared to first meet and interview their user and try to understand their everyday, and to afterwards plan and conduct user research following the Design Thinking principals and conducting the Make tools sessions (Sanders & Stappers, 2013) and Wardrobe interviews (Klepp & Bjerck, 2014).

We conducted the class twice in 2020. Each class was influenced by COVID-19 restrictions and rules on teaching and acting in physical places. During the spring 2020 class, the students were able to meet with the users and conduct their user studies physically. Teaching was normal until the lockdown, which in our case meant until the final prototypes were to be made. The consequence of this was that many of the prototypes worked only partially, and in the end, the main emphasis was on the concept.

We were not able to iterate with the physical models nor with the prototypes. This was a pity, since physical interaction to get further communication with the users would have given so much more in this setting of working with blind and partially sighted people.

The autumn class was also influenced by restrictions. Although there wasn’t a complete lockdown, we had to manage most of the teaching online. Further, contact with the users did not run as smoothly as before COVID-19 as some, both students and users, were more cautious in the current situation about meeting physically.
Design professional skills in the future

Within design, demarcation can provide new approaches to the profession. We can implement such approaches when we have enough capacity to maintain and control frontiers. We are living in a moment of time when we need to update the definition of the designer profession. To re-define it, we must look into design education and critically seek new ways of re-thinking the education. We cannot educate solo designers for the future labour market. We educators need to focus on the hybridity of the design profession. This means that we must educate not only team players but design professionals who can rapidly adapt to new ways of thinking, new approaches and new technologies and who have the will and motivation to apply those (Educators’ Summit, 2020).

At KEA, we have a strong focus on practice-based learning, and we emphasize hard skills within all our programmes. This means that our students in the design area are very competent in using computer programs to design products and produce graphic materials for their concepts. They are also competent in giving form to the products through an understanding of the material features and the production processes. However, they may graduate with a slight lack of transversal skills. UNESCO has emphasised a concern about the lack of transversal skills (Care, et al., 2019). According to UNESCO, transversal skills are: Interpersonal Skills, Intrapersonal Skills, Media and Information Literacy, Global Citizenship and Critical and Innovative Thinking. All the transversal skills, especially, the Interpersonal and Global Citizenship Skills require empathy. As a global citizen one ought to understand how people in different cultures, religious settings and countries live. What are their needs, desires and perhaps fears? Being a global citizen does not only mean understanding people who are physically far away, but it also gives readiness to understand people nearby but who are different. Understanding others requires interpersonal skills. By interpersonal skills, Care et al. (2019) mean skills like communication skills, teamwork and collaboration skills, organisational skills, being able to be social and collegial and being able to work with empathy and compassion (Care et al., 2019).

OECD discuss three different skill categories. “The OECD Learning Compass 2030 distinguishes between three different types of skills: cognitive and metacognitive skills; social and emotional skills; and physical and practical skills” (OECD, 2019). In our education, we are especially interested in becoming better at teaching social and emotional skills. OECD describe those as skills needed in workplaces and classrooms, which are getting more diverse. Diverse ethnically, culturally and linguistically. In these classrooms, and further on in the workplaces, empathy, self-awareness and respect for others, among the ability to communicate, are essential according to OECD’s Concept Note: Future of Education and Skills 2030. The Note emphasises the transformation that the skills sets are in, as computers and other technologies take over some of the labour tasks. These tasks are mainly repetitive tasks without analytical or creative aspects.

Focusing on the soft skills: social and emotional skills described by OECD and transversal skills described by UNESCO (Care et al., 2019; OECD, 2019), should include a focus on the mindset of future professionals in the design field. According to our experience with teaching wearables (Ahde-Deal & Henriksen, 2019), we have learned the power and importance of interdisciplinary teamwork. It is especially important to be able to adjust one’s own mindset to fit to the team’s mindset.

As Josefine from the spring 2020 class says, “We were in a group with two (PTI students) who actually was really engaged in the project and actually really good. So that gives your engagement a little boost, so you want to do it.” (Interview 1, spring).

In our programmes, there is much diversity in the groups. That is a richness that we can cherish and nurture with the right mindset and a focus on the soft skills throughout the education.
So, our mission with bringing empathy into the class was to summon up these inherent soft skills that many people have. We would like to emphasise the need to teach these skills in the design education especially in our institution. However, it is problematic to teach empathy and compassion and still be social and collegial in action and also true to the user we are designing with and for. We do not have any exact solutions to that, but we are happy to present our aim to summon up empathy in the design process and teamwork.

As Bea said about their cooperation with their technical expert: “It’s trying to also just have empathy with each other and be patient trying to explain and explain again what we actually want, but I think we are capable of doing that” (Interview 2, autumn).

6 The class setting

In 2020, we had two classes of students learning wearables with IBOS, Institute for the Blind and Partially Sighted. The methodological and theoretical learning goals were the same both times. The execution of the classes was slightly different in the spring due to an unexpected combination of online and offline teaching.

Due to a very insightful class in spring 2020 we continued our collaboration with IBOS and Miss Blindspot in the autumn 2020 class and repeated the project in a slightly different setting. We redid the empathy exercises and the close collaboration with the blind and partially sighted users. We have reflected on and evaluated our experiences with empathy exercises within these two similar settings.

In the spring class, we had 35 jewellery students and 12 technical students working in eight groups. In the autumn, we had 29 jewellery students in seven groups and two technical specialists (one teacher and one student helper) from PTI. We have interviewed students from both classes and asked them to complete a small survey. These interviews, evaluations and reflections form the base of our paper for DTRS13.
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<th>Table 1. An overview of the content of the two classes with similarities and differences</th>
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<td><strong>IBOS project – mandatory wearables project at KEA</strong></td>
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<td><strong>Specifications of the classes</strong></td>
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| **COVID-19 alterations of projects** | - The last 2 weeks online - guidance and final presentations: no feedback from the user, only from IBOS.  
- no access to workshops/ 3D printers: no physical prototype. | - Normally 5th semester students are in internship, but due to COVID-19, this class will have their internship in the 6th semester and school in their 5th semester.  
- Introduction of one day instead of two days (involving less people from outside school).  
- A lot of online guidance during entire project due to limitations in number of students allowed in classrooms, a fire that took place on our floor at school and changing COVID-19 guidelines. |
| **Collaboration with PTI (technological experts)** | - 12 student consultants from PTI, 1-2 consultants in each group. | - 2 technical consultants (one teacher and one student helper) responsible for guiding 3-4 groups each. |
| **External presentations for class** | - Stegeager & Hastrup – former BA students who specialised in assistive aids for the partially sighted using the Wardrobe method.  
- Miss Blindspot - partially sighted blogger, and owner of empathy goggles representing 5 different eye diseases.  
- Birgit Christensen, leader of IBOS assistive aids exhibition  
- Visit to IBOS assistive aids exhibition with introduction and test of various aids. | - Miss Blindspot - partially sighted blogger and owner of empathy goggles representing 5 different eye diseases.  
- Birgit Christensen, leader of IBOS assistive aids exhibition.  
- Visit to IBOS assistive aids exhibition with introduction and test of various aids. |
| **Empathy exercises** | - Empathy goggles worn for an hour over lunch, follow up discussion with Miss Blindspot and IBOS representative.  
- Preparing and conducting an adapted wardrobe interview/ Make tools session with user in their home. | - Empathy goggles worn for an hour over lunch, follow up discussion with Miss Blindspot and IBOS representative.  
- Preparing and conducting an adapted wardrobe interview/ Make tools session with user in their home. |
| **Meetings with target group** | - Group interview with all users.  
- Individual interviews with their specific user.  
- Wardrobe/Make tools session in the same user’s home.  
- Test session on the proposed design concept. | - Group interview with all users.  
- Individual interviews with their specific user.  
- Wardrobe/Make tools session in the same user’s home.  
- Test session on the proposed design concept. |
| **Final presentation of project for IBOS and users** | - Online presentations and demonstration of the technical prototypes.  
- Online feedback from IBOS representative and teachers. No blind or partially sighted users present. | - Online presentations and demonstration of the technical prototypes. Online feedback from IBOS representative, one partially sighted user and teachers. |
The two classes were alike in most of the content and the methods taught and applied. But, there was a difference in the students' overall motivation because of all the changes at school due to COVID-19. The students in the spring class had just come back from their internship and were motivated for new learning. However, towards the end, some of the students lost a little of their motivation due to the lockdown. There was also frustration during the last two weeks of the project, since there was no possibility to finish the prototypes properly, nor to test and have feedback from the users. However, the students kept their engagement in the project.

The autumn class had experienced many changes to their education due to COVID-19. The major deviations were: their internship was moved to the 6th semester and their 4th semester entrepreneurial project was prolonged to the beginning of the 5th semester, as it was not possible to finish it during lock-down. When they started on the IBOS project, the students were already tired from COVID-19 and a long entrepreneurial project, which many of them hadn’t completed as they still had orders to finish. This meant that there was a difference in the two classes’ motivation and engagement at the start of the project. Therefore, we do not consider the autumn project as successful from an overall view, but we still believe the insights the students gained from the different methods taught and practiced have given them valuable learning to take with them.

In spring 2020, the teachers, students and users were truly engaged throughout the whole project, even though it ended up being interrupted by COVID-19. The students took a genuine interest in their users and were in contact with them during the design process. The cooperation with students from different programmes was a success, due to the engagement built into the empathy exercise. The concepts designed by the students were all comprehensive and responded to their users’ needs, while being relevant for products for the non-blind also. So, what made it such a success? What made the students so engaged? One student replied in the spring survey “It has been the most interesting project (at KEA) for me, as it was about making a difference for some people, which affected the commitment” (Spring survey).

7 Methodological framework

We noticed that both users and design students gained inspiration from each other. In these classes, design research methods were combined, as the empathy exercise cannot stand alone. Orientating our students to expect reciprocation shifted their “empathy building toward opportunities for mutual sense-making, multiple first-person narratives, and shared accountability” (Bennett & Rosner, 2019, p.9). The applied methods involving users in these classes were Make tools sessions (Sanders & Stappers, 2013) and Wardrobe studies (Klepp & Bjerck, 2014). Both methods were adopted to the setting in which the students were going to use them.

In the generative design method, Make tools, users are invited to physically build rapid prototypes presenting solutions to their problems. It is therefore a generative approach in the sense that the participants can express their ideas and dreams and share their insights through a selected set of stimulus items (Sanders & Stappers, 2013). As experts on the subject, the participants can gain influence as co-designers of the project. Many Make tools session exercises are based on the visual sense, which does not fit well with gaining insight into the experiences of the blind and partially sighted, but the students adapted the method to touch, sound and smell. They also included strong colours and light if their user was partially sighted.

In the ethnographic research method, Wardrobe studies “materiality is at the core” and the focus is on practice theory which “emphasises bodily movements, things, practical knowledge, and routine (Reckwitz 2002: 259).” The participants are interviewed in their home together with their wardrobe, to gain insight into their emotional connection and interaction with it (Klepp & Bjerck, 2014).
As the Wardrobe method is mainly focused on clothes and accessories, we broadened the spectrum to include favourite objects in the participant’s home, objects that the user liked because of their functionality, material or emotional value. We also did this to gain insight into the everyday practicalities of a blind or partially sighted person, and further, to observe how they interacted with their objects and whether they had any needs or issues in their everyday life.

One example of an everyday obstacle was found by a group of students who noticed how their user had to scroll through all the apps on his phone every time he wanted to show them a special app he used (observation notes). This action put the user in a situation where everyone around him would get to know all his apps and personal information related to the apps, including passwords, because he had to use the voiceover function on his phone. Later, this group started working on a concept of discrete use of apps.

Figure 7. Student project, autumn class. Wisephone: "Make your smartphone smarter"

The beauty of combining many research methods is that you build a deeper understanding of the users’ everyday life with a holistic approach, meaning that as many aspects as possible were viewed in the user study. The students did not only look into a specific issue that blind and partially sighted people have but they started understanding their life in a broader perspective. Therefore, the students did not design new canes or patches that display the condition, they went further with their designs.
7.1. Method to evaluate the teaching

We conducted semi-structured interviews with students from each class. Two in the spring and two in the autumn. In the spring 2020 class, we carried out a short survey (11 students replied) to get an overall impression of the whole class and the empathy exercise. Likewise, we conducted a survey of the autumn 2020 class just before the end of the project (13 students replied). Our observations included the students’ level of activity and engagement during their classes at KEA. In the autumn class, we could not carry out many physical observations during class, as due to COVID-19 regulations, the whole class was only gathered physically at KEA when we had presentations. So here, the observations were mainly gathered from what they presented to us at feedback sessions, and from the online guidance.

8 Empathy in the classroom

The students created a connection with their blind and partially sighted users, and in both classes each group worked closely with one user. The users gave the design students access to understand their everyday, their needs and struggles. None of the blind and partially sighted persons were educated designers, nor had they worked or currently work in the design field.

The students had an introduction day, where they met Miss Blindspot and heard her compelling story about how it is to become partially sighted and learn to live with it; they did the empathy goggles exercise and heard insights by IBOS in a presentation of eye diseases and assistive aids provided to the blind and partially sighted people in Denmark. The students were thus given a basis on which to start brainstorming ideas for possible wearable concepts. This was combined with a visit to IBOS, where the students saw an assistive aids exhibition and met their users for the first time. They started with a group interview with all the users, followed by individual interviews with their own user.

A week later, after analysing their first interviews and preparing their Make tools kits and Wardrobe interviews, the students visited the users’ homes combining the two methods in a new interview.
Users are not designers, but they bring valuable and essential knowledge to the process as specialists. “The users’ analyses, knowledge and needs are translated and processed by the project group, thereby facilitating a process where users and the project group both contribute what they are best suited to bring to the process” (Balfelt, 2019, p 79). The participants act as co-designers in this project. They feed the ideas and the designers transfer those into products and services.

As Elisabeth explained about their user” (...) we found out with our user that he liked a lot of colours and he liked when he could help decide how the things should look. So it gave us something we could use in the design process” (Interview 2, spring). The combination of the empathy exercise and the close connection to their users through ethnographic research provided the students with knowledge they could not have gained by reading or by only observing their users. Accessing the users’ homes gave the students insights that would have been hard for them to study otherwise, for example in an interview.

Bea: “it is just like with the empathy goggles I guess; it gives us more empathy that we are able to see the person more in their own context” (Interview 2, autumn). We tend not to be able to observe even our own routines, and therefore visiting the blind and partially sighted people’s homes gave a lot of information that would have been impossible to ask for.

Many of the groups were surprised about the use of colours and patterns in the clothing and interior, just as they were surprised how much the users took an interest in natural materials. Pauline: “it was very interesting to see him do things inside his house, serving us coffee, having a friend over and seeing how the house was (...) put together, (...) we noticed that he didn’t have any pictures or like any of his family or anything. “ (Interview 1, autumn)

Some of the groups had male participants of 50 years and older and they discovered that some of the Make tools exercises they had designed for their user did not really work as expected, as Bea says: “Bo was very engineering, (...) he was like, judging Upon a functional aspect which was quite interesting because we prepared a more emotional interview with him, where he should connect colours with emotions and so on and that didn’t really quite work with him, but then we got to know Tina, his girlfriend, and she was way more like talking about emotional aspects.” (Interview 2, autumn).
As most of our students are female and in their 20ies it was a challenge for them to plan exercises that connected with their user. Nevertheless, through a combination of exercises, the visit to their user’s home and the conversation with their user, the students gained genuine respect and interest for their user.

Figure 10. Make tools session, spring class (picture from students’ final presentation)

We were able to witness excitement in the student groups that was rooted in their own bodily experience and their learning from the Make tools sessions, Wardrobe interviews and observations. Through the combination of these methods, the design students, whose life is quite different from that of their users’, were able to empathise with people who cannot see and are therefore trapped in their homes or routines. What most students found out is that blind and partially sighted people often find it difficult to change or alter their routines. Although some of the blind and partially sighted users impressed the students with being very active horse-riding, sailing or traveling abroad alone, they also spend more time in their homes than those who can see, because it takes a lot more planning and energy for them to actually go outside. Therefore, the wearables designed for them often had features helping them move more and break their routines in a safe and social setting. None of our insights claim that it would be easy for those who can see to change their routines or leave home. However, people who are not partially sighted have more choices. Their problems with changing routines or leaving home derive from something else than it being physically difficult. They may not want to go out, whereas if you are physically trapped in your home, you might still want to leave your home. Most of us have experienced some unwanted homestay during COVID-19 lockdown.

9 Insights and take-aways

By conducting empathy exercises, we learned about the importance of empathy. We learned that our students gained a solid base and many valuable insights by the empathy exercises which they would have had difficulties achieving otherwise. They acquired these insights by a combination of a thorough introduction day to the blind and partially sighted and the empathy goggle exercise and, subsequently, by a combination of interviews with the blind and partially sighted users and use of the ethnographic design research methods, the Make tools sessions and Wardrobe interviews. We also
experienced the importance of adapting the Make tools sessions and Wardrobe interviews to the specific participant that the students visited, and that no interview ever goes as planned. The students were able to design relevant products through compassion, humbleness, observation and relying on everyday experts’ insights and using the participants as valuable partners in the design process (Bennett & Rosner, 2019).

We also observed that the student from these classes applied the empathy methods later in their design research in different and new settings, inspired by their learnings from this project. Furthermore, we learned that the interdisciplinary focus was clearer and more fruitful for the students when they cooperated closely with students from another KEA programme (spring 20) and not only with teachers (autumn 20), although both classes learned about communication with specialists from a different field. As Josefine contemplated:

“I think collaborating with some other students (from a different educational field) has been really, really interesting because it gives a very realistic picture of how you as a designer in the labour market most likely will get to work” (Interview 1, spring).

Even though, due to circumstances out of our hands (COVID-19), the engagement of the students in the autumn was not as high as in the spring class, the jewellery students still learned valuable insights from the combination of wearables, the empathy exercises and an untraditional user group, all of which they can use further on in their studies, and hopefully later in their working career.

10 Conclusion

In this paper, we have presented a teaching case that has a strong emphasis on empathy. We have shown how we used empathy exercises to make both the design process richer and the teamwork in the classroom more fruitful. It is our ambition to make our experiences with these empathy exercises available to other design educators’ use. We have learned to consider the hybrid nature of future design professionals when teaching wearables to interdisciplinary teams at bachelor level in a design education programme.

We have built our empathy exercise on our learnings from earlier scholars’ notions on empathy. It is common to all these notions that using, utilizing and applying empathy in the design process or in design research is fundamental (see for example, Kumar, 2013; Koskinen 2003; Koskinen et al., 2011; Mattelmäki, 2006; Battarbee, 2004; Redström, 2017; Møller, 2019; Sanders & Stappers; 2013; Fletcher & Klepp, 2017). We are contributing to empathy in design and in the design research discourse with our empathy goggles exercise. We are hoping that our experiment and experience presented in this paper will help other design educators to experiment with empathy in their curriculums.

In this paper, we first browsed the so-called soft skills that UNESCO and OECD have foreseen as essential in future. We then explored the empathy exercise that we developed as a consequence of our experiences in classrooms with a great diversity of students. We conducted the empathy exercise twice in 2020 under the influence of COVID-19. What we have learned from these teaching cases illustrates the need for team members to be able to see the world from someone else’s perspective.

Josefine: “It is a reality picture of cooperation across professional groups, and then the empathy exercises- it was clearly a totally different way to create empathy with the user” (Interview 1, spring).

Our students gained an extra layer in their user-oriented design process. This was achieved by adding a wearables design project to the jewellery class which focused on technology and function and which included cooperation with technical specialist students. When designing wearables, some students discover that they have widened their design perspective and can design and cooperate in a much broader field than previously. Elisabeth: ”It shows a little how you also can work (...) it doesn’t have
to be just with jewellery, but you could get hired in a company working with technology(…) And be able to contribute with the knowledge I have gained …” (Interview 2, spring).

We believe that the empathy research methods applied, and the insights gained by the jewellery students throughout this project provide a valuable addition to the students’ transversal skills in their future work, as students as well as design professionals. We further believe that this will not only enhance their chances in the future job market, but also improve their empathic and collaborative skills and their abilities to be able to tackle future global challenges.

References


Empathic multispecies design – Using empathy to design with animal perspectives in mind

Daniel Metcalfe
Technion – Israel Institute of Technology, daniel.met@technion.ac.il

Abstract. Supporting a greater diversity of species within human-dominated habitats has been proposed as a way of achieving both conservation goals and addressing the growing alienation of people from nature. To advance the vision of more biodiverse human habitats there is a need for a design practice capable of understanding and addressing the needs of nonhuman species within human-dominated habitats. Here I explore the prospect of using empathic design when designing for nonhuman species, through analysis and reflection on a design exercise intended to help designers experience the world from the point of view of other animal species. The data gathered from interviewing participants in the exercise suggest that trying to perceive the world from the point of view of other species may have positive effects on the design process, including a deeper understanding and more holistic view of the animal, changes in sentiment and real-world interaction with the animal, and increased curiosity and motivation for designing for the animal.

Keywords: empathic design, human-animal interaction, multispecies design, umwelt

1 Introduction
This paper explores the topic of empathic multispecies design. To this end, I will first discuss the terms multispecies design and empathic design separately and then in integration. The prospect and possible application of empathic multispecies design are discussed through analysis and reflection on a design exercise named the umwelt apparatus, in which, designers created an apparatus for experiencing the world through the sensory abilities (umwelt) of an animal client.

1.1 Multispecies design
The devastating effects of unsustainable design on the natural world and other species with whom we share this planet have gained widespread awareness and are the driving force behind attempts to develop more sustainable design approaches. These efforts tend to focus on minimizing the negative effects that design has on the natural world by reducing material and energy use. However, the possibility that design may have an active role in mitigating the erosion of biodiversity has only entered the discussion in recent years and remains a marginal activity for design (Metcalfe, 2015; Root-Bernstein & Ladle, 2010; Wells & Yeang, 2010). The prospect has entered the discussion following an ongoing paradigm shift calling for the inclusion of a greater diversity species within human-dominated habitats, as a way of addressing both the erosion of biodiversity and humankind’s alienation from nature. Ecologists, who have long ignored urban ecosystems, are gradually realizing that cities are not only the problem but also part of the solution and that integrating nature in cities can benefit both people and biodiversity conservation (for example Colléony & Shwartz, 2019; Rosenzweig, 2003). The last three decades of urban ecology research have demonstrated that urban green spaces have the potential to support rich biodiversity that can be enhanced by implementing
certain design and management solutions (Beninde et al., 2015; Rosenzweig, 2003; Shwartz et al., 2013). Wild animals frequently interact with anthropogenic systems (Luniak, 2004). However, in most cases, these are not designed with the animal in mind and may lead to harm to the animal or human-wildlife conflicts. To facilitate a shift to more biodiverse human habitats and address its eco-socio-cultural implications, there is a growing need for a design practice capable of looking at the needs of both humans and wild animal species as well as the interactions between the two groups – a practice we may call multispecies design (Metcalfe, 2015). One main characteristic of multispecies design is the view of animals as clients of design (ibid). To develop this notion, we need new design methods for studying animals and their needs in the context of design. Here I look to the field of empathic design to examine its relevance for design instances involving nonhuman species.

1.2 Empathic design

The word empathy is used in a wide range of disciplines to convey a large variety of meanings (Cuff et al., 2016). Here I refer to the term as it is often used within the field of design, with some reference also to its use within human-animal studies. To this end, I adopt Young et al.’s (2018) definition of empathy as being “a stimulated emotional state that relies on the ability to perceive, understand and care about the experiences or perspectives of another person or animal”. Empathy is often described as incorporating two distinct yet related abilities: cognitive empathy and affective empathy (see for example Cuff et al., 2016; Kouprie & Visser, 2009). Cognitive empathy is the ability to understand another’s feelings and affective empathy is concerned with an emotional response to the state of the other (Cuff et al., 2016). Some authors add empathic concern, i.e., the motivation to act to relieve another’s suffering, as a third component of empathy (see Young et al., 2018). Empathic concern resonates with the notion of empathy as a driver of motivation seen also in the field of design (see Kouprie & Visser, 2009).

Empathy is increasingly viewed as a central concept in human-centred design as both a quality of the design process and a quality (state and trait) of the designer (Kouprie & Visser, 2009). The term empathic design is commonly used to describe a process of getting closer to the lives and experiences of existing or future users and gaining a deep understanding of the user and his or her experience (Kouprie & Visser, 2009). Various design thinking models place empathizing as a stage by itself in the design process, often the first stage (see for example Interaction Design Foundation, 2021) and different techniques have been developed for gaining empathy with clients as part of the design process. These typically include (1) immersive techniques, where designers immerse themselves in the lives and experiences of potential users (such as shadowing, visual diaries, empathic interviewing techniques, and bodystorming); (2) role-playing techniques, where designers imagine themselves in the place of users and act out different scenarios of interaction; and (3) simulation techniques, where designers use props or physical restraints to physically alter their experience or perception. The latter has been developed mainly in the field of inclusive design where designers use simulations to feel, for example, the effects of different types of capability-losses while using a product or service (Cardoso & Clarkson, 2012). Methods of empathic design have been suggested to be useful for (1) experiencing the world from the users’ point of view (Koskinen, Battarbee & Mattelmäki, 2003); (2) broadening the reach of the design and rendering it more inclusive (Cardoso & Clarkson, 2012); (3) approaching the problem from multiple perspectives (Smeenk et al., 2016), increasing curiosity and motivation (Kouprie & Visser, 2009); (4) conveying the subjective, situational qualities of human emotions to the design process (Lee et al., 2020); and (5) promoting empathic interactions through the final design proposal (Devecchi & Guerrini, 2017). To date, empathic design methods have focused almost exclusively on human users. This paper explores the relevance of the concept of empathic design when applied to nonhuman users.
1.3 Empathic multispecies design

The key motivations behind empathic design methods, described above, may apply also for design involving nonhuman species: understanding animal perspectives, experiences, and ways of interacting with the world may help reduce the designer’s human bias in the process and increase the chance that the design meets the needs and abilities of animals interacting with it. It may help approach the problem from both a human and an animal perspective. It may increase curiosity and motivation to design for the studied animal, and it may lead to more empathic interactions between humans and animals. However, applying these methods in a nonhuman context is not always straightforward. While some principles and methods of empathic design may potentially be adopted for multispecies design, there are some inherent differences it is important to note when developing an empathic multispecies approach. For example, as part of the empathic process designers often rely on their personal experiences, feelings, and emotions from within similar contexts to that of the design (Smeenk et al., 2016). Relying on personal experience may be useful when designing for other humans but when designing for animals it may cause a human-centric bias and misinterpretation of the animal’s actual needs. Another area where empathic design methods do not, for obvious reasons, transfer easily to nonhuman species involves methods based on dialogue and verbal interaction with potential users, such as interviews and methods of participatory design. Overall, the application of empathic design principles and methods in the context of nonhuman users is a novel and unexplored domain, much like the field of multispecies design itself. The purpose of this paper is to explore the prospects of empathic multispecies design, its areas of differences and similarities with human-centred empathic design and outline some considerations for developing methods in the field. The topic is explored through analysis and reflection on a design exercise named the umwelt apparatus, developed to promote empathy towards a chosen animal client, undertaken by design and architecture students at the Technion - Israeli Institute of Technology.

2 Methodology

In a monograph from 1934 titled A Stroll through the Worlds of Animals and Men, Jakob von Uexküll deals with the possibility of viewing the world from the points of view of species with entirely different sets of sensory organs than us humans. In it, von Uexküll invites us to take part in a thought experiment of experiencing the world through the sensory organs of other species, referring to this self-world of the animal as its umwelt. Inspired by this work we devised the concept of an umwelt apparatus: a simulation apparatus that would help designers experience the world from the point of view of a selected animal client – offering them a glimpse into the unique ways in which the animal senses and interacts with the world – to be used in the early (emphasizing) stages of a design process involving nonhuman clients. The challenge was presented as a design exercise to design and architecture students in the course Human-Animal-Machine at the Technion. The umwelt apparatus was the first of two design exercises developed in the course; the second being the development of a conceptual design intervention based on the insights gained in the first exercise and responding to the needs of the selected animal client. This paper’s focus is on the first exercise – building and using the umwelt apparatus – and its effect on the students’ attitude towards and perception of the animal. In the spring of 2021 thirty students took part in the exercise. Fifteen Master of Industrial Design students and fifteen Master of Architecture students, from different study and professional backgrounds. The exercise was conducted in Hebrew. The students were divided into thirteen groups, each working with a different animal client and focusing on a different simulated state or sense. Table 1 shows the animals, simulated state/sense, and a short description of the developed umwelt apparatus. For the exercise, the groups were instructed to conceive and build a device or protocol that would allow them access into the animal’s self-world, based on the animal’s unique sensory abilities,
behaviour, and ways of interacting with the world (see figure 1 for examples of umwelt apparatuses developed in the course). The explanation of the brief was followed by examples of work by various artists, for example, Chris Woebken’s Animal Superpowers (Woebken, 2007), as well as student work from the previous year. The exercise was presented to the students as being part of the research stage of their multispecies design process, where they seek to learn about their animal client to later develop a design intervention for it. The groups had five weeks to develop their umwelt apparatus followed by seven weeks to develop their final design proposal. After developing the apparatus, the students were asked to use it within a human-dominated habitat to interact with the environment as the animal might. This, to explore the animal’s self-world and the way it is influenced by human development, in a way that is both immersive and experiential [following Koskinen, I., Battarbee, K., & Mattelmäki, (2003), who state that empathic design methods should strive to be both immersive and experiential].

Table 1. List of studied animals, simulated states/senses, and a short description of the Umwelt Apparatus

<table>
<thead>
<tr>
<th>Group</th>
<th>Studied animal</th>
<th>Simulated state/sense</th>
<th>Umwelt Apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Common fruit fly</td>
<td>Smell</td>
<td>Development of substances for coding the fly’s’ olfactory language using various foods in different stages of decay. And training the human nose to detect and make sense (in a similar way a fruit fly might) of the different chemical cues.</td>
</tr>
<tr>
<td>2</td>
<td>Great tit</td>
<td>Vocal and body language</td>
<td>Simulation using role-play of typical scenes from the life of great tits using the bird’s vocal and body language to communicate (following field observations of the birds).</td>
</tr>
<tr>
<td>3</td>
<td>Golden jackal</td>
<td>Soundscapes</td>
<td>Simulation using sounds (howls) to communicate and perceive invisible geographical information such as territory size and borders. Drawing and comparing maps to finetune this (sense)ability.</td>
</tr>
<tr>
<td>4</td>
<td>Kuhl’s pipistrelle (bat species)</td>
<td>Proprioception</td>
<td>Apparatus simulating the first seconds of a bat’s takeoff from hanging upside-down.</td>
</tr>
<tr>
<td>5</td>
<td>Southern white-breasted hedgehog</td>
<td>Behaviour/danger perception</td>
<td>Simulation of behaviour during danger in hedgehogs using a blindfold hat with bells - connecting the sense of danger with the need to stay completely still</td>
</tr>
<tr>
<td>6</td>
<td>Rock dove</td>
<td>Behaviour/drinking</td>
<td>Apparatus simulating the dove’s distinctive drinking behaviour involving dipping its whole head in the water</td>
</tr>
<tr>
<td>7</td>
<td>Rock hyrax</td>
<td>Behaviour/walking, jumping, climbing</td>
<td>Apparatus simulating the rock hyrax's foot structure, prompting typical walk and interaction with the environment.</td>
</tr>
<tr>
<td>8</td>
<td>Nubian ibex</td>
<td>sight</td>
<td>Visual apparatus simulation the ibex’s visual capabilities (field of view) using lenses and mirrors</td>
</tr>
<tr>
<td>9</td>
<td>Hooded crow</td>
<td>Sight/tool use behaviour</td>
<td>Apparatus simulating the crow’s vision while using a stick as a tool and a series of tasks to perform while using the tool</td>
</tr>
<tr>
<td>10</td>
<td>Mediterranean house gecko</td>
<td>Sight and spatial movement</td>
<td>Video filming apparatus and postproduction process for creating footage simulating a gecko’s spatial movement, point of view of the environment, and colour range</td>
</tr>
<tr>
<td>11</td>
<td>Smooth cauliflower coral</td>
<td>Distributed sense of touch</td>
<td>Apparatus for a distributed sense of touch and response using multiple “arms” extending from the body</td>
</tr>
<tr>
<td>Group</td>
<td>Studied animal</td>
<td>Simulated state/sense</td>
<td>Umwelt Apparatus</td>
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</tr>
<tr>
<td>12</td>
<td>Western honeybee</td>
<td>Sight</td>
<td>Apparatus simulating the bee’s eye structure and visual spectrum and simulated environment using UV colours</td>
</tr>
<tr>
<td>13</td>
<td>Near Eastern fire salamander</td>
<td>Sensing humidity through the skin</td>
<td>Simulated rock crevice environment and navigation using only the sense of humidity on the skin</td>
</tr>
</tbody>
</table>

Following the exercise, I conducted semi-structured interviews with the students who agreed to take part in the study (N=27) to gain insight into the process of designing and using the umwelt apparatus. The data gathered from the interviews were classified and analyzed through a process of reflexive thematic analysis (Braun & Clarke, 2021) to identify, analyze, and interpret patterns of meaning and develop themes relating to the topic of empathic multispecies design. The thematic analysis was conducted with an inductive approach, grounded in the data collected from the interviews, seeking both evident and latent codes and themes. Concepts arising from the interviews were mapped onto the three components of the empathic process discussed above: affective empathy, cognitive empathy, and empathic concern highlighting common themes relating to the process of empathic multispecies design (figure 2). Some of the emerging themes related to more than one component of empathy – highlighting interrelations between the cognitive, affective, and motivational elements of empathy. These appear in the overlapping parts of the circles. The concepts arising from the thematic analysis are discussed in the following section.

**Figure 1.** Examples of umwelt apparatuses developed by three groups of students. Clockwise from upper left: 1. Apparatus for experiences the world from the point of view of the honeybee involving a visual filter and an ultraviolet light, developed by Ofek Raz and Dana Taub. 2. Apparatus for coding the common fruit fly’s “olfactory language”, developed by Erez Ezra in D.Dlab [Disrupt,Design] research facility. 3. Simulation using role-play of typical scenes from the life of great tits developed by Orni Bloch and Yael Salem.
3 Analysis and discussion

One central theme arising from the study relates to the level and quality of understanding the animal and its respective world. Participants reported a sense of a deep understanding of the animal; an understanding of its inner logic and a realization that the animal’s inner world and perception are more complex than previously imagined. This stood out particularly when considering the animal’s behaviour; after developing and using the apparatus participants reported a sense of understanding not only how an animal behaves, but also why it behaves the way it does and how this behaviour relates to its unique perceptive abilities. Some participants reported having moments of insight or discovery concerning the animal after using the apparatus, where the animal or some aspect about it suddenly made sense. For example, when talking about rock hyrax, one participant stated that she had realized that most human interactions with the animal have little to do with the animal itself and are determined by a third actor, in this case, the leishmania virus for which the rock hyrax is a host. Developing and using the umwelt apparatus granted her a fresh look of the animal, disconnected from the way it is currently portrayed in the Israeli media.

Another interesting aspect regarding new ways of seeing and understanding the animal developed around the concepts of empathy and detachment within human-animal interactions. Participants stated they felt less naïve regarding these interactions after imagining them from the animal’s point of view; realizing that when it comes to wild animals, empathizing and respecting the animal should, in many cases, be done from a distance, resisting the will to engage and connect. As Candea (2010) points out, empathy for animals is often associated with engagement, while detachment is often wrongly associated with coldness and lack of caring. The notion of an empathy of detachment in human-animal relations represents a more comprehensive view of these relations and is a crucial aspect in maintaining and respecting the wild nature of the animal (ibid).

A further thematic area, relating mainly to cognitive reasoning, was observed regarding the notion of similarity and difference between the studied animal and humans. Here participants reported that using the apparatus highlighted both similarities and differences, particularly around the (different and similar) ways in which humans and animals perceive and interact with the world. One participant specified that for her the cognitive study of the animal, before developing the apparatus, highlighted similarities while the affective experience of using the apparatus emphasized differences between humans and the animal. A good understating of the similarities and differences between humans and animals is important in multispecies design as it may lead to less anthropomorphizing of the animal and a clearer sense of how each group may interact or be affected by a design feature. An interesting example of how an anthropomorphic point of view may lead to misunderstanding the animal is the mirror test designed by humans to determine if animals have self-awareness. In the test, an animal’s face is marked with a red dot, and then the animal is given access to a mirror to see if it responds to the presence of the dot. Dogs categorically fail the test, leading researchers to believe they lack self-awareness. However, more recent studies suggest that dogs fail the test because they are considerably less affected by visual events than humans and that self-awareness in dogs is linked to their sense of smell and not sight (Cazzolla Gatti, 2015).
This deeper understanding of the animal was present not only in cognitive terms but also in affective resonance and emotional reaction towards the animal. Participants reported a sense of identifying with the animal, a sense of kinship and connection after seeing from the animal’s point of view, and a sense of awe and wonder in relation to the animal. In some groups – where the apparatus involved alterations to perception such as blindfolds, mirrors, or filters – subjects reported the exercise created for them new, unfamiliar, bodily sensations. For example, in the salamander group, where the umwelt apparatus involved a blindfold and a stimulated environment of smell and humidity, a participant stated that the blindfold and the sense of condensing water on her skin helped her “separate from the...
human and amplified an animalistic feeling”. For several participants using the apparatus resulted in increased empathy and respect towards the animal and led to a change in perception of the animal, causing the animal to seem different after the exercise. For example: “less scary”, “less dirty”, “more capable of taking care of itself”, or, in contrast, “more vulnerable and in need of protection”. Throughout the interviews, affective resonance and cognitive reasoning seemed to be interrelated and complementary in the view of the participants and some made an explicit connection between the deeper cognitive understanding of the animal and the change in their emotional response to it. In cases where the students had frequent interaction with the studied animal, some interesting changes in real-world interactions were reported after using the apparatus. Participants reported feeling more relaxed around the animal, less fear, as well as anticipation before encountering the animal, together with a sense that the animal is more present in their lives. One participant from the bee group said: “I cannot look at bees the same, I see them everywhere now, I feel connected to them and understand why they behave the way they do”. Members of other groups, working with songbirds, insects, and reptiles, also stated that they see and hear the animal more frequently than before in their everyday lives.

In terms of empathic concern, an increase in curiosity and motivation to take action has been observed. For some, this was propelled by increased awareness of the impacts of human systems on the animal and a desire to better share the space and interfere less in the animal's life. Cardoso & Clarkson, (2012) discuss the ability of simulations, used in inclusive design, to show how everyday products often disregard a large number of users with capability loss. Similarly, using the umwelt apparatus revealed how urban environments are designed predominantly for humans and ignore their influence on other species. An influence that can be extremely dire as is the case, for example, with over a billion birds that find their death annually in collision with glass windows (Klem, 2015). Some participants reported a sense of commitment to help the animal, a desire to change the way people perceive the animal, and increased belief in their ability to make a difference. This increase in motivation is strongly linked to the concept of empathy in design as described above.

The final thematic area developed from analyzing the data relates to the concept of accurate empathy. The term has been used by Young et al., (2018) to refer to an empathic response that is based on scientific knowledge regarding the animal. The authors acknowledge that our ability to perceive and understand another’s perspective, especially when it comes to animals, is always an approximation (Young et al., 2018), nevertheless, they stress the importance of basing this empathic understanding of the animal on substantive knowledge of an animal’s natural history and not purely on projected assumptions. This theme was present on different levels in the study. First, in the detailed research of the animal’s natural history the students felt they needed to conduct to develop the umwelt apparatus and select one typical attribute of the animal’s perception to explore in the exercise. Second, most participants openly talked about the limits of their apparatus to accurately simulate an animal’s perspective, acknowledging, as well, the limits of human perception in viewing the world from the animal’s perspective. The relevant question, in this respect, seems not to be about the fidelity of the apparatus in simulating an animal’s perspective, but about what changes in us in relation to the animal when we develop and use it. Different participants stated that although they do not believe the apparatus simulated an accurate depiction of the animal’s umwelt, the process opened for them a window into the animal’s world and profoundly changed the way they view the animal as well as their motivation to design for the animal. The newly gained understanding of the animal came together with an understanding that there is a lot we do not know, and perhaps, can’t know about other species and their self-worlds. This by itself, is an important insight for designers seeking to engage with nonhuman species.
4 Conclusions, limitations, and further work

The goal of this study was to explore the prospects of empathic multispecies design, its areas of differences and similarities with human-centred empathic design and outline some considerations for developing methods in the field. Methods of empathic design deal with the possibility of perceiving and experiencing the world from the viewpoint of prospective users. While it is generally acknowledged that it is not possible to fully capture the perspective of another being (human or animal), the field of empathic design sees value in trying to get closer to the point of view of potential human users. Reflecting on the umwelt apparatus exercise suggests that this is also true regarding nonhuman users. By creating and using a device aimed at exposing them to an animal’s perspective of the world, participants seemed to gain a deeper, more holistic understanding of the animal, greater respect and empathy towards the animal, and increased motivation to act for the animal. Studying the natural history of an animal is, no doubt, important when considering an animal in the context of design; however, complementing the factual knowledge of the animal with an affective, experiential, and immersive experience of the animal’s perspective may lead to a more comprehensive understanding of the animal, stronger commitment and increased motivation to appropriately respond to its needs. Although the study did not explicitly explore this, it seemed that the insights gained in the umwelt apparatus exercise were significant for the second part of the design process developed in the course, where the students developed a design intervention responding to the needs of their studied animal. This was notable, both, in the way the students talked and related to the animal as well as in the focus of the interventions, which could all be linked back to the initial exercise. Future research could focus more directly on how the emphasizing stage in multispecies design influences the design outcome at the end of the process.

The research presented here is limited by the fact that it was conducted on a group of students as part of a study course and that coding and analyzing the data was done by a single researcher. Measures were taken to separate the study from the curricular activity, such as making participation voluntary, offering no compensation for participating, and grading the exercise before interviewing the students to assure them that the interview will not affect them or their grade in any way. Future work could involve participants that are professional designers, to investigate the relevance of the method also outside academia.

The umwelt apparatus is presented here as one way to seek empathy in a multispecies design project. It takes inspiration mainly from role-play and simulations techniques used in empathic design. Immersive techniques were not explored because of the difficulty of immersing oneself in wild animals’ lives and experiences and the risk it may pose to the animals themselves. Further development of empathic multispecies design techniques could focus on finding alternatives to immersive techniques, through remote sensing for example, as well as developing additional role-play and simulation techniques. Somatic practices such as focusing, and Body Mind Centering (BMC) could be explored as ways of internalizing an animal’s perspective (see for example Metcalfe, 2015). Another possible path to develop simulation techniques could be using virtual and augmented reality, as was done in the interactive project in the Eyes of the Animal created by creative studio Marshmallow Laser Feast(2016). I encourage designers and design researchers to explore and develop new methods for achieving empathy for animals within the context of design; taking into consideration, both, animals that are direct users of the design and animals that might otherwise be affected by a design intervention.

References


10 Design Thinking: Methods, teaching and research
7D – Nature centered design

Ezri Tarazi
Technion – Israel Institute of Technology, ezri.tarazi@technion.ac.il

Abstract. Decades after Design Thinking first emerged and developed, it is now detached from its theoretical core, where some of its aspects have become a buzzword, specifically the famous Double Diamond five-stage methodology. 7D is an attempt to bring more integrative thinking into the creative and innovative design process and expand the scope of the human-centered approach by placing the individual in the context of human society, nature, and the world. Based on a natural agricultural metaphor that has been used and tested in various contexts with thousands of participants and hundreds of organizations, 7D is an attempt to make Design Thinking more relevant, comprehensive, and viable. It is open-ended in its structure and can support the mindful shift to a new integrated design approach. It offers a nature-centered design framework of values and processes, critically needed to tackle the mammoth challenges currently faced by humanity.

Keywords: 7D, Design Thinking, Integrative Design, Nature-Centered Design

1 Background

1.1 Design Thinking is not a monolithic theory
It does not need a full theoretical framework of Design Thinking to emphasis the claim that it is not a monolithic theory or toolbox, and that it is not based on one single origin. It was built on decades of research and work of many approaches and directions in design theory. To mention few, the Creative Problem Solving (CPS) (Treffinger, 1995) is one of the milestones in this, where it offers a framework which individuals or teams can generate creative options and plan effective implementation of new solutions. Treffinger has emphasis on an alternative to the traditional linear, prescriptive stage-sequential engineering models. In his CPS he highlights the need for both divergence and convergence thinking.

The three components of CPS are, Understanding the problem, Generating Ideas, and Planning for action. CPS was implemented in education, and there was a great emphasis it can be taught mainly by applying it through a challenge. Nigel Cross (2011) claimed that the classic methods of reasoning in problem solving are inappropriate in design. The range of interactive and iterative design techniques such as sketching, ideation, mockups, prototyping, scenarios, enable the designers to imagine a future ahead of the linear processes. The scope of ‘Design Thinking’ academic research, practice and application has grown exponentially, and it offers an opportunity for a reflection.

1.2 Stagnation in the application of Design-Thinking methods
One of the most influential theorists for Design Thinking was Béla H. Bánáthy (1919–2003), a Hungarian-American linguist and professor at San Jose State University and UC Berkeley. In his book, Designing Social Systems in a Changing World, he presented a comprehensive and prophetic theory (Banathy, 1996). In that book, Bánáthy set out the theoretical foundations for Design Dynamics and created the famous Double Diamond model of divergence and convergence processes (Figure 1). Based on the work of the psychologist Joy Paul Guilford on the Structure of Intellect (SI)
theory (Guilford, 1967), who coin under Operation Dimension the two opposite metal abilities or factors of intelligence: 1) Divergent production - The ability to generate multiple solutions to a problem; creativity. 2) Convergent production - The ability to deduce a single solution to a problem; rule-following or problem-solving.

Bánáthy’s original contribution was neglected, and he has received almost no recognition in the design community or credit for being the father of the Double Diamond model. The Design Thinking evangelists missed the deeper meanings of his radical theory, of which the Double Diamond model is only one part. For example, the Dynamics of Design model (Bánáthy, 1996, p. 74, Fig. 3.3) includes five spaces, which correlate with the more-recent Feedback and Feedforward movement and the iterative spiral movement between the spaces, resulting in “The Space of Displaying the Models”. Bánáthy argued for the evolutionary nature of the process. Yet, unfortunately, the common models of Design Thinking have not evolved.

![Figure 1. Banathy’s model of the dynamics of divergence and convergence (source: Banathy, 1996, Fig 3.4 p. 75)](image)

### 2 7D Nature-centered design process

7D is based on the unique nature of seven phases of growth and development, as reflected in growth cycles in permaculture and nature. 7D book was published as a practice-based reflections on it first use in variance of projects (Tarazi, 2013). 7D can be seen as a model for translating needs into new solutions and considering the shift from human-centered design to nature-centered design (Tarazi 2019). This 7- dimensional innovation process aims to answer future needs, in a manner that reflects the broader perspective necessary to meet the challenges facing humanity. As humanity faces multiple crises, there is a need for a radical shift to a paradigm that includes multiple dimensions.

When observing the seven dimensions alongside the 17 goals of sustainable development (UN, 2015), one realizes that the classic Design Thinking recipe for innovation is not sufficient and must be updated. The metaphor that underlies 7D is inspired by agricultural principles and is congruent with the United Nations’ sustainable-development goals. The once very important human-centered design must broaden its perspective to consider:

1. Humans as an integral part of nature and the world
2. Climate change and the way various industries impact it
3. The fundamental survival of individuals and widening economic gaps
4. Society in each country and region, and human society as whole
5. Culture, religion, and the relationship between them
6. Health and well-being, including identity, feelings, and social interaction
7. Unseen human systems and the evolution of the spiritual path.

Interwoven with the phases, there is the Five Intelligences model (Plasma 1998, Penza, 2020): Cognitive Intelligence, Creative Intelligence, Emotional Intelligence, Social and Ethical Intelligence, and Applicative Intelligence. In each of the phases, those five forms of intelligence can be applied to the analysis of situations, needs, human validation processes, and/or results.

One of the key questions when approaching innovation is to what degree that innovation is valid for future developments. The 7D process can be viewed as a systematic linear development process but can also be viewed and used as a multidimensional matrix of domains—more like seven balls flying through the air, with each dimension having its own nature, function, and tools. Although each dimension is linked to the others, the dimensions can also be considered independently in the context of a project at any given stage of development. Each dimension of the 7D process contains specific sub-methodologies, techniques, and know-how, and each one of the seven components can be used inside it.

2.1 Origins of the 7D

As a practicing designer, I felt that there were theoretical links missing from some parts of the Design Thinking process. I also felt that future process methods should include a larger scope of influences, beyond “unmet human needs.” As an IDEO worker (1998–2001), I was not aware of Bánáthy’s theories. I discovered those theories only after I had developed the permaculture-inspired 7D process. In 2007, I developed 7D, a process that is based on an agricultural metaphor, moving from a Plow phase to a Harvest phase in seven simple steps (Tarazi, 2013). It came from the perception that the common Design Thinking process lacked crucial components and was focused on winning over the user. I felt that design needed to evolve further. Instead of putting the human (user) at the center, 7D puts the human user into context, positioning the human as part of an ecosystem of nature. In a publication in which we considered methods for designing artificial coral reefs, my colleagues and I referred to this process as nature-centered design (Tarazi et al., 2019). 7D was applied in academia, government, education, and industry. 7D is currently used in Innovation Leadership courses at the Technion, in Israeli high schools’ system, and in European Innovation Technology (EIT) programs.

2.2 The Seven Phases

The seven phases or components of the 7D process add two half diamonds to Bánáthy’s model, at the beginning and the end of the process. It is a process designed for pursuing sustainable development, instead of focusing solely on technology (Industry 4.0). The process resonates with human faculties and the frequencies of unseen worlds, such as multiple intelligences, the seven spectra, the seven days of the week, and even the myth of the seven days of Creation. The agricultural metaphor connects us to nature and how we can work with nature in a pure and organic model. Every project starts with a plowing phase, in which we plow the soil of the potential field of challenge, and ends in a harvest phase, in which we harvest the solutions that are the fruits of our labors. Each of the seven phases has a different frequency and requires different approaches, tools, and techniques. The fundamental concept of 7D and the agricultural metaphor is that farmers do not create the crop on their own. Nature makes it happen. The role of the farmer is to create the necessary conditions and enable growth through connection, protection, stimulation, and support. A summary of the whole cycle of natural growth and its components is presented below:
Phase 1: Plow
In the plow phase, the point of view and current assumptions are flipped around and turned over, just as a plow turns over the soil in a field. The plow needs to be sharp and to cut deep, in order to penetrate the soil and turn it over. It disrupts the order of the solid soil, which may have been left untouched for years. The conformity, the old standard, the ‘this is how we did it for years’ is analogous to a dry surface on which nothing can grow. The creative process must start with the courageous act of being able to plow the ground with a blade that is sufficiently sharp. In the times in which we are living, one cannot start with only a focus on user needs or empathy for the customer. Creating a new perception starts with plowing the ground of one’s own formulas, beliefs, and unconscious conditions. The plowed soil, light and aerated, is like the plasmatic state of particles, amorphous and ready to be seeded. One of the methods used in the Plow phase of the design process involves a state of unattached, colorless, and neutral thinking called No-Box.

Phase 2: Seed
The Seed phase enables us to view the many intricate and complex aspects of the challenge and to inspect the ‘genetics’ of it. As in nature, countless seeds are disseminated, in various ways, to ensure that at least some of them will take root in the soil and eventually sprout. To collect seeds, there is a whole process of searching, listening, observing, collecting, learning, and matching information. This phase is not just user-centered, but also society-, culture-, and technology-centered, with the support of Big Data that has been digested into tangible insights. The Seed phase must include a global view of the impact, unseen consequences, and the prices that only nature pays, and it needs to go deeper than surface claims and pseudo-science. It requires humility and a not-knowing stance, as the seed is in the darkness of the soil.

Phase 3: Sprout
The Sprout phase is focused on letting early ideas grow. This phase calls for no specific brainstorming recipe, but rather an openness to the idea of a No Judgement Zone of Time that enables the receiving of the new. The sprout is a green shoot that needs to push up through the soil to reach air and sunlight. This is quite an enormous task for a tiny seed. In the Sprout phase, ideas are scattered, and it is futile to attempt to coordinate the process or push it to happen. The conditions that allow young sprouts to emerge are focused, first and foremost, on the elevation of freedom, in a safe manner. The sprouting needs first to happen in the person, through true inspiration, the joy of offering something new, and the urge to solve a mammoth problem or satisfy a need or vision. The spirit of growth and the urge to cultivate something new cannot be faked. The main barrier to the Sprout phase is fear and the team or the organization needs to attend to the deeper reasons for that fear. The Sprout phase may involve a ready-made transformed object that took few minutes to assemble, a short movie, taken and edited using a smartphone that shows a short future scenario, or an animation file that conveys the idea better than black text on a yellow Post-It note. There are cloud-based tools that can be used to share and work in teams, which can support the Sprout phase on a large scale and across great distances.

Phase 4: Bud
The Bud phase is focused on gathering the early concepts before the full direction of the project is selected. The bud phase sits at the middle point of GO/NO GO of the process, since the allocation of resources becomes meaningful after this stage. A variety of tools can be used in the Bud phase to visualize and express ideas as early concepts. The Bud shows the vision, without a heavy investment of resources. The bud, as the early flower, reveals only some of the details, while providing a concise impression of the concept. The bud gathers energy by developing more substantial components of ideas selected during the Sprout phase, such as visual manifestations, scenario-based stories, early mock-ups, fast prototypes, and early models of system design. The importance of this phase is that it
provides space to evaluate a few concepts at a time, before focusing intensely on one concept. The process is iterative in nature and feeds itself, through rapid cycles of Budding.

**Phase 5: Flower**
The Flower phase is aimed at creating an attractive, fully developed prototype. Nature promotes beauty as an attraction tool for reproduction. The full prototype should reflect the beauty of the solution, as a whole and in its details. The prototype is not as fully usable as the fruit, but the attention to details in all dimensions and the careful attention to the potential impact of the solution in various realms are most important. This phase includes making final decisions on what will not be part of the final product and prioritizing the most important aspects and giving those aspects all of the necessary attention. There must be iterations of testing and careful validation, until the Flower phase is complete, and we are ready to enter the implementation phase.

**Phase 6: Fruit**
The Fruit phase calls for balancing the systems into one coherent and viable solution that is ready to be fertilized. The Fruit phase is the phase in which all of the components must be integrated, before spreading out to the world. The fruit is a useful seed-bearing tool; as the fruit is consumed, seeds are disseminated. The Fruit is not just visually appealing, but also sweet and juicy. In this phase, the focus is on taking the necessary steps to transform the concept and the proof of concept into a real solution that can be implemented. The usefulness of the concept needs to be tested again and again, in cycles of iterations, until it tastes good and is useful. In a fruit, nothing is wasted, and the sustainable nature of a fruit must be the reference point for every new solution. The Fruit must contain nourishing vitamins and fibers, and not encourage harmful overconsumption.

**Phase 7: Harvest**
The Harvest process is an open diamond of establishment in the outside world. The fruits are picked when they have matured, by those who find them attractive. Those who harvest the fruit also distribute their seeds across distances, to places in which those seeds can take root and grow further. Only those seeds that can survive in the new environment are able to grow. The essence of the whole process, from the first intention to the attitudes, values, qualities, care, and love for a true solution, are manifested in the Harvest phase. The open side of the last diamond suggests that it is difficult to predict the way ahead, once a concept has gone out into the world, and that many modifications, turns, and mutations can occur after that point. The Harvest phase requires both the permanency of adhesion to the purpose and openness and flexibility, in terms of the ways to achieve that purpose. The Harvest phase rarely happens by itself; a successful Harvest phase requires the input of extra energy.

7D is a coherent process based on a metaphor that resonates with nature and sees nature as a source of inspiration. It is based on the belief that natural processes are congruent with the humans’ inner systems, stored in the unconscious, and that working inside that understanding will grant the users of those systems freedom and connection to their higher selves.

**2.3 The triple open diamond model**
In 7D, the Double Diamond model has been extended to include an open-ended half-diamond on each end (Figure 2). The first half-diamond starts off open and closes at the point at which the Seed phase starts. In the Plow phase, there is a considerable process of bringing together the main questions addressed by the project. This open start is essential for avoiding any pre-definition of the field, the problem, the challenge, or the solution. Beginning the process from an open position means that one should defy
definitions and the existing frameworks of the existing situation. In a rapidly changing world, pre-definitions can set the whole project on the wrong track.

![Open-ended triple diamond 7D model](image)

**Figure 2.** Open-ended triple diamond 7D model

The second half-diamond is open to the future. The Double Diamond model ends with the delivery of the project to the client. It does not deal with or take responsibility for the impact or outcome of the innovation output. The Harvest phase is open-ended, as it includes concern for what happens after the product is out in the real world. It is the innovator’s responsibility to care about the impact and consequences of the new product and the innovator should be open to what comes, ready to dramatically change whatever needs to be changed.

### 2.4 Integrating lean design and agile design into the 7D process

There are those who have asked how Design Thinking, Lean Design, and Agile Design differ from one another and it has been suggested that all these approaches can be integrated into one process. 7D can include all three. In the 7D model, the Plow phase uses PENZA ‘NO BOX’ methodology, Seed to Bud is Design Thinking phase overlapping in Flower and Fruit the ‘Lean Startup’ and overlap with Fruit and Harvest with Agile methodologies. The integration of these 4 methods makes more sense in the overall of progress.

### 3 Design Cases

Below, I present several design cases from the past seven years, which illustrate how the 7D process has been used since I first published my book on the subject (Tarazi, 2013):

#### 3.1 Tarazi Studio

The first design case comes from Tarazi Studio Ltd, which the author has owned and managed since 1990. Tarazi Studio has been a laboratory for the development of the 7D process, with clients such as Israel-based business organizations such as Electra, Tadiran, and Extal; international players such as Qualcomm, Intel, and Microsoft; and startup companies such as Magink, ZenithSolar, and Born Free. 7D provides a straightforward way to lay down the process phases from the first proposal sent to the clients to the follow-up on the process itself. The metaphor has resonated throughout the Tarazi Studio’s portfolio of projects aimed at sustainability and responsibility to the future. For example, Magink sells a digital-ink billboard designed to replace paper-based billboards that uses less energy than LED billboards. The ZenithSolar project was a 7-year effort to create a hybrid solar dish that
could very efficiently create both thermal energy and electricity in the same device (Tarazi, 2008). The BornFree project yielded the first line of BPA-free bottles for infants in the US and Canada.

3.2 d-Vision

The first application of 7D outside the Tarazi Studio was d-Vision, a unique design and innovation program supported by Keter Group, a global company in the fields of garden furniture, storage, toolboxes, and large children’s toys. This Israel-based company created a 2-year program for 20 design and engineering graduates every year, who would study and foster innovation across the entire company. The d-Vision innovation center ran from 2005 to 2012 and was an ultra-creative idea factory for Keter. The 7D platform enabled the group to have a larger scope then the company R&D and marketing departments could afford to realize and led to the development of a plethora of new products and services for the company. The value of sustainability was incorporated into the company’s development processes and the company portfolio began to shift. Examples include the development of a garden compost bin that is not only very affordable, but also shortens the time needed to create home compost by 85%; a program in which customers can return old Keter products to stores and be refunded based on the weight of the returned products; and garden shelters made of recycled plastic.

3.3 The Y7 program

The Y7 program of the PENZA Perception Lab was an initiative that aimed to foster “yielding entrepreneurship” and apply 7D internationally. A few dozen leaders from Israel, the Palestinian Authority, Germany, England, Brazil, and Denmark were trained at the Y7 center in Jaffa, Israel. Y7 entrepreneurship programs have also been started at other innovation centers in Israel. In China, there were a few attempts to promote Y7 in various programs involving innovation in education. In Germany, there were a few rounds of Y7 workshops in Cologne and Berlin. Later, the program was developed into the Y357 program (Penza 2020), which includes more codes and models for entrepreneurship leadership, to serve a wider population of participants and clients. The Y5 code of The Five Intelligences was adopted as a system for evaluating pupils in Tel Aviv schools. Some working groups that started in Y7 program have gone on to create successful hi-tech startup companies. Importantly, many Y7 graduates have gone on to become key leaders in the entrepreneurship ecosystem in Israel.

3.4 Israeli Ministry of Education

The introduction of 7D into the educational system started with an initiative in the Israel Ministry of Education that was led by the Ministry Chief Inspector for Design and Art, Einat Kritzman. She was familiar with the 7D from her own Master’s degree studies and sought to promote both design programs and interdisciplinary team education. The first program involving 7D started in 2017; that program was created to combine high-school students’ final projects in different courses, such as Computer Science, Mechanical Engineering, Electronic Design, and Art. It was followed by a 2-year workshop that included 55 teachers from 10 high schools, which along the years serve various populations and around 3000 individual pupils. The recent plan is to grow the program to 150 schools in 2022.

3.5 Government of Colombia – The National Innovation Program

A national innovation program, ‘Innovamos 2021’, was run in Colombia from 2010 to 2018. The project was initiated by the then-new government led by Juan Manuel Santos (later awarded the 2016...
Nobel Peace Prize). Penza Perception Lab, under the license of PF, created a national innovation program whose methodology was based on the 7D model. As a co-founder, in Colombia, I found fertile ground in which to seed this theory in hundreds of startups and companies. Over the course of a 5-year pilot program, we managed and ran workshops to support the germination and growth of hundreds of startup groups from Bogota, Medellin, Cali, and other cities. Some of these startups became successful companies. In recognition of these efforts, in 2021, the Wall Street Journal named Medellin the “Innovative City of the Year” (Wall Street Journal 2021).

3.6 EIT UMI

The European Institute for Innovation & Technology (EIT) has been supporting 7D and Y357 workshops on urban mobility (EIT 2020) through a program called Urban Mobility Innovation (UMI). That program had included a website (UMI 2020) and a podcast (Amstrong & Tarazi 2020). The project partners are the Municipality of Munich, Germany; the Municipality of Lublin, Poland; Zone Cluster of Budapest, Hungary; and the UnternehmerTUM Innovation Center in Germany. All of the partners met for the first time at Munich in February 2020, just as the first news started to arrive about the outbreak of COVID-19 in China. The original plan was to hold four live workshops in each country—Germany, Hungary, Poland, and Israel—over the course of 2020. In March, we all agreed that we needed to shift to online workshops. During the pandemic, the challenges of urban mobility changed dramatically from overcrowded cities to the need to create safe public transportation. The examples presented in the four online workshops varied from a bus that was specifically designed for the elderly population, with separated and isolated seats, to a system to connect elderly people with volunteers who could drive them to important meetings and help health-care workers commute to their regular jobs. As part of this program, the 7D massive online open course (MOOC) on edX was translated into English and made available to program participants.

3.7 Technion – Israel Institute of Technology (IIT), and other institutions of higher education

I have been teaching 7D at the Technion since 2016, as part of courses in the Industrial Design program that I lead and as part of courses in the Department of Humanities and Art that are open to all undergraduate students. More than 250 students have taken these courses. The Israel Council for Higher Education (CHE) has initiated a program to foster entrepreneurship and innovation centers in campuses. The Technion IIT has been fostering innovation through courses for almost 40 years, started with the legendary course initiated by Prof. Dan Schectman (a Nobel Prize winner in Chemistry). The Technion alumni became the backbone of the transformation of Israel into the “startup nation” (Senor & Singer 2009). In 2018, the Technion program won a CHE tender and the t-Hub, the Technion’s innovation and entrepreneurship center, was established. As the founder and chair of the t-Hub, I have used 7D as a platform for the innovation processes, in academic courses and entrepreneurship programs with more than 1500 students. Over the years, other 7D workshops have been held at the CERN IDEA² innovation center, Tel Aviv University, Haifa University, and other institutions.

4 Conclusions

A separate paper would be needed to fully cover the research, reflections, findings, and outcomes from each of the fields presented above. Yet, an overview of more than a decade of working with 7D in a variety of contexts (i.e., business, government, research, and education) provides a unique perspective. The conclusions from this overview are presented below.
What worked?

4.1 The 7D metaphor is engaging
The first engagement of people with the 7D concept flows easily in a variety of environments. The metaphor easily finds a home in people’s minds and creates a harmonic ‘knowing’ that this is nature’s way. This was quite evident in the workshops held in Colombia and China. Images like the dispersal of many seeds at the beginning of the innovation process are quite engaging. There have been almost no incidents of people or organizations refusing to learn the model. Most of those who were used to the orthodox Design Thinking approach have agreed that that approach lacked certain elements and that 7D is a more comprehensive approach. The 7D approach has been warmly received by high schools and one school even decided to use the 7D metaphor as the basis for its program for the next 10 years (Hornstein, 2021). The metaphor has been effective across a variety of cultural contexts. 7D covers more of the innovation process than classic Design Thinking and enables people from more disciplines and fields to take part and engage in the process. The missing components are a 7D book in English and other languages, an online course in English, and other scale-up tools, which need to be created.

4.2 The presentation of 7D through online platforms is a viable model
There is a variety of knowledge scope and depth needed for the participants and teams to start to work. In general, most individuals grasp the concept intuitively and quickly; they can start to work on one of the phases after an hour of explanation with examples. Before the COVID-19 pandemic, the 7D MOOC on edX was used successfully by both teachers and students. The EIT project added an English version, with subtitles for the movies and English text for the tasks. For 2020–2021, the Entrepreneurship and Design Thinking course at the Technion Department of Humanities and Arts was transformed into a hybrid course that included a combination of longer videos (around 45–60 min each), video conference meetings, and team presentations. KAN, a national Israeli radio station, created a Hebrew podcast about 7D (Markovitz, 2019). Those interview sessions helped to spread the word about 7D.

4.3 With 7D, creativity grows
The 7D process does not hold only one method for ideation. It aims to create new and unending ideation processes. It creates a mindfulness process of ideation with the person in solitude. We have also conducted experiments with 7D ideation in pairs, using something called the Chavruta method. This method was inspired by the tradition of studying sacred Jewish texts in pairs. The Chavruta method can replace larger brainstorming group session (7–10 participants). We found that working in pairs could double or even triple the engagement rate and number of ideas. We also suggest establishing a crowd-source system within organizations, to bring out new ideas. Promoting freedom in the Sprout ideation process is part of the understanding that there are differences between cultures, disciplines, ages, and levels in the hierarchy of an organization that call for flexibility in the way that ideation is carried out. There is also an acknowledgement that some ideas will arise only after the process, a day, or a week later, maybe in the shower…

4.4 7D boosts inspiration and motivation
Even during the COVID-19 pandemic lockdown (2020–2021), the 7D process boosted motivation among university students, as compared to traditional processes. At the Technion, we conducted four 7D workshops (4–5 days each), and three full-semester courses in which we observed high levels of
student engagement. The students worked in teams to develop viable and innovative solutions and there were zero dropouts. The students’ presentations were full of humor and the feedback from the students reflected high levels of motivation and satisfaction with the process.

4.5 7D provides a more holistic perspective

The 7D process provides a more holistic perspective since it calls for more than the individual user to be in the center of the creative process. It includes the ethical, social, and environmental considerations that come up in every process. The participants are asked to use the ‘Five Intelligences’ model to analyze the needs of the situation at hand. In many 7D projects, we have observed high levels of social considerations, such as projects that consider solutions for less-developed countries, elderly populations, and minorities.

4.6 7D actualization in organizations is a reality

7D has slowly, but surely become the accepted method for design and innovation processes in educational systems. The 7D process has been incorporated into all Design studies in Israeli high schools, using the 7D MOOC on edX and a detailed documentation process to help teachers to go into the details of each step of the process. Both the Technion and Haifa University use 7D in their entrepreneurship programs. In 2021, Israeli governmental organizations, including the Prime Minister’s Office, used the same 7D MOOC. Workshops for municipalities, teachers’ organizations, and hi-tech companies have been held since 7D was first established. The adoption of 7D by those organizations has given it a much wider scope and broader relevance.

4.7 7D has the potential to scale and grow

The application of 7D has a potential to scale and grow beyond what has been done so far. 7D speaks the language of the new awareness among younger generations, who view the abandonment of sustainable and socially conscious development as a crime. The 7D process, with its metaphor and language, can reach those young people who are more willing to balance their innovation and progress with the wider scope of the multiple crises they will face in the future. The growth of 7D might trigger that awareness and help the younger generations to feel more involvement with sustainable innovation.

What did not work?

4.8 Limitations of the metaphor

Many of the situations in a new project or start-up development are utterly new and undefined. Every process has its own unique and unprecedented elements. The agricultural metaphor of 7D, with all of its advantages, does have its limits. Not all that happens in building a new product or service can be likened to the growth of a fruit tree. At some points in the process, individuals must feel free to let go of the metaphor and think freely about the situation at that moment. This calls for an acute awareness of what is needed at any moment in time, for the team and in light of the tasks ahead.

4.9 Linear order vs. chaotic order

The natural metaphor is that of linear organic growth, which makes a lot of sense for those who are developing new and innovative projects for the first time. Yet, the linear route of natural growth does not match the reality of project development, in which there is often a need to go back from the middle of the Flower phase to the Plow phase or to create a quick Sprout phase. Although this point is
mentioned in any workshop or full 7D process, in practice, the metaphor sometimes seems to limit those loops. The other important feature of 7D is the use of the natural strategy of having a plethora of Seeds and Buds on hand and the ability to go back and start down a different path or toward a different niche, if necessary.

4.10 In short workshops, little attention is paid to the fruit and harvest phases

The nature of workshops that last 4–6 days or a semester course comprised of 14 two-hour meetings does not allow for full attention to be paid to the Fruit and Harvest phases. One dilemma faced by instructors is that of whether it is a waste of time to even teach those phases at the beginning of the process. Although it might seem unnecessary to mention those phases in a short workshop, projecting for these two phases is important. Participants tend to lose energy when they get over the Flower project final presentation. The main excitement of an innovative breakthrough concept is there. Yet the difference between yielding and non-yielding innovation lies in the ability put to focus on the Fruit and Harvest vision, and not just on a promising presentation. Teaching the full 7D, it is important to convey these visions of Fruit – a viable, tested, and ready-for-market product/service – and Harvest – a serious attempt to launch the product/service to the actual reality (market, users, clients etc.). It is crucial to plant this distinction in participants’ minds, even if it is not very relevant to the specific workshop in which they are participating.

4.11 Organizations tend to return to existing patterns

Every organization has its own patterns of processes based on various reasons, which are planted in many areas. Some call these patterns the DNA of a company/organization. We have found that in young organizations that include people with little experience, there are few pre-existing patterns and 7D can be easily adopted, with an agile, very flexible, and open way of navigating the new territory of creating a product/service. The experience with larger, older organizations has been that although 7D is very inspiring and fruitful for them, they are not very quick to adopt the 7D approach. They prefer to move on to the next management consultants and learn another method, instead of using and perfecting 7D by creating effective, innovative leaps in their lines of products or services.

4.12 Wider scopes are difficult for for-profit organizations to grasp

The world economy has not digested the full-scale implications of the climate crisis, the social transformations, and the wider scope of any innovation path. Slowly, new regulations and laws have started to emerge, but it has been quite difficult and challenging to convey the holistic view of 7D to businesses focused on year-end profits. Case studies and stories about failures due to people ignoring those issues have encouraged some openness to the 7D concept. Over the last 10 years, we have witnessed a transition in sentiment and attitude in the business world toward the assimilation of a wider scope of considerations in companies’ innovative processes, products, and services.

4.13 The danger of making 7D part of innovation theater

Many companies and organizations start to adopt “innovation strategies” and even recruit “innovation managers” to their leadership. 7D provides a coherent and comprehensive language for this process and yet the tendency in some organizations is to direct efforts toward quick public-relations accomplishments and stop there. Innovation theater (Blank, 2019) is a danger that can sometimes takes years and a lot of resources to find and heal. The challenge faced by 7D has been the tendency for the methodology to remain with the creative team within an organization and rarely move and integrate into the stream of the serious Harvest of products and services that generates results and
impacts the organization’s short- and long-term results. For example, in one large project, 7D was used successfully to foster 36 teams that, over a period of 4 months, reached an advanced phase with a good business model, prototype, and proof of concept test and validation. However, the organization then refused to advance the project. Instead, based on innovation theater, it chose to launch a larger program, in a plan that quickly ended in failure.

4.14 The 7D might stay frozen, as happened to Design Thinking
7D is a step forward with few aspects concerning innovation methodology, yet it might end up with the same fate and stop to evolve.

5. Summery
7D is an attempt to further develop the Design Thinking process and integrate it with Lean and Agile methods. It involves adding open diamonds at the beginning and the end of the Double Diamond frame, to form a Triple Diamond model. The use of a natural agricultural metaphor helps to engage people with the inner frequency of each of the different phases, making them tangible and resonant. Due to the global pandemic, there was a shift to teaching 7D through a MOOC that includes videos and online conference engagements, which has opened new possibilities for disseminating 7D process to additional populations around the world.

The use of a natural metaphor helps us to be inspired by nature in the innovation process, moving us from human-centered design to more holistic, nature-centered design. There is a new generation of young creative people that is looking for up-to-date processes that reflect the current situation and values. While it may sound naïve, there is a belief and hope that this approach may create a transformation among those who embrace it and adopt its deeper meanings.

Acknowledgments
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References
Changing roles in interdisciplinary Research-through-Design

Berit Godfroij\textsuperscript{a}, Sebastiaan Peek\textsuperscript{b}, Remko van der Lugt\textsuperscript{c} and Rens Brankaert\textsuperscript{c}

\textsuperscript{a} Research Group Co-design, Research Centre of Learning and Innovation, Utrecht University of Applied Sciences, The Netherlands, berit.godfroij@hu.nl, remko.vanderlugt@hu.nl
\textsuperscript{b} Tranzo, School of Social and Behavioral Sciences, Tilburg University, The Netherlands, sebastiaan.peek@gmail.com
\textsuperscript{c} Fontys School for Allied Health Professions, Eindhoven & Industrial Design, Eindhoven University of Technology, The Netherlands, r.g.a.brankaert@tue.nl

Abstract. Increasingly, Design Thinking has influence beyond the confines of traditional design disciplines and expands its’ role in connecting domains and integrating resources. This study focuses on the changing role of design researchers involved in interdisciplinary research projects, following a Research-through-Design (RtD) approach. The research context for this study is a project on designing and evaluating digital solutions in the context of dementia. Based on process research methods this study provides a holistic view on dynamics between actors from different domains and an understanding on the role of design researchers within the complexity of the larger system of an interdisciplinary RtD-collaboration. Findings on organizational-, process- and product level emphasize on three changing roles for design researchers in interdisciplinary RtD: 1) A mediator role, 2) a sensemaking role, and 3) a role in improving processes by applying research artefacts.

Keywords: Collaboration, Dementia, Interdisciplinary, Process, Research-through-Design.

1 Introduction

Design Thinking has a growing role in connecting disciplines (Cross, 2018) in design processes, and in coordinating the integration of resources and various perspectives (Prestes Joly, Teixeira, Patricio, et al., 2019). Design Thinking supports organizations to leverage existing business models and to create organizational futures (Liedtka & Kaplan, 2019, p.6). Connecting design with non-design disciplines and coordinating the integration of resources require an interdisciplinary approach (Peek, 2015; Stock & Burton, 2011) that integrates research and design activities. Design and research come forward in practical experiments and are shared in the activity of the design process (Roggema, 2017; Cross, 2001). Bringing research and design together in process and using the act of designing as a form of research is labeled ‘Research-through-Design’ (Stappers & Giaccardi, 2017; Zimmerman & Forlizzi, 2014).

Over the years there has been a spate of interest in Research-through-Design (RtD), and many academics have formulated their perspectives regarding it. They define RtD as a practice-based inquiry that generates transferrable knowledge (Durrant, Vines, Wallace, et al., 2017) in an interdisciplinary process (Sleeswijk Visser, 2018) with the intended goal to instigate societal change (Brankaert & den Ouden, 2017; Roggema, 2017; Zimmerman, Stolterman, and Forlizzi, 2010; Zimmerman, Forlizzi, and Evenson, 2007; Binder & Redström, 2006; Swann, 2002). In RtD, artefacts are iteratively designed as a creative way to investigate a potential future (Roggema, 2017; Zimmerman et al., 2010), focused on generating knowledge rather than focusing on improving design
practice (Roggema, 2017). Godin and Zahedi (2014, p.11) suggest that “the artefact is not the goal of RtD; knowledge and understanding is” and that it is not predictable and “riddled with issues that come with its heavy reliance on design.” Table 1 summarizes how RtD is understood and provides an overview of RtD-features on organizational, process, and product level.

<table>
<thead>
<tr>
<th>RtD-COMPONENTS</th>
<th>RtD-FEATURES ON 1) ORGANIZATIONAL-, 2) PROCESS-, AND 3) PRODUCT-LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interdisciplinary process to instigate societal change (Brankaert &amp; Den Ouden, 2017; Roggema, 2017; Zimmerman, Stolterman, and Forlizzi, 2010; Zimmerman, Forlizzi, and Evenson, 2007; Binder &amp; Redström, 2006; Swann, 2002).</td>
<td>Organization: Interdisciplinary structured It’s a process Project ‘product’ is societal change</td>
</tr>
<tr>
<td>Merging research and design processes, design practice and academic experiments and reflection (Stappers &amp; Giaccardi, 2017).</td>
<td>Organizational structure includes actors from academic research institutes and from practice Process of merging research and design Products: designs, experiments, and reflection</td>
</tr>
<tr>
<td>A process of iteratively designing artefacts as a creative way of investigating a potential future (Roggema, 2017; Zimmerman et al., 2010).</td>
<td>n/a Iterative process Products: Artefacts to investigate potential future</td>
</tr>
<tr>
<td>Practice-based knowledge generation (Durrant, Vines, Wallace, et al., 2017; Roggema, 2017). The artefact is not the goal (Godin &amp; Zahedi, 2014).</td>
<td>n/a Process is practice-based Product is communicable knowledge and understanding</td>
</tr>
<tr>
<td>The preferred state is that of what ‘will be’, by learning from interaction of the current state by means of dialogue with artefacts (Godin &amp; Zahedi, 2014).</td>
<td>n/a Process of dialogue with artefact(s) Focus on what ‘will be’ &amp; learning from interaction</td>
</tr>
<tr>
<td>Very similar, in appearance, to a regular design project. Goals are different, the influence of research is present at most steps, and documentation of the process is a key concern (Godin &amp; Zahedi, 2014).</td>
<td>n/a Process is very similar to a design process; influence of research inquiry is present at most steps Product: Process documentation</td>
</tr>
<tr>
<td>RtD is not able to provide predictability. It is riddled with issues that come with its heavy reliance on design (Godin &amp; Zahedi, 2014).</td>
<td>n/a The process is riddled with issues that come with the heavy reliance on design. The product/ outcome is unpredictable</td>
</tr>
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</table>

The empirical context of this study is an applied RtD-dementia research project, called ‘Dynamics of Dementia in Design’ (DDD). This project surfaced the RtD-features of Table 1. The DDD-project aimed at improving and maintaining social health and social participation of independent-living people with dementia and their caregivers by designing and evaluating digital solutions. Here the interdisciplinary dynamics between researchers involved from creative, health, and social behavioral domains are investigated further. This paper takes a holistic view on interdisciplinary RtD-dynamics. It considers various aspects of a RtD-project like the actors involved, the process of merging research and design practice, and project aims regarding development of (non)tangible products, e.g., design artefacts and knowledge. It structures the analysis on organizational- (structure of actors), process- (interdisciplinary ways of working), and product-level (project aim: artefacts and/or knowledge) to understand changing roles of design researchers within the complexity of the larger system of an interdisciplinary RtD-collaboration.
1.1 Interdisciplinary collaboration in Research-through-Design

Interdisciplinary collaboration within the field of design has increased in the last decades (Christensen & Ball, 2019; Cooper, 2019). Such collaborations deal with cross-cultural challenges and opportunities, reflected in practices, behaviors, design tools and materials, as well as in social organization, power relations and politics in organizations (Halskov & Christensen, 2018). However, despite the growing interest, dynamics in interdisciplinary RtD-collaboration are still not completely understood.

There is limited research on how project actors collaborate in RtD-teams (Sleeswijk Visser, 2018). Some scholars directly or indirectly investigated aspects in interdisciplinary RtD-collaboration. For example, Enninga et al. (2013) showed how designers learned from different perspectives and novel ways of working, and Meroni (2008) and Haug (2015) mentioned a shift in design towards actors that increasingly work together to define projects. Higgins and Klein (2011) emphasized the importance of jointly determining scope, which is according to them subject of ongoing discussion and negotiations regarding sense-making and scope refinement. Sleeswijk Visser (2018) stated that confusion in the knowledge generation process of RtD-projects easily occurs about roles, processes, and results. She suggested to provide structure, by explicitly assigning roles and using tools to integrate perspectives. However, she focused on various design roles rather than on dynamics between actors from different disciplines.

Unfortunately, earlier research does not sufficiently address change regarding various aspects of interdisciplinary dynamics in RtD-collaboration. Although Roggema (2017) linked theory on dynamics with design phases – in which he distinguishes between a pre-design, a design, and a post-design phase in which according to him respectively “coupling”, “interweaving” and “decoupling” dynamics (Bashalle & Halskov, 2012) occur – empirical evidence is lacking on such dynamics related to how design and non-design researchers work together and align roles within various phases on organizational-, process-, and product-level. This study provides a holistic view on dynamics - in all phases of a RtD-project – between actors from different research disciplines (design and social sciences) to provide understanding on changing roles for design researchers in interdisciplinary RtD.

We build on previous work (Godfroij & Van der Lugt, 2020) in which we investigated collaboration in design practice on the intersection of creative industries and healthcare. In this earlier work, we identified “disruptions of flow” (Yanow & Tsoukas, 2009) as experienced in collaboration between design researchers and professionals from an academic hospital. We investigated how disruptions in project flow (discrepancies between the designer’s expectations and experiences) changed the role for the design researcher on three levels: On organizational-level, on process-level, and on product-level. In this current research, we build on these previous findings through empirical research, and observe change in a design research project regarding 1) the organizational structure, 2) processual change in (creative) ways of working and collaborating, and 3) on product-level change in project aim and focus. The research question that we address is: How and why do changing roles for design researchers unfold on organizational-, process-, and product-level in an interdisciplinary Research-through-Design project?

1.2 Changing roles in Research-through-Design

Godfroij and van der Lugt (2020) identified change in a designer’s role on three levels: First, on organizational level they found that a senior designer had many more meetings with professionals from various departments and on various levels within the health organization than he was used to in previous projects, which played an important role in structuring the project. Secondly, on process level they found that a designer was searching for leads to build on existing knowledge together with professionals within the health organization. Thirdly, on product level they found that a designer
shifted in focus from the creation of prototypes and artefacts towards improving strategic processes. Here, we extend and further explore the theoretical foundations of the three levels of change by grounding them in theory (see Table 2). The theoretical foundations (Concepts) in Table 2 are based on a single case from practice (Godfroij & van der Lugt, 2020). Aim of the current study is to provide empirical evidence on how and why the structure of actors, ways of working, and project aim and focus evolve over time in an interdisciplinary RtD-research project. By offering theoretical concepts in the introduction, the structure of this paper follows a “conceptualized composition” (Berends & Deken, 2019).
Table 2. Theoretical foundations regarding changing roles for designers (adapted from Godfroij & van der Lugt, 2020)

<table>
<thead>
<tr>
<th>ORGANIZATIONAL LEVEL</th>
<th>CONCEPTS</th>
<th>GROUNDING IN THEORY</th>
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<tbody>
<tr>
<td>Structure of actors</td>
<td>Meetings with various professionals from different departments and on various levels of organization.</td>
<td>How and why does a structure of project actors change over time? Include supervisors and a steering committee in which all disciplines are represented (Andriessen et al., 2019). Traditional roles, tasks, and components are reshaped (Meroni, 2008) and divided among disciplines, and take into account various modes of inquiry and languages (Roggema, 2017). Include boundary crossers, to support integration between disciplines (Akkerman &amp; Bakker, 2011). Organize by assigning roles and components of roles to project actors (Sleeswijk Visser, 2018), and align plans across all levels of an organization (Van der Lugt &amp; Van der Laan, 2017). Exploring and building relationships are important dynamics in design innovation journeys, in which actors couple and decouple (Godfroij, 2021).</td>
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<table>
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<tr>
<th>PROCESS LEVEL</th>
<th>CONCEPTS</th>
<th>GROUNDING IN THEORY</th>
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<tbody>
<tr>
<td>Ways of working</td>
<td>Building on existing knowledge (e.g., customer segmentations) together with other professionals (e.g., an econometrician).</td>
<td>How do project actors align perspectives, attitudes, methods, and approach, and how do they share knowledge, tools and skills with other actors involved? It is worthwhile to spend time together with the other discipline(s) to create understanding on multiple perspectives with regards to time, structure, control, position, and grounding approaches (Zielhuis et al., 2020). Jointly define, determine, and redefine project definitions and scope, in an ongoing discussion and negotiation between project actors (Haug, 2015; Higgins &amp; Klein, 2011; Meroni, 2008), rather than following a project proposal as approved at the start. Exploring an interdisciplinary field of design research and practice is about learning (Enninga et al., 2013). When coupled, actors involved manoeuvre as a team and interweave by focussing on encouraging and balancing diverse views (Godfroij, 2021).</td>
</tr>
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<table>
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<tr>
<th>PRODUCT LEVEL</th>
<th>CONCEPTS</th>
<th>GROUNDING IN THEORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim and focus</td>
<td>From creation towards research to improve strategic processes.</td>
<td>How does the project aim and focus evolve over time? Exchange of competences (knowledge, skills, tools, mindset), rather than a shift in the emphasis of the type of output that is under investigation (Vargo, Koskela-Huotari, &amp; Vink, 2020, p.14). Shared sense-making between multiple actors ((Vargo, Koskela-Huotari, &amp; Vink, 2020). A more strategic role, rather than a role as creator (designer) or as traditional researcher (Calabretta, Gemser, and Karpen, 2017). Building on existing products and knowledge of the own and the other organisation/discipline, rather than creating new (tangible/knowledge) products that stand alone (Godfroij &amp; Van der Lucht, 2020). Co-creating value that is determined by the beneficiary: Added value for all actors involved (Vargo, Koskela-Huotari, &amp; Vink, 2020). Co-creating value with a system perspective: Contribution to complex societal issues in a bigger system than the project ((Vargo, Koskela-Huotari, &amp; Vink, 2020). Joining and/or aligning with ongoing projects and activities in organizations (Godfroij &amp; Van der Lugt, 2020). Design innovation journeys that are very or extremely complex and networked, focus on ongoing discussion, negotiations of sense-making, and exchange of knowledge and skills, rather than moving around products or exchanging objects (Godfroij, 2021).</td>
</tr>
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</table>
2 Research Methods

This study investigates change regarding structure of actors (organization-level), ways of working (process-level), and project aim (product-level). We conducted a longitudinal field study of three years (2018 – 2021) and analyzed the data by means of a process research approach focusing on temporality, activity, and flow (Langley & Tsoukas, 2017; Langley, Smallman, Tsoukas, and Van de Ven, 2013; Langley, 2007). Below, we further explain the case and the actors involved (2.1), the data gathering (2.2) and data analysis (2.3).

2.1 The case and the actors involved

The project Dynamics of Dementia in Design (DDD) run between January 2018 and January 2021 as part of a Dutch research program ‘Create Health’ that contributes to societal problems with regards to healthy and active aging. Tables 3-5 show the RtD-nature of the DDD-project by explaining how RtD-features – as discussed in the introduction – manifested in the interdisciplinary research project regarding the structure of actors (organizational-level), ways of working (process-level), and project aim and focus (product-level).

Structure of actors. In the DDD-project scientists from different disciplines were involved to investigate and design digital applications to increase the social participation of people with dementia. As Table 3 indicates, the project structure connects design with another discipline and combines research and practice. There were researchers on various organizational levels: PhD-level, post-doc, assistant professor, and full professor. The interdisciplinary consortium (see Figure 1) consisted of researchers from the School of Social and Behavioral Sciences of Tilburg University, the Department of Industrial Design of University of Technology Eindhoven, Mental Health Institute Eindhoven, and a local innovation network for active and healthy aging (Slimmer Leven 2020). The innovation network was involved particularly to recruit participants and to disseminate results, and has connections with healthcare institutions, technology companies, municipalities and so on.

Table 3. RtD-features on organizational-level and the nature of the DDD-project: Structure of actors

<table>
<thead>
<tr>
<th>ORGANIZATIONAL LEVEL</th>
<th>RTD-FEATURES</th>
<th>NATURE OF DDD-PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project organization is interdisciplinary structured</td>
<td>Consortium with academic actors from design research (industrial design) and social sciences (longitudinal research), and practice partners from a mental health institute and a local innovation network.</td>
</tr>
<tr>
<td></td>
<td>Organizational structure includes actors from academic research institutes and from practice</td>
<td></td>
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A senior design researcher (assistant professor) and a post-doc behavioral sciences researcher jointly wrote the project proposal. The senior design researcher involved a junior design researcher on PhD-level, who together with the behavioral sciences researcher formed the inner circle of the project (see actor map in Figure 1). They conducted the research – and had weekly progress meetings together. The PhD-level design researcher had also weekly meetings with the senior design researcher – who acted as supervisor - to discuss the research and project. The actor map in Figure 1 shows that the senior design researcher is positioned next to the inner circle, as well as the three advisory senior researchers from Tilburg University. The behavioral researcher in the inner circle had a temporary position at Tilburg University (post-doc) and was supported by a full professor in behavioral research, who also functioned as the main applicant. The post-doc and full professor in social and behavioral science were able to discuss the research and project irregularly at the university. Two researchers
from the mental health institute (GGZE), also affiliated with Tilburg University, had an advisory role, and were engaged in the analysis and dissemination of results. Consortium meetings between all persons mentioned above took place every six weeks.

**Figure 1.** Actor map Dementia Dynamics in Design project on which the post-doc behavior researcher made notes during an interview. After the interview, the map was complemented with quotes, actors, and organizations. Various versions of the map were created in iterative rounds of analysis.

**Ways of working.** As Table 4 mentions, DDD is pre-eminently a project in which research and design were merging: Although the process initially consisted of four separated and sequential research activities (longitudinal field research, design and creation, field evaluation with prototypes, and adaptation and extension of a theoretical framework), the researchers organically searched for a process to benefit each other’s discipline. Gradually the process became more interdisciplinary and interwoven, in which researchers applied three design tools: A social mapping tool (Figure 2), a diary probe (Figure 3), and a hobby -and activity tool (Den Haan-Wintermans, Brankaert, & Lu, 2019) (Figure 4). Initially, idea was that insights from the longitudinal field study (qualitative data) formed input for the design process, or as the social behavioral researcher put “bluntly, the psychologist tells the designer what to make”, and that the participants who were involved longitudinally would not be influenced by design interventions. However, over numerous discussions the researchers found an approach integrating design research tools, where longitudinal field research and design research (co-design sessions) took place in parallel and informed each other.
### Table 4. RtD-features on process-level and the nature of the DDD-project: Ways of working

<table>
<thead>
<tr>
<th>RTD-FEATURES</th>
<th>NATURE OF DDD-PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RtD is a process: of merging research and design of iterations that is practice-based of dialogue with artefact(s) is riddled with issues that come with the heavy reliance on design that is very similar to a design process, in which the influence of the research inquiry is present at most steps</td>
<td>Combining research and design by applying design tools (e.g., a social mapping tool) in traditional field research and interweaving co-design sessions with an interview study. Practice-based fieldwork and field evaluation with a high-fidelity prototype at people’s homes. Various iterations took place with professionals to design the prototype. Researchers interacted with participants in dialogue with tools created for and applied in the field research: A social mapping tool, a diary probe, and a hobby tool. The project lead (social behavioral researcher) realized over time that the research heavily relied on design and that “design methods are so good for getting ahead”. Issues occurred because the social behavioral researcher initially resisted design methods to apply as part of the longitudinal field research, not wanted to influence his participants, this is considered “not done”. Appearance of the process: Discover by means of interviews and co-design sessions at peoples’ homes; (re)define that the problem is also about going somewhere by means of transport; development of three design tools and a high-fidelity prototype; delivering knowledge and understanding based on field evaluation with the high-fidelity prototype at people’s homes.</td>
</tr>
</tbody>
</table>

DDD followed a field study approach in which most of the research takes place in practice. The researchers conducting interviews and co-design sessions at people’s homes. This was used in combination with input from professionals to design a digital intervention (Kolasinska, Thoolen, Peek, et al., 2021). Figure 5 shows a high-fidelity prototype of this intervention that was evaluated in real life (Brankaert & den Ouden, 2017). The evaluation of the prototype was conducted via a mixed-methods approach that combined qualitative research and the monitoring of usage data. Both in the longitudinal field research as well as in the co-design sessions, researchers interacted with participants at home.

![Figure 2](image1.png)

**Figure 2.** Left: Social mapping tool using who, what and how frequent cards to understand social activities and their emotional intimacy in people living with dementia (from left to right: intimates, friends, acquaintances)

![Figure 3](image2.png)

**Figure 3.** Right: Diary study to understand a participant’s personal situation in-the-wild. The diary consists of a dice with colored sides, colored playing cards with personalized questions, and three different mediums such as a notebook, voice recorder and a camera to express experiences.
Figure 4. Left: Hobby- and activity tool to understand a people’s personal interest in activities that do not fit in their lives or cannot be done anymore, they still like to do, and they would like to do (adapted from Den Haan-Wintermans, Brankaert, & Lu, 2019)

Figure 5. Right: Participant is interacting with the high-fidelity prototype in real-life setting

DDD-researchers spent much time on discussing issues regarding e.g., design methods to apply in traditional field research, influencing participants, and publishing design research. The social behavioral researcher realized over time that the research heavily relied on design and that “design methods are so good for getting ahead”. The process was very similar to a regular design process: First, discovering the field by means of interviews and co-design sessions at people’s homes. Secondly (re)defining the problem and focus, which the social behavioral researcher explained by “I knew that the scope of research needed to be well formulated after we wrote the project proposal, and I wanted to formulate it sharper, however the design researcher made clear that we cannot know in advance what to do exactly and that we just had to start.” Thirdly, three design tools were developed and applied, and fourthly the project delivered knowledge and understanding based on field evaluation with the high-fidelity prototype.

Project aim and focus. DDD aimed for research on the design of e-health products and services that support elderly people with dementia who experience substantial cognitive changes. It focused on expanding the body of knowledge on design research in a real-life dementia context. Aim of the study was to generate fundamental knowledge about long-term user involvement of people with dementia by working on two knowledge building blocks: The primary knowledge building block is a longitudinal framework applied in the design process, and the secondary knowledge building block is about how to design and employ design interventions that address the needs of people living with dementia. Table 5 shows that the DDD-project created and evaluated digital solutions for social activity, not in the first place to deliver a predefined product, but as part of a process on generating knowledge on research in real-life dementia context. Project outcomes aim to contribute to societal change regarding social health and social participation of independent-living people with dementia and reducing the risk of loneliness. The generated knowledge was communicated through events for academic and design professionals, via the design tools (maps and prototype) and in academic publications.

Table 5. RtD-features on product-level and the nature of the DDD-project: Project aim and focus

<table>
<thead>
<tr>
<th>RTD-FEATURES</th>
<th>NATURE OF DDD-PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>The product/ project outcome is unpredictable</td>
<td>Aim is not to deliver a predefined eHealth product but generating communicable knowledge and understanding on social health and social participation of independent-living people with dementia, to contribute to societal change by improving social health and reducing the risk of loneliness.</td>
</tr>
<tr>
<td>Project outcomes contribute to societal change</td>
<td></td>
</tr>
<tr>
<td>Projects aim to generate communicable</td>
<td></td>
</tr>
</tbody>
</table>
knowledge and understanding

Tangibles are research artefacts rather than project outcomes
Focus lies on what ‘will be’ & on learning experience
Insights on evaluation of designs, crafts, experiments, and reflection.
Process documentation is a key concern

Creation of four tangible design tools and a high-fidelity prototype as research artefacts, which were applied in interviews, co-design sessions, and a field evaluation to “actively build a future” and focus on what will be. Insights are based on experimenting with design tools in longitudinal field research, and on field evaluation with the high-fidelity prototype. Besides, there were many cross-over and reflection sessions with six researchers of the consortium.

Documented process, which evolved from the collaboration process, was presented in a final project event.

Besides, the DDD-researchers created the three design tools and the high-fidelity prototype and applied them in practice to actively building a future. As the project proposal (2018) stated: “By designing research objects and placing them into a real-world context, design can change the current state, creating new situation”. DDD-researchers experimented with the research artefacts and reflected on the process with the six researchers in the consortium as a learning experience. Insights are based on experiments and evaluation of the design tools and the prototype, “also about what we cannot know yet”, and on reflection.

2.2 Data gathering

The data gathering is based on principles of organizational ethnography (Ybema, Yanow, Wels et al. 2009). The methods applied are participant observation, document analysis, and interviews. The participant observation concerned a qualitative longitudinal (three years) collection of naturally occurring data (things observed and heard) within a single case (DDD). It includes observations of six participants (see Table 6) with different backgrounds in creative, health and social domains: Social and behavioral science with experience in mental health and industrial design (Human Computer Interaction) in context of health.

Table 6. Main observed participants

<table>
<thead>
<tr>
<th>RESEARCHER</th>
<th>BACKGROUND</th>
<th>ROLE IN DDD-PROJECT</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Social and behavioral sciences</td>
<td>Main applicant and responsible, advisory role from research</td>
<td>Full professor</td>
</tr>
<tr>
<td>2</td>
<td>Social and behavior science</td>
<td>Project manager, senior researcher</td>
<td>Post-doc</td>
</tr>
<tr>
<td>3</td>
<td>Industrial design</td>
<td>Project manager, senior researcher</td>
<td>Assistant professor</td>
</tr>
<tr>
<td>4</td>
<td>Industrial design</td>
<td>Junior researcher</td>
<td>PhD-student</td>
</tr>
<tr>
<td>5</td>
<td>Social and behavioral sciences</td>
<td>Advisory role from practice (mental health institute)</td>
<td>Full professor</td>
</tr>
<tr>
<td>6</td>
<td>Social and behavioral sciences</td>
<td>Advisory role from practice (mental health institute)</td>
<td>Post-doc</td>
</tr>
</tbody>
</table>

* From project proposal, 2018: “the researchers from [name University] and [name University] are jointly responsible for project management, coordination and communication to partners (professors from both universities will provide guidance where necessary).”

Two researchers (second and fourth authors of this paper) participated in the DDD-project and gathered data concerning the process and collaboration in two reflection sessions (focus groups in September and October 2019) in which all six researchers listed in Table 6 were involved. In the two reflection sessions, they reflected on collaboration dynamics. Basballe and Halskov (2012) describe collaboration dynamics as a process of coupling, interweaving, and decoupling over the course of a project. They define “coupling” as a dynamic that unites interests from various disciplines that
establishes a common point of departure. They define “interweaving” as a dynamic wherein one activity or material informs various disciplines’ interests, and “decoupling” as a dynamic that modifies the focus, by turning one discipline’s interests into the salient focus of the process.

The two reflection sessions were audio-recorded and transcribed. In addition, two sets of documents were gathered: First, a form that the six researchers filled in as preparation material for the first reflection session, and secondly presentation slides presented at the second reflection meeting. By seeking for evolving processes from within and highlighting how meanings and experiences evolve over time and in context, the two DDD-researchers (authors) conducted ‘prehensive research’ (Langley & Tsoukas, 2017, p.9) on how contingencies shape the paths taken, or not taken.

A team of other researchers (amongst them the first and third author of this paper) observed the DDD-project from outside. They observed from distance how the flow of events over time represents shifts in configurations of actions on organizational-, process-, and product-level, and hence conducted ‘configurational research’ (Langley & Tsoukas, 2017, p.9). The configurational data-gathering consists of three interviews with the project manager (June 2019, February 2020, and December 2020), in-between-contact with participant 2, 3 and 4 via e-mail, telephone, and video-calls, and observations during conferences (Dutch Design Week 2018, 2019, 2020, 2021 & Dementia Lab Conference 2019), project events (November 2020, and January 2021), and network events: Two days of presentations and workshops organized by the research program Create Health, which is financed by The Netherlands Organization for Health Research and Development (ZonMW), and two knowledge sharing events organized by the overarching research Create and Health Innovation WAYS of Working Analysis (CHIWAWA). The interviews were audio-recorded and transcribed, and the observations and things heard in between were documented in fieldnotes. Besides, the configurational data gathering includes project documents like the DDD-project proposal (2018), three progress reports (2019, 2020, 2021), and internal documents, e.g., persona-development information, pictures, and tangible maps and tools that DDD-researchers applied in their field research.

2.3 Data analysis

The transcriptions of interviews and reflection sessions, fieldnotes, reflection forms, project proposal and progress reports were coded in Atlas.ti analysis software regarding change in 1) structure of actors, 2) ways of working, and 3) project aim and focus. These three codes are similar with the concepts as introduced in Table 2. The codes were used as “theoretical signposts” (Berends & Deken, 2019, p.7) in the creation of a narrative and in connecting findings to theory. Visual project documents like presentation slides, tangible maps, tools, and pictures were used to get a better understanding of the project and its content, and how that evolved over time. To provide understanding in and explain change regarding the theoretical signposts this study made use of deeper levels of narrative, in which the analysis moves from the surface to structures that cannot be observed (Pentland, 1999). By means of four levels of narrative – which are text-level, story-level, fabula-level, and mechanisms-level – it takes the reader from raw data and raw participants stories (text-level) towards the story and theories of the researchers (mechanism-level), which is an interpretation of the data. Table 7 provides examples of the four levels of narrative.
Table 7. From surface to deeper levels of narrative (adapted from Pentland, 1999)

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DEFINITION</th>
<th>EXAMPLES FROM DDD-PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>Particular telling (Chronological dataset, including quotes)</td>
<td>“The senior design researcher immediately wanted to apply design activities in my field research. I am educated not to influence the field research, and I did not want participants of my field study to be influenced by design activities, in the sense that in the journals I publish that is ‘not done’. So, I resisted for a long time.”</td>
</tr>
<tr>
<td>Story</td>
<td>Narrative version from a specific point of view (Authors’ version)</td>
<td>The senior behavioral researchers have resisted for a long time against design methods employed in the longitudinal field research since the method conflicted with their traditional research approach.</td>
</tr>
<tr>
<td>Fabula</td>
<td>Generic description of a particular set of events and their relationships (How &amp; why things happened)</td>
<td>To allow designing together with participants and to evaluate design work in practice, the design researchers proposed openness and methodological flexibility to respond to emerging perspectives. The behavioral researchers came from a more traditional field of research and sought to maintain methodological rigor. After lengthy discussions, the social behavioral design researcher accepted an integrated approach to learn by experience how design contributes to traditional research.</td>
</tr>
<tr>
<td>Mechanisms</td>
<td>Underlying structures that enable or constrain in fabula (Overall general process)</td>
<td>The constraining factor to methodological flexibility explained by the social behavioral researcher was that the journals in which he publishes are “nicely multidisciplinary for psychological terms, but not that creative like let’s all start using design methods”. The enabling factor was learning by discovery, or as the social behavior researcher put: “We will see what it yields”. He wanted to learn from the other discipline (design), rather than sticking to tradition and publishing in referred journals.</td>
</tr>
</tbody>
</table>

To create the four levels of narrative, we first organized the data in chronological datasets that includes the raw data on text-level like quotes, text documents, and visual materials. This forms the participants stories in which we observed change over time, for instance “while shaping our original framework, we have created (graphical) longitudinal case descriptions [...]. In the DDD project we will do the same, but for people with dementia” shifted towards “we call it persona but, it is an impression of a persona. At this moment it is not a combination of several people, but it is one-on-one insights.” These chronological datasets provide understanding on e.g., changing terminology like the (graphical) longitudinal case descriptions (Figure 6) that evolved into personas (Figure 7), but also understanding on how this visually changed over time in the elaboration of materials. Secondly, on story-level we created a narrative that provides understanding in and tells the story of the DDD-project regarding change in structure of actors, ways of working, and project aim and focus from the point of view of the authors. As the example in Table 7 shows, the story stays close to the raw data but at the same time it compresses and summarizes it. The narrative of the project comprises almost 3500 words. It was used to identify change on organizational-, process-, and product-level, of which examples are given throughout the paper, and to select the focus on fabula-level.
For the identified change, we created on fabula-level generic descriptions that explain how and why particular sets of events happened. For instance, the attitude of the researchers changed over time with regards to applying design methods in the longitudinal field research, because the phase was used for discovery. Another example is that DDD-researchers changed their focus regarding technology and included means of transport rather than solely means of communication like computers and telephones that were stated in the project proposal, since the first interview with a participant made clear that “going somewhere, to someone, seemed also important for the social life of people living with dementia”.

Last step in analysis was that we, on mechanisms-level, searched for explanations of enabling and constraining factors for the fabula – as explicated by DDD-researchers – and connected them to the theoretical grounded concepts (Table 2) on organizational-, process-, and product-level. Based on these theoretical explanations for change in the structure of actors, ways of working, and project aim and focus of an interdisciplinary RtD-project (DDD), we propose changing roles for design researchers within this larger system of interdisciplinary collaboration in RtD.

### 3 Findings

The next three paragraphs present findings on fabula-level regarding change in the (organizational) structure of actors (3.1), ways of working (process) (3.2), and project aim and focus (product) of the DDD-project (3.3), and how and why roles for the design researchers within the interdisciplinary collaboration unfold over time. Paragraph 3.4 discusses on mechanisms-level enabling and constraining factors for the identified change.

#### 3.1 Changing structure of actors in DDD

The six researchers and practice partners were involved since the writing of the project proposal, except for the PhD-level design researcher who was involved some months later. The latter became responsible for much of the work involved in shaping and materializing interweaving by informing actors of both research domains (design and behavioral science). She described here role as being a mediator between the more experienced design researcher and behavioral researcher who jointly wrote the original project proposal (without her involvement). Both senior researchers agreed with her on this, noting that they “may have been shaped more by our respective disciplines”. In the project proposal, the idea was that a researcher from one discipline would participate for 20% in research activities of the other discipline. Along the way it turned out that this investment of time was not...
feasible for the senior researchers, but the PhD-level design researcher did attend several interviews of the senior behavioral researcher, and hence participated in research activities of the other discipline. The senior behavioral researcher put “I cannot spend the same amount of time by attending design sessions, but I did contribute to the creation of a probe that the PhD-level design researcher used in a diary study. We discussed the questions together and tailored them for each participant” (see probe for diary study in Figure 3).

On two types of occasions, decoupling occurred in the project. First, when the project was delayed too much because of coupling and interweaving dynamics and difficulty in recruiting participants. When this occurred, it was decided to temporarily decouple. For instance, there were times when design researchers and behavioral researchers collected and analyzed data together, and times when this was done separate. Second, decoupling occurred in periods where researchers were occupied with other projects or tasks. This could occasionally lead to tensions that were subsequently discussed in meetings. However, the researchers also noted that this occurred in many other projects they had been involved in, interdisciplinary or not. Finally, researchers expected that decoupling would take place once they were expected to publish articles or proceedings in their respective journals or conferences. However, there was a shared desire to publish in interdisciplinary outlets that would require less or no decoupling and all researchers who participated in the project felt they had a strong will to couple the interests of behavioral and design research. As one respondent put it: “I feel like we are pushing each other to do that. So, not letting go to achieve that”.

3.2 Changing ways of working in DDD

The project proposal suggested that most of the longitudinal field study would be carried out by the social behavioral researcher (post-doc) and would consist of interviews and observations without design research tools. It also proposed that most of the co-design study would be carried out by the senior design researcher (assistant professor), and that the design researcher closely works together in interviews and focus groups with researchers from the mental health institute, in which they would apply a participatory design approach. However, when the project started, the design researcher suggested design methods that could be employed as part of the longitudinal field research with the same participants. The purpose of this approach was to design together with the participants, and to uncover insights via designerly approaches in practice. To allow this the design researcher proposed openness and methodological flexibility to respond to emerging perspectives. On the contrary, the behavioral researchers came from a more traditional field of research and sought to "maintain the methodological rigor needed to address our research questions".

Over time, the researchers resolved in the creation of an activity and a material that informed both disciplines: A social mapping tool (see Figure 2) and an approach integrating design research tools. In this approach, the PhD-level design researcher and senior behavioral researcher (post-doc) were exchanging insights from the longitudinal field research to keep each other in the loop and up to date of each other’s perspective. This implicated that the interviews conducted by the post-doc behavioral researcher alternated with co-design sessions at people’s homes conducted by the PhD-level design researcher. Based on the interview and the co-design sessions, the post-doc behavioral researcher and PhD-level design researcher together developed (one-on-one) personas (see Figure 7). In iterative rounds of analysis and information sharing, insights became increasingly sharp as the behavioral researcher put: “Also about what we cannot yet know, for example whether a lack of initiative is a problem for people with dementia or whether they may not want to take the initiative at all. So that's why those design methods are so good for getting ahead!".

When evaluating the ways of working, the behavioral researcher on one hand explicated that he would focus less on his own frame in the future, however he would have liked to embed findings more in
theory and to analyze more statistically as well rather than only capturing qualitative snapshots, for example: “We just take a picture of the tool and in the next session, we take another picture and then things are placed differently on the map, which feeds the next interview round. It is not statistically analyzed”. Besides, he had hoped for more involvement of creative industry and would suggest involving business from the start of the project: “Just because I wish the project continues”. The senior design researcher (assistant professor) on the other hand explicated that next time in an interdisciplinary project he would define and argue for the design research part stronger, since: “Now, it was too messy, since we left the design part very open and that caused a lot of discussion”. Besides, both design researchers (PhD-level and assistant professor) would suggest for a next time to make use of design tools or objects earlier in the project. According to them, involving business could be interesting but also work obstructive due to additional requirements such as limitations regarding costs and possibilities. But hesitating the PhD-level design researcher put: “When we come close to a final design, we encounter that although it has potential, we are not getting any further” with bringing the product to the next stage. However, by designerly ways of working the longitudinal field study captured insights over time that could not have been foreseen before, for instance by testing and validating assumptions with design tools. According to the researchers, due to these tools more honest answers of people living with dementia were given. Hence, the interweaving of designerly ways of working and traditional longitudinal field research was valuable for research actors of both domains in the sense that behavioral researchers try to understand how aspects evolve over time (as is) and design researchers try to improve situations (as could be). On many occasions, researchers from both disciplines were pleasantly surprised and inspired by the insights that were gathered by interweaving.

3.3 Changing project aim and focus of DDD

This RtD-project aimed to 1) further develop a theoretical framework, 2) to improve design methods, and 3) to create longitudinal personas for the benefits of future research and design. First, the elaboration of the theoretical framework had become less relevant during the project because the earlier model is about elderly people using technology longitudinally (Peek et al., 2019), while the field research shifted in focus towards social activities of people with dementia, possibly with the use of technology. Based on growing insight and limitations in recruiting participants, the project focus shifted from reducing loneliness amongst people living with dementia by means of technology use, towards enhancing social activities (possibly with technology) amongst people living with dementia who live together with a partner. The design research perspective allowed for the adaption of this perspective in the project, based on first user engagement sessions. Secondly DDD partly succeeded in improving design methods. There are reasons for this, as the behavioral researcher put: “It’s just really hard to do longitudinal co-design, and we have not yet reached saturation in the data. So, it needs to be more fine-grained.” The design researchers wanted to further develop the co-design methods by combining it with longitudinal research, however it was really hard to understand whether the sessions they conducted were co-design or not “because we haven’t made anything in the sessions with participants”, and “it is very difficult to conduct co-design longitudinally, especially when those involved are cognitively impaired. Because that asks for observing how a process evolves over time rather than chopping up design in sub-activities”. Thirdly, the aim was to produce relevant content for the creative industry, which DDD-researchers did through an event at the end of the project. However, in the project proposal it was stated that the project would have continuously disseminated insights – by means of academic publications and longitudinal persona descriptions – to allow industry to create designs based on that. Because of delay in project timeline by the lengthy discussions and interweaving activities, a shift in focus centered
towards the development of research artefacts (the three design tools) rather than focusing on the development of the longitudinal personas. The three tools tailored to the project guided the diversity in disciplines in a way that it supported collective sensemaking and finding a common ground. The tools were used to share ideas, to exchange information, and to develop a common point of departure on each stage in a longitudinal research project. Besides – also partly caused by restrictions during the first Covid lockdown in The Netherlands – a high-fidelity prototype was developed accelerated (Godfroij, van Beest, & van Gessel, 2020). The prototype was tested at homes of people living with dementia and their families for at least six weeks.

Last, disseminating academic publications was difficult during the project because publishing in interdisciplinary outlets would require less or no decoupling, which asked for much effort of all researchers involved. It was not immediately clear where to publish, since the outlets that the researchers of both disciplines were used to did not easily accept the ways of working and language applied in the other research domains, e.g., longitudinal field research influenced by design activities. But now, two publications have been submitted – and accepted – based on both the longitudinal field work, as well as the design evaluation in the field. All researchers were involved in both publications.

3.4 Mechanisms-level: Enabling and constraining factors of narrative

The fabula-level of narrative empirically shows that the organizational structure of the DDD-project changed particularly from a preferred joint project management by a social behavioral researcher (post-doc) and a senior design researcher (assistant professor) towards project management conducted by the post-doc who together with a PhD-level design researcher conducted the field research. Enabling and constraining factors regarding change in the structure of actors include on the one hand difficulties because of differences in function: PhD-level, post-doc, and assistant professor. A PhD- or post-doc level researcher frequently has one or two projects to focus on, while an assistant professor has an advisory role in many projects. On the other hand, senior researchers have been shaped more by their distinct discipline than junior researchers who therefore can act as mediator to cross boundaries.

On process level this study particularly shows that the lengthy discussions meant that applying design tools and tangible objects became postponed compared to design researchers’ expectations. Ambiguity and uncertainty are part of a design process, as the senior design researcher put “since outcomes of a design process cannot be predicted”. This may be a constraining factor if researchers want to know exactly what they are going to do and why, like the social behavioral researcher explicated “because I want to do it the best way”. The lively and lengthy discussions in which the researchers sought for shared understanding and language took a lot of time but also generated many occasions in which researchers from both disciplines were pleasantly surprised and inspired. Enabling factors in this were interest in the other discipline and being open to learn from each other, to “see what it yields”.

On product-level empirical findings show four aspects of change: 1) shift in focus towards enhancing social activities (possibly with technology) amongst people living with dementia who live together with a partner, 2) the focus on improving co-design methods became part of a larger process, 3) focus centered towards the development of research artefacts, and 4) unexpected search for ways to publish in interdisciplinary outlets. The journals in which the social behavioral researcher publishes are “nicely multidisciplinary for psychological terms, but not that creative like let’s all start using design methods”, which was a constraining factor to methodological flexibility. However, enabling factor was that researchers from both domains were “pushing each other” to couple the interests of behavioral and design research and to publish in interdisciplinary journals. The focus on social activities and co-design methods became part of larger processes due to complexity, in which a RdD-
approach enabled to focus on research artefacts rather than on the creation of longitudinal personas as knowledge products.

4 Discussion

The theoretical concepts in the introduction (see Table 2) suggest that in design practice designers increasingly have meetings with various actors from different departments and on various levels; build on existing knowledge together with other professionals; and improve processes besides creating prototypes and products (Godfroij & van der Lugt, 2020). Findings of this current study show in similar way that in a design research project designers engage in interdisciplinary collaborations with researchers from another domain: Social behavioral sciences. They explore relationships that take more often place in complex networks beyond organizations, in which actors couple, interweave, and decouple (Godfroij, 2021). We presume that the change that researchers with different backgrounds are experiencing, plausibly represents the change that is ongoing in the field of design thinking and has a growing role in connecting disciplines (Cross, 2018) and in coordinating the integration of resources (Prestes Joly, et al., 2019).

In this case study, a PhD-level design researcher was appointed, who acted as mediator: To anchor the research in both disciplines (social behavioral science and design), to make the contributions of the two research domains equal, and to provide both research domains with input from the other domain. This junior design researcher operated as boundary spanner and crossed boundaries to support the integration between disciplines (Akkerman & Bakker, 2011) and embodied much of the work involved in shaping and materializing interweaving (Babsalle & Halskov, 2012). The mediator played a role in aligning plans across various organizational levels (van der Lugt & van der Laan, 2017) in academic research: PhD-level, post-doc level, and (assistant) professor level. As the junior researcher (PhD-level) was less shaped by a single discipline, she was very suitable to function for this role in the project. Godfroij and van der Lugt (2020) found something similar in a design practice case: A junior design researcher (graduating student industrial design) operated as boundary spanner between design practice (senior designer) and various departments and levels of a healthcare organization (an academic hospital). These findings on changing structure of actors in RtD suggest on organizational-level a mediator role for a junior design researcher – who is less shaped by a discipline than more experienced researchers are. This mediator role contributes to the roles in RtD as proposed by Sleeswijk Visser (2018), who distinguishes roles for theory researcher, design researcher, designer, problem owner, and project lead, but did not specifically pay attention to connecting different research domains in RtD.

Findings on process-level provide understanding in issues regarding collaboration dynamics that come with the heavy reliance of RtD on design, which is not able to provide predictability (Godin & Zahedi, 2014). This contributes to existing theory by providing insight that aligning ways of working in interdisciplinary RtD takes a lot of time meaning that applying design tools and tangible objects become postponed compared to expectations of design researchers. This reinforces the theoretical concept on changing ways of working (see Table 2) for which Godfroij and van der Lugt (2020) found that design interventions and the creation of prototypes to test with participants (health patients) was postponed in a design practice case. Rather than creating tangible tools and changing objects, that case in design practice focused on talking to many professionals to search for shared sensemaking and knowledge to build on. The lively and lengthy discussions in which DDD-researchers sought for shared understanding and language took a lot of time but also generated many occasions in which researchers from both disciplines were pleasantly surprised and inspired. This emphasizes that it is worthwhile to spend time together with the other discipline to create understanding on multiple perspectives (Zielhuis et al., 2020). In ongoing discussion and negotiation, the DDD-researchers
redefine definitions and scope (Haug, 2015; Higgins & Klein, 2011; Meroni, 2008), and the design researchers – over time – convinced the behavioral science researcher of the added value of applying design methods in longitudinal field research. The behavioral science researcher experienced that an interdisciplinary field of design research and practice is about learning and discovery (Enninga et al., 2013).

Findings on product-level reinforces the theoretical concept (see Table 2) regarding changing project aim and focus in interdisciplinary RtD. It identified a shift in focus from delivering (research) products – like the graphical longitudinal case descriptions and domain specific journal papers – towards the creation of tangible design tools and visual maps to apply in the longitudinal field research to generate knowledge relevant for interdisciplinary outlets. Godfroij and van der Lugt (2020) found something similar in a design practice case, in which the designers planned to create personas as a product of field research with users (health patients). But along the way they elaborated existing personas based on knowledge and information that was available in the health organization. They used the elaborated personas as research artefacts. Hence, both the design practice case study (Godfroij & van der Lugt, 2020) and the design research case (DDD-project) study identified a similar shift regarding the use of design tools. Both changed in focus from tangible or visual creations as project outcomes, towards the creation of design tools that contribute to improving processes, exchanging competences, shared sense-making, and understanding complex societal issues (Vargo et al., 2020).

5 Conclusions

This study provides understanding on changing dynamics in interdisciplinary RtD, and specifically on the role for design researchers within the complex structure of actors that merge research and design activities across domains. Findings on organizational-, process- and product level emphasize on three changing roles for design researchers in interdisciplinary RtD: 1) A mediator role for junior design researchers to cross borders, 2) a sensemaking role by discussing and elaborating on knowledge and tools of both disciplines, and 3) a role in contributing to processes of a larger system together with actors from other domains by applying interwoven activities and materials in fieldwork to contribute to complex societal issues. Overall, on organizational-level findings show difficulties in structuring the project management anchored in different disciplines. The data suggest a mediator role for junior design researchers in interdisciplinary RtD to cross boundaries between disciplines. On process-level, findings show that applying design tools and tangible objects became postponed compared to design researchers’ expectations. RtD-researchers sought for shared understanding and language and generated many occasions that inspired the other discipline. The data suggest a changing role for design researchers towards lengthy discussing and sensemaking, aiming to interweave activities and materials from both disciplines to apply in fieldwork. On product-level, findings show that researchers from both domains were “pushing each other” to couple interests and changed their focus from creating tangible or visual products as project outcomes, towards creating tangible research artefacts. The data suggest a changing role that centers towards contributing to and understanding processes of complex societal issues – like social participation of people with dementia – together with research partners from other domains.

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References


Innovative teaching methodology: A learning process on how to translate DT knowledge and tools to non-designers

Ana Thudichum Vasconcelos, Carla Paoliello and Ana Lia Santos.
FBAUL - Lisbon University Fine Arts Faculty, anavasconcelos1@belasartes.ulisboa.pt, carlapaoliello@gmail.com, a.lia@belasartes.ulisboa.pt

Abstract. This article presents an educational strategy to spread Design Thinking (DT) among non-designers (N-D). We challenged the students from Product Design degree, at Fine Arts Faculty (Lisbon University), to create DT Workshops (WS) for N-D. This procedure was carried out over two semesters of the last two consecutive years. Repeating the process allowed us to obtain a set of representative WS and stabilize the following pedagogical practice: (1) Creation and development, (2) Testing and feedback incorporation, (3) Communication, and (4) Academic evaluation. The students were placed at the center of the problem, questioning the objectives of their intervention, and shaping the process communication tools. They switched from “creative way(s) of knowing, thinking and acting” as said by Alain Findeli to “creative ways of sharing”. The findings are based on identifying the likelihood for dissemination of DT to N-D, going far beyond the transfer of know-how.

Keywords: Design Methodology, Design Thinking, Pedagogical Practices, Social Engagement, Workshops.

1 Introduction.

The academic project analyzed here is based on our experience as educators supported by DT potential in searching innovating solutions to solve problems. DT tools enable people to promote transformation processes, leading to positive changes in their lives and, in addition, the improvement of society and community quality of life.

Thus, the research question was how could DT be disseminated among non-designers (N-D) and, what are the design skills that could be interesting to propagate? Next, we wanted to identify how DT tools can enable N-D and how can they scale transformation through it? The design curricular exercise was a creation of DT workshops to an N-D, with the title Design Workshop for Non-Designers (DWS4ND). The main objective was to create DT awareness, and positively and actively share its ideals, principles, and tools with the community. The students became real actors in the process. We invited them to discuss DT practice and bring personal insight into the process of transmitting knowledge in DT.

2 What interest might DT have for N-D?

Design is a human activity. It is an active process of learning and critical problem-solving. Brown (2010) stated, "design is a powerful tool” capable of providing working methodologies to intervene in many different areas.

In our perspective, the design promotes skills capable of generating social transformations (Vasconcelos, 2017 a and b). Through the recovery of our design capabilities, we can instigate democratic actions that, collectively, aim to a better, more just, and egalitarian world (Porto, 2019).

Design through DT methodologies can trigger innovative processes where critical thinking combines
with critical making. DT is an approach capable of generating innovation in today's world (Vasconcelos & Porto, 2019; Cardoso, 2012) due to the great potential that DT has to solve complex problems, which can be a formative contribution to both designers and N-D.

Jones (1992) was the first to use the term Design Thinking with an outside-in perspective. The original version of his book dates from 1970. He stated that DT contributes to generating information and insights (p. 45). He also reflected on the advantages of adopting collaborative systems. Later, Buchanan (1992), in ‘Wicked Problems in Design Thinking’ focuses on the human being. He used multidisciplinary, collaboration, and the perception of thoughts and processes to build paths that lead to innovative and creative solutions. As stated by Brown (2010), there is a set of principles that different people can apply to a wide variety of problems.

We find DT skills in the development of creativity (Vasconcelos, 2014), empathy (Paoliello, 2018), entrepreneurship (Paoliello et al., 2013), collaboration, and communication. It means that DT develops soft skills through innovative processes. These features are useful for all, increasing self-satisfaction and life quality.

3 How can the DT - knowledge, and tools - be transmitted to N-D?

We recognize two distinct strands in the way of transmitting the DT knowledge. There is one promoted by non-designers and another from inside the design culture. In the first group, we observed two trends. One related to the teaching of DT in the scope of management and business courses. For example, there are the Stanford Design Thinking Research Program Management; the Executive Education, MIT, Mastering Design Thinking; and the Business School and Aalto University Executive Education that promotes “skills to bring new value-driven creative solutions into your company”.

From the design point of view, Emily Pilloton’s ‘Project H’ stands out as described by Rawsthorn (2013), “It was intended to nurture skills that could help them (the students) with problem-solving, communication, leadership, and innovation in the hope that their experience of studying design and the design process would give them practical and intellectual tools to draw on for the rest of their lives.”

There is also the work carried out in the context of the educational activity promoted by the Smithsonian, Cooper-Hewitt, National Design Museum, with the seal of the designer and director of the museum, Bill Moggridge. And the children’s workshops developed by Bruno Munari (2004), documented in his book ‘The tactile workshops’.

Another perspective we found in ‘Bright Minds, Beautiful Ideas’ (Schwartz, 2003), which documented how design can go beyond problem-solving in an inspiring experimentalist and creative proposal.

Our vision of DT fits into a humanist perspective. We propose to raise awareness and disseminate DT - in the same sense of fostering and disseminating knowledge about design (Bonsiepe, 2011; Papanek, 1992; Norman, 2000) - through the creation and communication of several WS for N-D. Our solution emerges as a way to create a dynamic knowledge transmission platform based on intellectual curiosity and unconventional attitudes towards the presentation and resolution of problems through DT. In short, a rich field for experimentation.

In our approach, design students have an active role as creators of these innovative pedagogical processes. They become facilitators of the DT methodologies, and more than that, they become active agents of fertilization. This learning process is also positive for the students because DWS4ND is a living and critical laboratory in the classroom. When implemented (even if only implemented in a restricted circle) it hints as to the bridge between the academy and the community, as well as a link.
between designers and N-D. We adopted the Education by Design model by Oliveira (2017) and Fontoura (2002). Chasing a contribution in expanding the existing competencies of the designer’s students and N-D to create thinking focused on innovation and collaborative work.

4 Plan and methods

This project began in the 2019/2020 school year. The teaching experience was then repeated in the following years of 2020/2021. The educational project was framed within the scope of the subject of Project IV, a curricular unit in the 5th semester of Equipment Design Degree, from the Fine Arts Faculty of Lisbon University.

Our first perception of this academic activity’s unusual success, because of its positive impact on students, motivated us to look for local institutions to install the proposal. The local institutions were the Center for Modern Art of the Calouste Gulbenkian Foundation, the National Museum of Natural History and Science, the MAAT - Museum of Art, Architecture and Technology, and the IPDJ - Portuguese Institute of Sport and Youth. They have all welcomed the proposal and showed interest in integrating the WS in their cultural programming and activities, unfortunately, this was put on stand-by due to the restrictions of the pandemic.

The method of execution of the WS creation exercise presented to the students are divided into 4 phases: (1) Creation and development, (2) Testing and Feedback incorporation, (3) Communication, and (4) Academic evaluation of the WS. We repeated the same process, with different students, each first semester of the 2 years and selected a set of WS that become our representative models. To help students better understand what was expected to be delivered at each stage, we named deliverables of the first 3 phases similar to software development, because they correspond to the same kind of process development: phase (1) delivers an Alfa version / not functional version of the WS; phase (2) a Beta version / ready for testing and incorporation of feedback functional version of the WS; phase (3) a Release candidate (RC) / the best Alfa version to be presented, but not yet launched, to the public WS version. Phase (4) corresponds to the Academic evaluation and delivers the seriation of the WS proposals, by the following criteria: overall quality, fulfillment of the proposed objectives, coherence and control of the design, applicability, and potential for replication. The evaluation, not only the final one, but all that accompanied the different stages of the process, also delivered data for the investigation.

4.1 Phases breakdown

(1) Creation process and development. The questions for this part of our study were: how could we motivate our students to deepen the design culture, broaden their references, and debate knowledge in the design process? And also, how to pass its tools to an N-D public? The answers establish the basis for WS creation. This process includes several steps, first, we promote an open debate about the student ideas and concerns about design to situate them in the problem, and then we provide a list of the 100 relevant designers from the 20 and 21 centuries. From that list, each student chose a designer to make an in-depth study to identify his/her philosophy of work, i.e., Design input in a multilevel perspective, and they presented it to the class, so every student gets to know all the chosen designers (about 40).

Afterward, the students form groups of three, compare the 3 chosen designers and, with the help of the Uffe Elbaek model, choose the one with whom they most identify and that they consider appropriate to serve as a base referent for the WS development. This phase completes the presentation of each group concept for the WS. This approach required them to deepen their design process knowledge and methods since each group had to set the WS goals through a participatory process and
answer four questions about their WS proposal: what, why, to whom, and when; in continuation, they map their concept through a divergent and convergent thinking approach. They are also invited to build User Profiles to define the target participants and Value Proposition Canvas to streamline the WS practical aspects: the materials used, the WS duration, the cost inherent to the activity, and evaluate the space where the WS would happen. As referred above, the deliverable is an alpha version of the WS - an understandable but not yet functional version.

(2) Internal and external testing and feedback incorporation. The questions for this second part of our study were: How can we map the WS process? does it make sense? does it achieve our goals? how can we improve the process? did we choose the correct methods, means, and tools? The answers establish the WS process. Testing and feedback incorporation streamlining it until it's functional. After creating WS in the classroom, the testing phase followed. The importance of testing relates to the feasibility of the WS proposal and the measurement of its adequacy to N-D. We encourage the students to use online Surveys, Feasibility Testing Scenarios, Storyboarding, House of Quality (HOQ), and Service Blueprints to prepare, document, and evaluate the WS testing. The first series of assessments happened in the classroom context where creation and testing coexist. The same students that created the WS were the ones that tested it. Then, other internal tests were carried out, now between pairs of student groups. The pairs exchanged experiences with each other, allowing the improvement of their proposals. This phase allowed the selection of the most relevant WS activities. The more feedback data they got, the more they easily identify pain points to solve and better understood the WS potential. We recognize that it would be important to have external testing, with the stakeholders from the institutions involved, however, the circumstances postponed this phase, our solution was to carry out these external test sessions with the students’ acquaintances and relatives: 12 groups of students tested at least 2 or 3 times with groups of 10 /15 people, a total around 500 people per semester. The deliverables were functional WS Beta version, not yet complete, but fully operational and, more important, tested with a reasonable number of target people.

(3) Communication. Our initial idea was that students could be the ones to implement the DWS4ND in our partner institutions. They would be responsible for launching their WS, in a real situation with the partner institutions’ audiences. As such was not possible, we ask students to prepare a final communication (a Presentation Deck) in the classroom exactly as they would do for one of these institutions. It’s not the same but gave the students time and space to check and reassess all stages of the WS development; and, as preparing the final communication, the Beta version of the WS was again adapted and refined until became de RC version. This phase deliverable is similar to what in software development is called RC (release candidate). It is the best beta version, which is fully functional and ready to be published, but is not the final version, because it was not released to the public.

(4) Academic Evaluation. The WS dynamic is not about transposing the design formal educational structure to a non-formal one. It is rather to create a set of activities that allow N-D to experience the DT strengths. Namely, those associated with soft skills, creativity, and innovative processes. In this way, the continuing investigation intends to deepen the way DT could interact with N-D. How could it intensify collaborative work? And how could we investigate more relationships "through design"? Our great challenge lies in the exploration of a DT’s new pedagogical processes. One that relies on innovative teaching processes. At the end of the process, each semester, we observe the existence of strong quality, variety, and diversity of WS proposals. The WS creation process allowed the idea of appropriation which was important to each student's growth. That translates into several original proposals and build potential in terms of the impact on N-D.
Phase 4 evaluation results in a synthesis of the other phases assessments, as the overall result, incorporate the reference research, de concept idealization, the development and feedback from testing with an N-D audience, and streamlining for communication. The deliverables of this phase are a) our assessment of the process express in conferences and papers, b) the work of the students presented below, and c) the N-D feedback. We trust in the potential of WS because this exercise has been developed for 2 semesters, produce 26 WS proposals, involving around 1000 people, and the majority of stakeholders showed positive reactions throughout the process. Those positive reactions are patent in the WS results because the success of the DWS4ND is mesurable by the ability of the N-D to complete the task successfully. That proves DT transmission. In the showcase of the students’ work is visible that people with no previous skills or inclination can, through DT, perform tasks that in other situations they thought to be difficult or even beyond their capabilities. We can also consider, with due reservation, that the final semester grades can also be linked to the success of this exercise in this curricular unit because in the last two years we assist in a 10% improvement on the average student grades. We also verify that the students are more engaged, it is visible in the quantity and quality of work done in class. But to prove cause-effect we need to put in place different assessment protocols and as we will continue to implement this study, we will invest further in the evaluation phase.

5 Results: The most representative WS showcase

We gather 8 of the most representative WS carried out by the students during the last years to showcase the DT concepts studied. The students made their interpretations, adaptations, re-textualizations, and propose new models of the DT process. Afterward, they researched, presented, and developed several design methods. The following examples illustrate the process and the result of the WS. Under the umbrella concept DWS4ND, everything in the WS was designed. Once each group of students set their scope of actions (design, in general, is a too large subject to be addressed in a WS) and lock their focus (design-related specific set of objectives to achieve) and goals (set of information or skills to embed in the WS to pass to N-D) then proceed to design the Process Tree and the Activity Flow. Then they evaluate the means, develop the methodology, and create tolls to be used by N-D. The user interface is carefully polished until de overall WS experience produces consistent results when tested with different subjects. We stress again the importance of the level of performance of the N-D involve in the WS testing, because achieving it is a very difficult part of the WS development, and students invested a lot of time and resources. After all, it is there that the fulfillment of objectives is effectively measured.

We selected 1 WS to illustrate in detail the overall process, and the other 7 WS are presented with a summary framework and visual contents that were developed by students for phase 3 Communication.

5.1 One WS that illustrates the overall process

One of the top 8 WS stands out from the others for having the development process clearly illustrated and a more systematic testing-incorporation feedback loop.

B.1 VISUAL 2020/21 WS by Bruno Vilar, Inês Leite, and Renata Cabaça is about the representation and visualization of abstract concepts, in this case, identity. Show the importance of designing visual language in cultural communication. Starting from designer Sergio Rodrigues, and the way he always pursued to incorporate the Brazilian identity into his objects, a system was developed that allows N-D to create a visual presentation of their own identity, and then take the process with them and apply it in everyday life situations (Figure 1 and Figure 2).
Figure 1. B.i visual WS by Bruno Vilar, Inês Leite, and Renata Cabaça (2020/21)
Figure 2. B.i visual WS by Bruno Vilar, Inês Leite, and Renata Cabaça (2020/21)
5.2 The other 7 most representative WS

The following 7 WS also had the best classification, i.e., obtain A (18-20 in 20) in overall quality, fulfillment of the proposed objectives, coherence, and control of the design, applicability, and potential for replication.

5.2.1 Technology for humans not robots 2020/21 WS by Elisabeth Durin, Mariana Rosa, and Miguel Teles, starts with Jonathan Ive input to draw a WS that would allow N-D to better understand the interface design that is present in objects and equipment and that allows humans to use them. The participative dynamics and tools of this WS motivated the discussion about intuitiveness and human/machine design empathy tools (Figure 3).

5.2.2 “Everythinker” is a word invented to combine “Everything” and “Thinker”, that Ângela Pinto, Sara Jesus, and Shihan Wang propose for the 2020/21 WS title. They departed from the work of Kenya Hara to explain the concepts of "void" and "white" in design and their role in creativity. The work was developed to the point of becoming a product, i.e., a set of cards that allow the process to be replicated autonomously by N-D (https://wangshihan1996.wixsite.com/everythinker and Figure 4).
5.2.3 Modular 2020/21 WS by Catarina Martins, Inês Silva, and Lara Beato it’s an approach to readability and reading workshop for N-D and it aimed to enable them to understand the basic rules of these two fundamental aspects of Typography. Using Jonathan Hoefler as a reference, they created a very open and free-of-fear process for experimental typeface composition (Figure 5).
5.2.4 *Photostorming 2020/21* WS by Ana Pedro, Diogo Mindouro, and Eduardo Rebelo had Naoto Fukasawa as a reference. They understood that observation and changing perspective were important in the development of the idea. Their WS invites N-D to behave like a designer, providing N-D with new ways of thinking by creative ways of looking at the world. They also promote the use of everyday objects and spaces in a different context (way) and encourage emerging narratives about those activities (Figure 6).
Figure 6. Photostorming WS by Ana Pedro, Diogo Mindouro, and Eduardo Rebelo (2020/21)

5.2.5 Ar-chi-tec-ture 2019/20 WS by Stijn Haegen and Marta Bat, first semester. They elected Peter Zumthor reference to challenge N-D to work with the tools common to architecture and spatial design, namely: line, plane, scale, color, texture, light, and perspective, to build conceptual habitats as a way to encourage new relationships with our surroundings: from the specific to a general situation, from the solved to the act of solving (Figure 7).
5.2.6 Object (id)entity 2019/20 WS by Maria Amélia Silva, Gustavo Calé, and Mariana Martins. The activity starts from Andrea Branzi’s dichotomous premise ‘object-culture’ and moves towards the elaboration of a cultural scenario, and after it explores the integration of an artifact in the projected context. The general objective is to reflect with N-D up-to-date design-related society subject through brainstorms, sketching, and theoretical discussions (Figure 8).
Figure 8. Object (id)entity WS by Maria Amélia Silva, Gustavo Calé, and Mariana Martins (2019/20)

5.2.7 Alternative realities 2019/20 WS by Inês Guimar, João Calado, and Xavier Guerra develops the Dunne & Raby’s reference concept of speculative. They aimed to introduce this concept to a larger and more varied audience. They propose that the WS should take place in a circular (safe) space where N-D can experiment free use the imagination by using one toolkit designed specifically to the WS: diagrams, future scan, brainstorm, and prototypes to help them draw alternative realities (Figure 9).
Discussion and conclusion

WS for N-D creation by the students involves a process that takes place at two distinct levels. On a first level, it is based on the input from a personal identification with the work philosophy of a reference in the design world. On a second level, the interpretation and appropriation of what DT enables and the definition of what a DWS4ND should be.

This means that the students had the task to find their voice and choose the message to pass and the posture to adopt with design, and design dissemination. Once they defined what WS should be, the reference designer became less important. From that moment, they felt free and autonomous to work on the concepts learned or new.
Throughout the workshop development process, they choose what is important to them, as they grow more aware of the importance to include others (the team, the N-D, the community) in the chain of decisions. They understood that design concepts and tools will be used by another’s in a context explicitly design-related. Their relationship with design became deeper and more personal. In the end, the majority of students show a sense of ownership of their ideas, and a willingness to make them heard. We think that they became more prepared to be designers and ambassadors of the design culture as they switched from “creative way(s) of knowing, thinking and acting” as said by Alain Findeli (2010, p.289) to “creative ways of sharing”.

Although we cannot (yet) implement the project in its entirety, we saw its positive impact in nearby social circles as well as in our classes. Our teaching pedagogy places students at the center of the didactic action. Their behavioral transformation was so tangible that gives us more will to continue the research. The feedback, although it was still informally quantified, is positive enough to make us believe that there is a real opportunity for cultural and social intervention through a program of DWS4ND implemented by students, as a form of cooperation between the academy and other structures of knowledge and cultural dissemination such as Museums and public institutes dedicated to promoting development. As we like to call it, is the first step to inoculate designers in levels where they are absent in this kind of institution, and transfer it to everyday public life, starting the design dissemination we so strongly defend. And the best part is doing it by creating the educational strategy to empower the next generations of designers to carry it on.

References


11 Visual representation in design
Design communicating space tech innovation

Janett Adler, Jea Hoo Na and Martyn Evans
Manchester School of Art, Manchester Metropolitan University; janett.adler@stu.mmu.ac.uk, J.Na@mmu.ac.uk, Martyn.Evans@mmu.ac.uk

Abstract. This paper explores the role of visual design in the high-tech sector in the UK. It presents a design thinking model suitable for communicating innovation values of UK based satellite and space tech organisations. It comprises findings from five case studies involving design-led brand development and creation. Research challenges were identified during the process of combining design with future technologies, including the development of an effective problem-solving approach that helps build business cases to enter new markets, enhancing communication with prospective funders, and establishing a professional level brand identity that is representative of innovative organisation culture. A new design thinking model was developed using a hybrid of case study and grounded theory methodologies through engagement with industry partners in the North West of England, UK. These together inform, generate and advocate solutions for enhanced collaboration between design and the space tech industry.

Keywords: brand creation, communication, design thinking, innovation, space technology

1 Introduction and literature review

The research explored how a bespoke design thinking model and subsequent design practice can effectively represent innovation culture in space technology organisations. Therefore, the aim of this research was to establish the effect that design can have on communicating innovation and technology, chiefly the impact design can create in the industry. Hence, the objective of the secondary research was outlined as a contextual review with literature search directed at the presented overlapping areas, see Figure 1. As an industry of the future with enormous potential for growth and a vast area for new inventions and exploration, has always been and still is an inspiration to all generations. With the Space Sector Deal of the UK Government’s Industrial Strategy, a policy intended to boost the UK economy, a ‘new space age’ has taken off (Satellite Applications Catapult, 2018) and productivity is increased where space collaborates across sectors (Space Growth Partnership, 2018). The five projects conducted for this research explore how visual design and creative techniques can contribute to growth and prosperity, fostering impact in the region, fuelling the imagination of prospective audiences, and communicating new ideas to a world that is constantly adapting and adjusting itself.

The relationship of design and innovation in space tech was the key driver of the contextual review that served as a platform for the work with project partners. How visual design can contribute to growth of the economy by communicating space tech innovation was the core question that helped examine the relationship of the emerging themes. Here are some of the insights the author found.
Design generates competitive advantage, it contributes to the success of new products and adds value to businesses (Hernandez et al., 2017, Verganti, 2009). Design helps to give meaning to a product and helps make sense of a task (Verganti, 2009). Design is one of the main drivers for innovation and productivity, it advances economies and proposes clusters (Hernandez et al., 2017). Design skills achieve long-term productivity and portray innovation (Design Council, 2017). Businesses are in need of new patterns in innovation with value creation, idea generation and implementation, motivated leadership and commitment (Parmar et al., 2014). For design this means: differentiating to advance markets; developing new products; creating business opportunities and managing change; improving brand value that is inclusive, growth that can be exponential, needs and desires that can be understood, and ensuring employees are satisfied and new markets established. Collaboration allows interaction and informal communication that are conducive to innovation. Design thinking is capable of evaluating organisations’ challenges (Borja de Mozota, 2006). Design helps businesses develop innovation opportunities, and to become more productive and profitable (Benton et al., 2018). With applied design thinking, businesses can grow (AHRC, 2013). Organisations are advancing by embedding design into their innovation processes (Bason, 2015). The hybrid between future tech and creative design serves as a pioneering instrument and concurrently as a consistent quality asset. Design can enhance productivity and communicate future technology to new users (Transformation North West Cohort, 2018). In a steady progression, design is increasingly linked to branding. It is capable of learning about new audiences and working strategically, breaking through to new markets (Verganti, 2009).

As the author created and developed brands for partners in the industry, it was crucial to build a base through researching the areas from background secondary resources about design, economy, innovation and technology respectively.

2 Methodology

The research methodology can be understood as exploratory in the context of this empirical research. It was a hybrid of scientific inquiry with the dynamic of creative input. Research in the field of visual design can be an analytical as well as a practical tool, bringing about critical thinking and mature design practice (Noble and Bestley, 2011). Two intertwining methodologies were used to produce holistic insights from contrasting evidence. Together, case study and grounded theory methodologies
foster exciting research that has had minimal attention up to now. From an interpretivist perspective (Salmons, 2016), involving the research aim from the start, data collected during case studies was analysed through coding concepts and categories, and recognising patterns (Chun et al., 2019), concluding in grounded theory. As an ambassador for all project partners, the researcher examines the data and explains it, creating a new hypothesis that is open to change (Pettigrew, 1997), while obtaining a perspective that encourages a flexible process (Mills et al., 2009). Grounded theory operates as a way of analysing all contexts, e.g., qualitative secondary research in the form of literature review, and primary research from case studies and therein focus group discussions (FGDs) that include workshops and in-depth discussions with industry partners. Through a design thinking process, case studies generated both low- and high-fidelity prototypes. Exploratory interviews with stakeholders in person and online together with feedback served as further primary research resources that attempted to relate back and link up to the secondary research at the beginning. The methodologies were concerned with the main aim that focussed on objectives, as seen in the research structure, see Figure 2.

Figure 2. Research structure – the relationship of research objectives (O1-4)), methodologies (MA and MB) and methods (M1-3).

The aim of this research was to answer how communicating the values of space tech organisations through a design thinking process can work towards creating a culture of innovation. Using the sequence diagram (Figure 2), the research aim could be broken down into objectives that could be fulfilled via methods to create new, thought-provoking knowledge. The core question was examined using case studies (MA) and grounded theory (MB) as this research’s applied methodologies. This included initial coding, the interrogation of all collected data, and the creation of concepts, concluding in a theory to methodically establish the hypothesis (MB). The data investigated was collected in focus group discussions (FGDs), interviews, feedback and prototypes (M1-3) through the five case studies with project partners (O3). It was generated through testing and failing (Silverman, 2017) and prototyping again in a constant loop (M3), using the design thinking model (O2). The benefits were
that through coding, data could be explained, and the interdependence of methodologies, methods and processes promoted practicable quality (Chun et al., 2019). However, when looking at data and producing theory (MB), a constraint implied that the research may lose some of its energy and become passive (Krippendorff, 2006). The researcher’s chosen combination of the two methodologies with a substantial amount of practical work as case studies (MA) helped create a unique dynamic interrogating grounded theory (MB).

As part of the contextual review (O1) the researcher was analysing background literature, working with organisations (O3) and interviewing its employees (M2), using an interpretivist research philosophy (MB) with a focus on innovation of satellite and space technologies, design and its contribution to innovation that were anchored in the Industrial Strategy of the UK Government.

The author undertook workshops as part of focus group discussions (FGDs; M1) in collaboration with colleagues as well as industry partners (O3) in order to establish a design framework (O4), through grounded theory (MB) that implemented primarily qualitative research and identified a matrix which served as a map as part of the design thinking model (O2).

When thinking about the research approach, its epistemology, theoretical perspective, methodologies and methods are exploited (Crotty, 1998). Primarily constructionist – through a tailored design thinking process brands were created or developed with lo-fi (low-fidelity) prototypes along the way that meant that the prototypes embodied knowledge. Figure 3 depicts the cross-fertilisation of the various methods used in this research, creating a landscape of both case studies and grounded theory methodologies, all in the relationship of theory and practice.

![Landscape of methodologies with methods used in context of research practice and theory.](image)

**Figure 3.** Landscape of methodologies with methods used in context of research practice and theory.

Though research may seem to be a idea that is remote from design practice, it can be a motivating force for makers. Intuition rather than creating meaning? Thinking, albeit not too structured, and analysing when creating visual prototypes, helped evaluate new insights. This is design research in its most applicable way: using a design process for design practice is the combination of making and thinking (Frayling, 1994).
3 Design thinking

The author gained advanced insight from literature sources and interviews that helped create a platform from which a bespoke design process could be derived, which is both practicable and can serve as a base for all future case studies. The author’s own experience as a design practitioner with a background in visual design, particularly in branding, has helped shape the design thinking model further, because “Branding has become such a well-known concept, that both in the public discourse and academia most people are well aware of the business dynamic of a good brand…” (Schroeder and Salzer-Mörling, 2006:145).

The literature search generated a couple of key sources that helped evaluate the author’s tailored model. With its ‘Double Diamond’, the UK Design Council established four stages – ‘discover’ ‘define’ ‘develop’ and ‘deliver’ – that summarise and support many of the designers’ processes. A creative approach can be demystified, utilising and iterating the stages throughout the thinking process (Design Council, 2019). The Hasso Plattner Institute of Design at Stanford has also been instrumental in individual and organisational understanding of ‘design thinking’ as a corresponding process. This goes through six stages: ‘empathise’, ‘define’, ‘ideate’, ‘prototype’, ‘test’, and ‘assess’. The design process is not essentially linear and can be enacted according to organisations’ or individuals’ requirements, enhancing their innovation methods. Design thinking can be applied to existing challenges at work, employing design tools, and respecting collaborative approaches and personal growth in the process. The design thinking process helps develop insights through re-evaluation of perspectives, it appropriates the creation of prototypes that are then tested in relevant conditions to assess their value, with repetition and refinement of the individual stages to generate new working practices, techniques and equipment (Stanford d.school, 2019). Different design agencies’ approaches, such as Fitch, Superunion, Pentagram, Interbrand, Landor and Wolff Olins, also matched up with the Design Council’s and Stanford’s design thinking processes.

The author interviewed a UX Designer and UX Researcher at a large social media company to gain further insight into the influence design thinking has on their work and the people they work with. Aside from the significance their adapted processes have for innovative thinking, the UX Designer also specifically identified the use of visual design to establish partnerships from a new business perspective: “For two almost identical products or services [to be] considered, the delights of visual design can make the difference in people being more comfortable using the one or the other” (UX Designer, 2020). Branding played a crucial role in distinguishing an organisation or a product from competitors, and interviewees also highlighted the importance visual brand applications play in being perceived as more innovative than their competitors.

To advance an approach tailored to the satellite and space sector, a new design process was developed for this research as a practical approach and employed in five projects. This process has elements of design thinking approaches with divergent and convergent activities, as well as a more complex feature in the ideation phase which can be understood as “magic” (Bierut, 2018:20-21). This model is divided into five stages, see Figure 4. However, rather than working simply stage by stage, the various stages are to be seen as a holistic investigation, where parts often overlay and intertwine in a constant loop of iteration within individual stages as well as some or all stages together, generating a complex structure, unique to the organisation or product to which it is applied.
Figure 4. Design thinking model – individual stages.

The names were developed on reflection of each stage’s specialism. The first stage KNOWING is to learn to understand and determine the organisation’s needs, to listen to its values and gain insight into its current innovative projects. The second stage PACE means progressing steadily and is the first part of the ideation and making process, where initial ideas are taking shape, a creative orientation originates, and the branding process accelerates. The third stage CRESCENDO, where ideas and making culminate, is the actual creation of a design route, the peak of the process delivering visual outputs that aim to communicate the organisation’s innovation. The fourth stage REFLECT is to review, revise, to apply and advocate design elements to a publishable output. And RECOVER stands for impact in connection to the UK Government’s Industrial Strategy to help productivity in adding value to the economy, and in articulating feedback from the partner organisation and its stakeholders.

This model and individual stages iterate as the author tailors them to each project independently without restriction, which then can be compared to the other case studies in order to draw overall conclusions.

Augmenting the design thinking model, the author created a design thinking activity map (see Appendix) that served as an analytical framework, summarising as well as comparing key elements of the work done with partner organisations that were useful to the research. It is a model that unfolds how different types of analysis were carried out and directly links to the research aim. The distinctive design thinking stages are presented in relationship to the input, actors, activities and output of each case study.

The individual case studies of collaboration with project partners are presented in the following sections with found data interpreted for the reader.

4 Intelligent transport

The author designed a visual language, using the design thinking model to communicate innovation in the first project, ‘intelligent transport’, that uses satellite technology to improve traffic flow. The visual output in the form of a brand assists the company in building a business case to take the project onto the market.

Intelligent transport is a multi-modal approach to boost productivity in freight transport for two major freight feeders in the North West – the Port of Liverpool and Manchester International Airport. Based on the design and technology company’s earlier project that allows ambulances to get through traffic faster (GOV.UK, 2017), the smart freight project uses space data via GPS / VPS controlled sensors managed by big data principles to ensure green light corridors for, but not reduced to, trusted traders and suppliers moving through the entire urban transport networks that can cut congestion, and idle and response times. Intelligent mobility is achieved, addressing future industrial, political, societal and environmental challenges (Catapult, 2018).

The technology company aims to communicate their innovation by creating a cohesive brand language for their intelligent transport application that reflects its smart nature. The company was
seeking to utilise the project as an umbrella activity to help them move forward in introducing their new product to the market.

**Figure 5.** Design thinking milestones. Intelligent transport.

**KNOWING** – Through FGDs, the author gained insight, into how satellite technology is used in day-to-day traffic. After the initial briefing from the partner organisation, the requirements for a brand language emerged for the smart traffic project. This involved creating a brand that could now serve as a foundation for brand communication supporting new business development opportunities.

**PACE** – This stage included research on how brand language can be used to communicate an innovative product by establishing form, colours, and a relevant font and illustration style. The activities in this first part of the iterating design process included: contextual observation; decision matrices and mind mapping; and the creative orientation as an output with designers, with the digital lead and CEO involved (see design thinking activity map in the Appendix).

**Figure 6.** From tilted square to free-flowing shape, creating brand language.

**PACE** – For the company’s new smart transport project, the original idea was a tilted square or diamond shape with four sides, corners pointing into the air or space, rail, road and sea connecting freight etc. via different modes of transport. **CRESCENDO** – During the process of creating the logotype, it became evident that the design needed to adapt a flexible role within the development of the project. **PACE** – The naming process as part of the branding process had three parts, with the chosen name for the brand ‘AI Traffic Flow’. **CRESCENDO / REFLECT** – With ‘flow’ in the name, the idea of the tilted square had to become more flexible in shape – an unconfined, more organic, yet interconnected shape was formed, within the parameters of the shape of a diamond with four sides. A gradient of traffic light colours with the green light prevailing has helped shape the logo for the new business case, as shown in Figure 6.

Here design outputs involved prototypes of the brand name, a design route and brand elements, the author was collaborating with one of the animators and the digital lead. Brand guidelines were created as well as a business model canvas. The author learned to adapt when finding the brand name, changing the direction of the design route; lo-fi prototypes helped embed that change.

**RECOVER** – The logotype was key to the company’s brand development, with its shape and colour palette being adaptable to further brand applications, e.g., the author worked closely with one of the company’s animators to create an explainer video to exploit and apply the visual design elements developed for this project. For the CEO of the company, the project was an opportunity to access
talent for real-life industry collaboration that resulted in distinctive brand creation for an innovative product (Intelligent transport CEO, 2019). In response to the Industrial Strategy (BEIS, 2017), the project depicted support for a local SME, and as a result, a shift in thinking and value to the region, and it addressed issues such as the improvement of productivity by developing innovative opportunities, e.g., entering new markets. During the project, in FGDs, creative thinkers sat at one table as a catalyst for collaboration, stimulating innovation with engineers and businesspeople, freight and logistics specialists and a transport director. The project highlighted that within activities of cross-industry collaboration, there is a need to listen to a variety of voices in order to understand and balance collective perspectives and use this to inform the project development. The role of creative thinkers included facilitation and visual communication in these collaborations, enabling cross-pollination of ideas that were not previously considered. As a result, making future technology more receptive to more traditionally minded employees and partners, who may think millions need to be invested to improve roads and build bridges, small interventions like sensor technology can be the answer, as a result of different ways of viewing the problem.

The researcher created a brand language for this particular project which could then serve as a foundation for publications and brand applications as well as deriving businesses from it. The author specifically looked at how brand language impacts the company’s innovation to cultivate a shift in long-term thinking, entering new markets and developing new business, while identifying suitable visual design tools. Lessons learned include adapting to change within the ideation and making phase, and that good communication in FGDs prevents misunderstandings because of the problem being well defined.

5 Asteroid mining

The second project partner is looking for funders for a first satellite launch ahead of asteroid mining activities. The author developed the brand to communicate the organisation’s innovation and promote it for an optimal market position.

The collaboration with the space mining start-up culminated in the creation of a tailored, flexible design strategy. The priority of the project was to attract investors for a satellite launch that would then allow activities to follow, using ground-breaking technologies that will enable extraction, processing and use of materials from near-Earth asteroids. The project involved brand development, concluding with a visual portfolio that aided in promoting the start-up externally, and to assist the internal structure of the organisation.

KNOWING – The space mining organisation is targeting the off-Earth commercial market. Asteroids contain large amounts of precious metals (Lewis, 1992), to a greater extent than materials on earth, potentially advancing the global economy (Jamasmie, 2017). “Mining the skies is no longer a subject of science fiction stories and movies” (Sukumaran, 2016:125).

During a FGD with various professionals in the company, the CEO, engineers, a geologist and designers, the need for a professional identity including key elements such as an investment brochure
was found to be most pressing to find additional funders for the upcoming satellite launch, as well as a business collateral for presentation externally and structure internally.

PACE – To advance the development of the organisation’s brand, the author designed a creative orientation – an initial concept of prospective imagery, fonts, layout and colours, to get an idea of how the identity was anticipated to look and feel.

![Figure 8. Creative orientation.](image)

CRESCENDO – The Microgramma font was determined for bold, extended headers that represent attention, power and the horizon, urging slow reading to make keywords memorable. Depicting a contrast to the element of brand language and different uses of copy, the Silka font for shorter text was chosen to look geometric and contemporary, and Noto serif font was selected for the main text for a distinctive yet easy-to-read quality. A thin line was formed as the brand element, complementing the brand image depicting ‘delicate perfection’ and contrasting the logotype’s hexagon shapes. The line depicts both quality and weightlessness – near zero gravity that is pointing upwards in the reader’s direction, and diagonal, indicating floating in space and open-endedness that symbolises excitement, anticipating growth. The amber shade depicts energy and looks confident and cheerful, combined with impartial, yet sophisticated warm grey tones, creating a spectacular mood, especially when applied to imagery, see Figure 8.

REFLECT – In combination with the existing logotype and characteristic hexagon shapes, the brand language was developed to create meaning directly linked to the organisation’s innovation by building confidence in its propositions.

RECOVER – A coherent, professional identity acts as a conversation starter that is adapted and further developed by the organisation. The design-led approach was valuable in creating the corporate identity, but it was also considered as a beneficial tool to developing the business. For the pioneer in Space Resources, the opportunity to conduct an innovative approach to design that represents the industry is the most practical application, yet one that challenges the norm. With the investment brochure ready for publication, the organisation is moving forward to the investment stage of the business model, helped by the brand development to become visually recognised and the Asteroid Mining concept to be accepted. A professional brand contributed to the start-up’s confidence, a
momentous development in the organisation’s history with considerable impact on its business (Asteroid mining CEO, 2019).

6 Space engineering

A rebrand was welcomed by the third partner that is working to explore and develop space with four subdivisions, including lunar and Mars rovers, rocketry, space balloons, and cansat, which are can-sized satellites. The space engineering organisation aims to attract more sponsors, partners and potential colleagues with enhanced presentation through new brand creation. This project immediately had an entirely different dynamic to the design thinking process, see Figure 9. The student society concerned with space exploration and development is based at a university in England’s North West and is successfully involved in worldwide competitions as well as workshops to educate and encourage the next generation.

Figure 9. Design thinking milestones. Space engineering.

KNOWING – The UK Space Agency is increasingly working together with academia with an interest in research and development of space tech innovation (Grossman, 2020). The space engineering partner has four departments. ‘Rovers’ has its focus on robotics with distinct teams from diverse backgrounds for a lunar and Mars rover that will go through a design and quality process to create a working object for a challenging environment. ‘Rocketry’ concentrates on robotic, hybrid rockets. The department is concerned with self-landing mechanisms and looks at a possible launch from a space balloon. The ‘high altitude balloon’ moves comfortably into the stratosphere, this department is science- and practice-focused. ‘Cansat’ is short for a satellite, the size of, and moreover a satellite built in, a can. A cansat is usually launched from a research rocket in order to imitate an industry-like satellite with its duration from first design to review following a flight. A diverse team of students working in science, space technology and engineering, is entrusted to this organisation. All departments are engaging in projects individually or collaborating together and with stakeholders (Issuu, 2019; Manseds, 2019).

The first brief was to find a suitable logotype for the organisation as a whole, with the knowledge that there are sub-departments to follow. While learning about the organisation’s values and what it wants to convey, the question arose as to how these can be translated into a visual system that works. PACE – The original creative orientation involved finding the right inspirational words to describe values that could then be decoded into images in the aerospace engineering context.

CRESCENDO – The character inspiration already started extracting a number of ideas on potential colours, typography, brand language and illustration style. The insight for the primary colour ‘sky vs sea’ came from looking back to earth from space. Supplementary colours were established alongside six secondary colours to have a comprehensive choice for versatile usage. The Ailerons font as the basis for the organisation’s main logotype, made up entirely of the letters in its name, is integrated into the space environment and has a timeless look. Another font, Bariol, was found for the tagline and text in contrast to the main logotype and to allow more of the organisation’s values to come through, having a friendly and accessible appearance. REFLECT – A clear-cut, delicate logotype in
the space context is used to set the organisation apart from other branches in the UK and internationally as well as serving as an umbrella to the four different departments.

KNOWING – Rover, rocketry, balloon and cansat depict the sub-divisions of the student society with the objective to create a coherent and accessible brand. PACE – Appropriate for a replay mode, logo icons were the most suitable with recognisable graphics, characteristic for each separate department, yet together identifiable as one organisation. The circular shape indicating the movement in orbit, that is infinite, limitless and complete.

**Figure 10.** Logotypes for primary brand and sub departments.

CRESCENDO – The initial prototype logos were of great detail within the parameters of a circle and of previously determined colour and imagery palette. REFLECT / KNOWING – During a FGD workshop, co-designing with department heads and the organisation’s president included mind mapping, card sorting and scribbling, a simpler design was preferred that can be scaled as needed.

PACE – In-depth insight helped the author uncover the visual implementation of the various departments’ characteristics allowing for interesting angles, contrasting shapes and cropped elements, see Figure 10. CRESCENDO – With moving, yet captured logo icons, brand guidelines were created including proposed brand applications for strategic design use on different types of layouts and brochures, websites, and on textiles etc., and use of illustrations e.g., in explainer videos, flyers and posters. REFLECT – This project has become much more layered, with reiterating elements to solve a complex task for an organisation that wants to set itself apart from other branches and its parent organisation nationally and internationally, and to bring about a varied brand that makes itself and its divisions comprehensible.

RECOVER – Creating a brand for a space engineering organisation has resulted in a valuable kit that translates a name into an identity to share the interest of space exploration and development and to address prospective members, partners and sponsors. The design thinking process and subsequent successful rebranding work by the author was the result of integrating the organisation’s interests and activities by understanding its ambitions and preferences. This project provided the evidence that design can help understand innovation through visual communication, which encourages funders to
consider higher-risk yet innovative organisations that create new products, facilitating the growth of entrepreneurial thinking in the region (Space engineering President, 2019).

7 Remote sensing

The fourth partner is mapping wildfire patterns via satellite earth observation (EO) data. By understanding and exploiting the power of visual design, the remote sensing company is able to reach new audiences, and initiate enthusiasm in the space industry and the nature of its work. The remote sensing start-up’s new brand was created to enhance its presentation. The award-winning company is interpreting radar data with a flexible approach to expanding the organisation’s offer. A professional identity was requested to set the brand apart and convey the right message to the audience.

<table>
<thead>
<tr>
<th>how can satellite technology be used to prevent wildfires</th>
<th>in depth research creative orientation first design route</th>
<th>creating logotype variations continued idea finding brand guidelines</th>
<th>audience receptive to geoportal service through design</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMOTE SENSING</td>
<td>PACE / KNOWING</td>
<td>CRESCENDO</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 11.** Design thinking milestones. Remote sensing.

KNOWING – Firefighting efforts spent on moorland and heathland can be cut significantly if not completely by monitoring wildfires using remote sensing techniques that help restore the affected area by reseeding (Copernicus Masters, 2016). Variations of moss can hold water like a sponge and help the area to be more resilient (The University of Manchester, 2018). Through EO data, carbon can be detected and models created to help restore peat and improve wildfire response mechanisms (EnviroSAR, 2020). Open source satellite data makes it possible to uncover patterns in the context of landscape and its protection, and imagery from space can be a tool comprising different remote sensing techniques (Discover Magazine, 2015). The company’s breakthrough occurred after significant media interest in a wildfire in a North West moorland in 2018. With land mapping and experience in geomatic benches, the start-up wants to present itself as doing justice to nature and also to emerging technologies with an underlying sophisticated tone. The author and the CEO undertook several FGDs to seek co-innovative opportunities.

PACE / KNOWING – Initial ideas involved finding a layout system for all kinds of text as well as a colour study. With research into comparable companies and prospective clients, the colour palette may remind one of, but need not be immediately connected to, nature. Another visual element is the background in layouts such as the website, which may primarily be white, as this is associated with light and with earth observation, a service that is coming from space to the planet (and not the other way around). As a supplement charcoal grey is used for typography and e.g., book covers rather than black for legibility and accessibility. In order to develop the brand language, the author obtained knowledge on how satellite technology is used for conserving landscape and how fire destroys vegetation and kills animals due to loss of habitat.

PACE – For the creative orientation to establish a brand language, inspirational words were found that arose through researching the company and its immediate surroundings. The words were then translated into images, which helped define colours and patterns. Typography was established, depicting a hierarchy with DIN, a realist font, and the robust serif Caslon and visual elements together helped create a basis for a layout that could then be specified for website applications.

CRESCENDO – The first draft of the design route was set out with a logotype based on the sans-serif font with a flexibility of surrounding patterns inspired by satellite imagery that can adapt to different
applications. For the desired accessible branding, a professional look of the bespoke service needed to be followed through all platforms, including social media, in order to captivate viewers.

Element of KNOWING with PACE again – The CEO favoured a flame that was part of the old logo and, following many conversations, by combining ideas of patterns inspired by the perspective of satellites, radar pulses and the visual translation of flames, a solution was found for the logotype and favicon that leaves room for interpretation to the viewer, see Figure 12. With the company’s approach to dynamic mapping generating more detailed predictions in terms of fuel and fire risk, visibility, safety and curiosity in brand presentation were not compromised by aesthetics and preference.

![Figure 12. Full layout and book cover. Use of brand elements.](image)

CRESCENDO again with REFLECT – With a recurring loop of design stages, patterns that emerged were refined in an organic approach. Ideas were communicated and evaluated against design criteria, highlighting visual and functional elements of the brand, which can speak for the company and build flexible structures that can be adapted to a wide range of applications. The ability to co-brand with national and international organisations as well as projects became an important aspect to include in the brand identity. Brand guidelines have been developed combining visual elements with possible future assignments across physical and digital spaces.

PACE – A combination of technological and natural aspects of the company required additional translation, creating more rhythmic phrases and a meaningful adaptation of the brand.

REFLECT – Short as well as detailed brand guidelines that include all design elements were created for both in-house use and external suppliers.

RECOVER – Feedback from the remote sensing company comprised the value of design expertise and the role of design as a communication tool to customers and funders by visually providing the right kind of messages. By understanding and exploiting the power of visual design, the company is able to reach new audiences, initiate enthusiasm for this start-up in the space industry and the nature of its work, and to enhance the receptiveness to its ideas. A professional presentation helps develop the business and takes the design forward into e.g., a geoportal service online. With competitive advantages in applying elements of effective visual design combined with EO technologies, cross-industry collaboration is stimulating innovation (Remote sensing CEO, 2020).
8 Space settlement

For the unfinished fifth project, the author generated a creative orientation and worked towards brand development, brand application and guidelines. The partner is established in the field of education in space settlement that develops workshops aimed at high school children. The project was halted due to the restrictions of the COVID-19 pandemic, which resulted in physical workshops being suspended.

In this non-profit organisation, young people take charge of their future skills through trying and testing construction, communication and societal scenarios on Mars. What technologies do we take to Mars? What would we want to create there? How could we communicate? And what would the ethics be like when we land there? Using tools that embrace virtual reality, data security, 3D printed buildings, sensors and the Internet of Things, workshops simulate settlement on Mars. The brand creation project was interrupted halfway through the design thinking process loop with a number of lo-fi prototypes created, which can serve as a practicable platform that is useful to the organisation’s future brand strategy, see Figure 13.

Figure 13. Design thinking milestones. Space settlement.

KNOWING – Mars is the reason for numerous space missions. It is the most explored and most approachable planet in the universe (IntechOpen, 2020). Collaborative tasks in Constructing a Life on Mars workshops, aimed at high school-aged children, include role play of a range of professions and activities. Different team challenges arise in a space environment and are of tangible, intellectual and societal character. Participants are given confidence to take charge of a career in a constantly reshaping world that functions in a digital form (Waters, 2019).

Figure 14. Martian Sunset. Brand applied to backdrops.
PACE / KNOWING – After thorough research into Mars settlement scenarios and technologies useful in workshops, the author developed a creative orientation. CRESCENDO / PACE – During further conversation with the partner, the first draft of the design strategy was created. The logo is based on typography for flexible and dynamic application with the chosen font looking engineered and intelligible, reflecting the company’s values. Figure 14 displays a backdrop with the Martian sunset gradient resembling energy and determination. REFLECT / CRESCENDO – Through strategic use of design elements that creatively combine digital and analogue ideas, the charity that helps people get into employment, can build its main brand on the project’s brand language. Innovative use of visual design can activate awareness of digital skills needed in the future of work.

The author gained insight into space settlement scenarios suitable for high school-aged children through mind mapping, FGDs, interviewing and empathetic modelling (see design thinking activity map in the Appendix).

9 Discussion and conclusion

The insights gained through the case studies are valuable independently as well as collectively as they fostered a deeper understanding of the application of a bespoke design thinking process to a specialised industry, tailoring individual stages of that process to the projects, and connecting design practice and design theory.

The first case study, the Intelligent Transport project, offered the opportunity to create a brand, and through this development, the author was able to identify and communicate the organisations underlying innovation values providing the potential to enable the organisation to enter new markets.

The second case study involved in brand development in the context of the exploration and exploitation of asteroids and supported securing funding by generating a professional identity that improves the organisation’s identity and helped to establish partnerships. The promotion for an optimal market position was crucial at a stage where funding was still needed for a satellite launch prior to asteroid mining activities.

The third case study, Space Engineering, focused on an organisation that supports projects involving lunar and Mars rovers, self-landing rockets, space balloons and can-sized satellites. The creation of a brand helped to define the organisation’s identity and set it apart from parent and sister organisations. A significant element of the rebrand was to enhance organisational image and set a platform for more effective communication to sponsors, partners and potential new members.

With the fourth case study, which uses satellites to help prevent wildfires and maintain natural resources, a professional presentation enables the organisation to develop further and to reach new audiences. Creating a brand for a company that uses satellite data has become a tool for cross-industry collaboration that is stimulating innovation.

The evolving fifth case study uses a space settlement scenario to engage young people in workshops highlighting digital skills needed in the future of work. A creative orientation and first design route provide the industry partner with brand elements useful for application of the organisation’s Mars project as well as its main brand.
When comparing the five design thinking models that supported brand creation and development, the individual stages varied considerably depending on each project (Figure 15) but all stages were evident in all case studies. Case study one and two commenced in a fairly similar manner but then saw differences in the ideation and making phase of the process when Intelligent Transport had to adapt the different modes idea to a more flexible one after the naming process, while asteroid mining was more straightforward going from creative orientation through to identity creation with iteration within each stage. The design thinking process in case study three immediately had a completely different ‘vibe’, as with the organisation’s four sub-divisions the structure was much affected by iterative approach due to the larger variety of design elements addressed. However, within iterations, similar patterns emerged. In the fourth, a unique rhythm became clearly visible as the stages of the process were aligned to distinctive design features depicting the initial concept, the design direction with the creation of logotype variations, and brand language and guidelines essential to communicate the partner’s value were made suitable for the company and its stakeholders. The evolving fifth case study drew its inspiration from in-depth research and conversations with the partner, the creative orientation and first design route that can be useful work in progress for the charity’s umbrella brand. The differentiation within individual design thinking processes was as a consequence of the uniqueness of each organisation’s needs and the subsequent identification of solutions. Design thinking is found to be a valuable approach for the space tech sector due to its adaptability and ability to accommodate a range of contexts.

Figure 15. Design thinking model – all case studies.

Figure 16. Interview keyword metadata.
In light of both primary and secondary research (emerging themes in design, economy, innovation and technology, Figure 1), the word map in Figure 16 points to the number of key areas that account for the aim of this research and the overlaps therein. Through this approach, extensive interviews with diverse professionals from all five partner organisations helped evaluate the research. A list of actors involved in the analytical framework can be found in the Appendix.

The combination of research methods, including interviews, feedback and FGDs, as well as the various visual prototypes, an intelligent and flexible design thinking process was developed that created an environment that cultivated long-term growth in businesses. This demonstrates that an applied design thinking model can help organisations become more resilient.

Therefore, visual design can represent innovation culture through a tailored design thinking model in the field of satellite and space technologies. In the context of the UK Government’s Industrial Strategy (BEIS, 2017), visual outputs help build a business case to enter new markets and advance communication with prospective funders and new audiences, and to establish a professional presentation. These contrasting projects apply the same design thinking model, tailored to each context, resulting in a complex yet accommodating structure. This process is divided into five stages: KNOWING, PACE, CRESCENDO, REFLECT and RECOVER and inform, generate and provide novel approaches and to solve problems strategically, creating opportunities conducive to innovation, and helping ensure the longer-term sustainability of organisation. Primary data correlates with secondary research which aligns with the overarching aim of the research and informed a final model that is valuable to space tech organisations.

Limitations to the study include pressure from partners, when something needed to be ready quickly for a launch or when a partner preferred a certain colour to be translated into the brand. With good communication and integration through FGDs with co-design activities, the partners were involved in decision making and problem solving.

The partners’ images have been transformed as a result of applied design thinking. The enhanced brand value indicates the contribution that visual design has in communicating space tech organisations’ innovation.

Acknowledgment

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References


Cooper, R., Hernandez, R., Murphy, E. & Tether, B. (2016). Design value: The role of design in innovation. Lancaster University, Lancaster.


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<th>Activities</th>
<th>Outputs</th>
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<td>engineer, digital twin, business model canvas</td>
<td>engineer, creative mindsets, product development</td>
</tr>
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<td>architect, design thinking, business model</td>
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**Appendix: Analytical framework: design thinking activity map**

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<td>innovation, feedback, social</td>
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Distributed Design Thinking: Understanding the role & use of design representation

James Andrew Self \textsuperscript{ab}
\textsuperscript{a} UNIST (Ulsan National Institute of Science & Technology), Department of Design, jaself@unist.ac.kr
\textsuperscript{b} Brunel University London, School of Design

Abstract. Due to the ill-defined nature of design problems, and resulting search for solution candidates, the embodiment of intentionality through design representation is important to design thinking. Design representations are employed as means to support designerly thinking between ill-defined design problems and coupled solution candidates. One way into developing further understanding of design representation, its role and use as scaffold for design thinking, is to adopt theory on distributed cognition. I offer a review and discussion of design representation as distributed cognition. I then position distributed cognition as a possible means to scaffold design research aimed at building general theory to explain design representation’s role and use in design cognition.

Keywords: Distributed cognition, Design representation, Design Thinking

1 Design Thinking

Since its launch at TU Delft in 1992, the DTRS (Design Thinking Research Symposium) has explored and extended an understanding of Design Thinking (DT). In contrast to a set of tools or methods for use in applying DT, or in training individuals to engage DT, the DTRS is concerned with a holistic understanding of what DT is, how it manifests itself in practice, and what an understanding of DT can tell us about design more generally.

Many design researchers have made progress in understanding DT as a particular type of thinking unique to design activity: from Cross et al.’s earlier work on design activity (Cross et al., 1997), originally as outcome of the first DTRS, to the applied methods and tools generated by Stanford’s D School (Anon, 2021). For an inclusive review of DT, including its use in management, as method for innovation, and as means to understand designerly thinking, I point the reader to Johansson-Skölöberg et al. (2013) comprehensive work.

For the purposes of this current paper, I wish to use the term Design Thinking to describe a particular type of cognition. Schön (1983) originally described a type of thinking-in-action associated with design activity, whereby the designer reflects upon design works as a scaffold for thinking. Others have since extended Schön’s original concept (Cross, 2007; Dorst, 2011). In my approach, I am interested in DT as a type of cognition engaged during design practice, rather than as method to address a design problem, or as used to describe a strategic set of design tools/methods.

Fundamental to my approach is a definition of DT as a type of thinking in action. Thinking in action is underpinned by procedural knowledge, wherein the activity and types of cognition required are fundamentally linked to the practice or embodied experience of doing. For example, knowing how to ride a bicycle is a type of practiced or procedural knowledge. The ability to ride a bike comes from practice and experience, rather than the explicit declaration of rules and laws that govern bike-riding activities. In this sense, learning to ride your bike comes through knowing how to ride. By way of
contrast, *knowing what knowledge* is a type of knowledge that can be learnt through explicit declaration (for example in a lecture-based format).

Returning to design, procedural knowledge seems important to design as a practiced and applied discipline. The activity of design offers opportunity for reflection upon possible solutions (expressed as design sketches for examples). This in turn supports a generative activity towards the definition and development of design solutions. Although design as reflection-in-action does not exactly describe a type of procedural or know-how knowledge, reflective design activity has overlap with know-how knowledge because both describe a practice and activity. However, whereas know-how knowledge is interested in a type of knowledge applied to certain activities (i.e., learning to ride a bike), design as reflection-in-action is concerned with external expression of design ideas, and their role as catalyst for a particular type of cognition, i.e., design thinking.

2 Design Thinking & representation

An important activity in Design Thinking (DT) is the designer’s expression of solution ideas through external representations of design intent. Design practice has many terms to describe these design representations, from the humble concept sketch, through to high-fidelity, pre-production prototypes. Pei et al. (2011) provide an inclusive taxonomy of design representation types. Based upon a review or their use in industry, and with particular focus upon product and industrial design, the taxonomy classifies design representations between four taxa: design Sketches, Drawings, Models and Prototypes. Sub-categories identify more specific representational types within each of the four main categories (i.e., Concept Sketch, Technical Illustration, Experimental Prototype). The Pei et al. (ibid) taxonomy focuses attention upon the representation itself, its features, and characteristics, rather than interaction effect between representation and the designer’s interaction with it. In an extension to the original journal article, Pei and Self (2022) provide a comprehensive account of the role and use of various representational types in industry, including case-study examples of application.

In contrast, others have adopted the purpose a representation is used for to identify different kinds of representation: representations to persuade, to inform, to describe and to explain (Olofsson, 2007). Interestingly, these categories have close relationship with those employed to describe different types of non-fictions writing styles. Still other classifications systems map relationships between the type of representation employed, and its place of use during a process of design (Lawson, 2006). For example, concept sketches used during a conceptual ideation phase of process, developmental design renderings used in communication of intent during design development, detailed technical illustrations supporting design implementation and production.

In this mapping between process and the characteristics of design representations, a relationship emerges between fidelity of design expression and the types of thinking required at different phases of design process. For example, a more emergent and divergent type of cognition required to support conceptual design ideation applies low fidelity and easily produced concept sketches. In contrast, the confirmatory and specificity seen at later stages of a design process employ the use of technical representation with prescribed rules of production and communication. The rules and conventions of design representations at later stages in process are informed by shared rules and conventions. This is not the case in early phases of design development, where sketches and illustrations both adhere to fewer conventions and are thus more open to greater interpretation.

Although the use of design representation is ubiquitous in design activity, we do not understand why design representation is important to DT. That is, why are various representations of differing levels of detail and fidelity ubiquitously used as scaffold for, what Cross (2007) described as designerly thinking?
I can almost hear you say: it’s because doing so helps the designer, and other stakeholders, keep track of the progress of design ideas. Or design representation supports thinking towards and framing of the design problem (Dorst, 2015). Or perhaps, it scaffolds bridging between an ill-defined design problem (Self, 2017), and the emergence of possible solution candidates. Although empirical works support the responses above, the question of why and how design representation is important to DT is then simply moved back one place. Why do design representations help track the progress of ideas? Why do they support problem framing in design, and so on?

A comprehensive understanding of what design thinking is, or how and why design representations support it, is beyond the scope of this paper. In fact, I would argue that our knowledge of human cognition and the mind (let alone design thinking) is still too limited to make such an ambition possible. Instead, my modest aim will be to present a possible way into understanding the relationship between DT and design representation. This will then contribute to building general theory on the role and use of design representation in support of DT. To do this I will first present the concept of embodied cognition. Within theory on embodied cognition, I will discuss distributed cognition, its relationship to design representation and DT. I will finish by positioning DT as a (higher level?) type of distributed cognition.

My approach may be useful for understanding how DT differs from other types of human cognition. Central to my thesis will be the concept of Distributed Design Thinking. That is, DT as described through a type of cognition that interacts with external representations of design intent in a way quite unique to design, although also observable in other types of thinking, albeit at a shallower interactive depth.

Before I begin, some notes on terminology. One thing to note from the outset is my use of distributed cognition in a more localized sense. There is already much work on cognition distributed across teams and individuals. This is not the definition I use here. Here I operationalize distributed cognition to refer to a situated act of design between a designer and her representation of design intent. Likewise, in my discussion of DT, I adopt the term to describe how an individual designer thinks when designing. Her cognition in practice. A personal, localized activity as she considers possible solution candidates. This is not to say DT cannot be described in other ways, or that design activity only happens in the way described above. Of course, teams of stakeholders are involved in almost any process of design. Likewise, communication between individuals is an important aspect of design process. However, here I wish to focus upon the craft of design (Sennett, 2009), as experienced by the individual designer in a situated activity when reflecting upon personal representations as expressions of design intent.

3 Distributed design cognition

A designer works on a project to explore and develop ideas towards a new product concept. As part of this effort, she develops and communicates indicative examples of possible solutions at an early stage in the process of design. She explores possible solution candidates through the sketching and illustration of ideas as representations of design ideas. Through the expression of intent as externalized design representations that approximate possible solution candidates, the designer explores possibilities, reflecting upon representations of intent, and is thereby better able to think about and evaluate the potential of solution possibilities.

The above scenario is an instance of employing objects within the external environment as scaffold for thinking. Embodied cognition understands thinking as taking place through and between the mind and our external world. Rather than thinking as skull-bound, cognition extends to include the external
environment in which we live. In this way, cognition is embodied in the sense that thinking is described as influenced by the physical, and embodied experience of our material environment.

Embodied cognition describes an assumption that our lived environment is an active component of how we think. A definition of thinking as embodied cognition can be radical in the role the external environment plays in thought. For the purposes of the current discussion, I will not detail the various definitions of embodied cognition. For a holistic treatment, I refer you to Wilson and Lucia (2015). Suffice to say, a theory of cognition as embodied advocates for thinking as an interaction between the mind and our external world.

In contrast with embodied cognition, a conventional theory of mind states all thinking takes place within the brain. Cognition is described as skull-bound in the sense that we experience the external world through our five senses. This information is then processed within the brain as we perceive and make sense of the world around us. We, in some way, represent these perceived experiences within the mind as thoughts, which then drive actions, further reflections, insights, and at a deeper level, drive motivations, opinions and emotional responses. Although dependent upon information gathered through the senses, the brain thus conceived is independent of the world in its ability to make sense of it. The mind is skull bound.

In contrast, an embodied approach suggests sensation (through the senses), and perception of our external environment, continually interact with the mind to an extent that cognition is embodied and enacted through interaction between the mind and external environment. Rather than a linear process of sensation, perception and cognition, embodied thinking advocates for a circular model of embodied thoughts and actions. Our body is thus seen as a sensory organ, interacting with the world to influence what and how we think moment by moment. Adopting an embodied definition of thinking, cognition is not limited to the skull, but extends outward to include our embodied experience of the external world around us.

Within theory of embodied cognition, the concept distributed cognition (DC) is used to describe a type of thinking that extends beyond the mind to include external objects and artifacts within our material environment. As an example, when working through math problems, students often make use of paper and pencil as means to express component parts of a problem. These expressions then provide scaffold for thinking as part of a process of working through to a correct answer (Figure 1). Thinking, thus conceived, is an interaction between mind and the embodiment of thought as expressed and represented within external objects. In this case, formula expressed on paper.

![Figure 1. Working through a math problem. The use of external representation as distribution of cognition](image.png)
The external expression depicted in Figure 1 acts as a representation to scaffold thinking. That is, sums on paper are the representational artefacts through which a problem is explored, and solution achieved. In Figure 1, thought is distributed between the mind and marks on paper as representations of the process whereby a solution is derived. Through the distribution of thinking, the mind is extended to include these external representations. These are reflected upon in an iterative interplay between mind and externalized thoughts. Thinking, described as distributed, is thus characterised by the iterative, cyclical use of representations external to the brain, as extensions of and scaffold for the mind. This contrasts with a linear model of sensation, perception, and interpretation, perceived through the senses, and processed within a skull bound brain.

Distributed cognition has much in common with Schön’s (1983) concept of a reflective design practice. Schön describes a type of thinking that requires a reflective conversation with the (design) situation. Whereby, the design problem is better understood through iterative reflection upon the potential of solution candidates expressed as propositional design representations. In the case of Schön’s work, representations take the form of architectural plan drawings, sketches, and illustrations. While the jury for an embodied understanding of cognition may still be out for traditional cognitive sciences, the theory continues to gather support. For example, limitations in efforts towards artificial intelligence have questioned the use of computational conception of the world, that sees cognition bound within the skull (Goel, 1995). An oft cited limitation of skull-bound cognition is the allusive goal of designing AI computation that can come up with original, creative works.

Together with shedding light on creative cognition, and in line with Goel’s (ibid) earlier work, a description of DT as distributed cognition has the potential to further understanding of what DT is and why designers express solution ideas through external representation. In other words, a general theory of Distributed Design Thinking (DDT) has the power to help describe creative cognition generally, and the role and use of representation in DT more specifically.

Drawing on theory from embodied and distributed cognition, my thesis states that DT is a type of higher-level distributed thinking. By higher-level I mean to suggest that DT is a higher order type of distributed cognition more particular to design, and perhaps creativity. This contrasts with the types of distributed cognition cited within the cognitive sciences and psychology literature that often describe the distribution of cognition as limited to memory aids (i.e., memos, notes, diaries, see also Figure 1 above), or in way fairing (maps and navigation).

4 Design representation & Distributed Cognition

In the section above I described embodied cognition as a type of thinking that extends from the mind and into the world. Within an embodied approach to design cognition, I focused upon the distribution of thinking through external design representations. At a lower order of distribution, shopping lists, notations and formula are used in everyday life. At a higher level of distributed cognition, however, design drawings and illustrations, as external representations of design intent, are employed as scaffold for distributed design thinking (DDT).

Important to DDT is the use of design representations as expressions of intent towards solution candidates. Some work has suggested the need to sketch is in fact not necessary to Design Thinking (Bilda, Z., Gero, J. S., & Purcell, T., 2006). However, there is far more evidence to suggest the importance of design representation in design cognition. See, for example, Goldschmidt’s (1991) early work on dialectics of sketching, Geol’s (1995) attention towards design representation and its ability to confound a computational theory of mind, or Purcell and Gero’s comprehensive review of work towards drawing and its relation of drawing and sketching in design process and as related to cognitive psychology and cognitive science.
I would argue that the discipline of design, as a creative and applied field, is synonymous with ubiquitous types of representations (i.e., various sketches, drawings, illustrations, models, and prototypes), of different levels of detail and fidelity in the communication of design ideas. Both the skill and technique of producing design representations, and their various uses for different purposes and at different phases in design process, offer some support for my claim for design representations as critical to distributed design thinking. For an extensive discussion of the types of representation used in design, see Pei, Campbell, and Evans (2011).

Design representations come in many forms, levels of fidelity, and are often expressed through various tools and media (i.e., CAD/CAM, 3D Printing, CADC, 2D illustration software, tablets, and sketching pads). The tool of use will influence the type of representation produced. And, following the distributed cognition thesis to understand DT, have profound implications for the kinds of thoughts engaged and solutions derived Self (2012). However, I will not discuss the influence of these various tools here. Instead, I wish to focus upon the need for representation itself, as used in design practice. This will then support my thesis argument for DT as a higher-level distribution of cognition more unique to design.

So, what is design representation? Well, to constrain the scope of my current discussion, here I will define design representation as not symbolic. I do not include for example written or spoken language in my definition of design representation. This is of course not to say that written and spoken language is not used in or important for the representation and communication of design intent. Only that, in my thesis argument for design thinking as distributed cognition, I wish to highlight the iconic representation of design ideas; their role and use in DDT.

I use the term *iconic* here as derived from semiotic theory. Briefly, semiotics is the study of signs and their interaction with human psychology. Semiotics indicates two main types of signs: the symbolic and the iconic sigh (a third are indexical signs which will not be discussed here). A symbolic sign is a sign whereby what is signified does not share any physical properties or characteristics with the signifier. For example, the word ‘tree’ (signifier) does not attempt to embody any of the physical characteristics of a real tree (signified). In contrast, the small battery icon (signifier) on the laptop PC where I am currently writing this paper, does attempt to embody some of the properties of a real battery (signified). For example, it has a similar outline to a typical battery you may find in an electronic product (rectilinear in form, a small bump at one end to express the positive terminal). My PC’s battery sign, then, can be described as iconic (in fact it is named an icon for this reason). My battery indicator icon attempts to express the characteristics of the object it signifies, i.e., the physical, archetypal AA sized battery.

Likewise, often (but by no means exclusively) design representations are iconic in their expression of design intentions. They attempt to approximate at varying levels of detail and fidelity, the physical appearance and/or characteristics of a potential design. Again, I am not claiming that symbolic design representations, whether spoken or drawn, are not important to DT. Here, however, I wish to focus upon representations that are iconic (or mostly so) in their expression of design intent. That is, representations that attempt to approximate in their expression the physical, material, or functional characteristics of a design solution. How the solution would function, feel, look, or behave through approximating form, function, materials, colours, textures and so on (Figure 2).
This is because these iconic representations are more interesting due to their unique association with creative practices generally, and design activity more specifically. For example, the concept sketch, design rendering or pre-production prototype. For design, arguably more so than any other discipline, iconic expression of intent appears to go hand in hand with practice.

5 Distributed Design Thinking

I will now return to the thesis of the current paper. Namely, DT (Design Thinking) as a type of enhanced Distributed Cognition. I have already discussed a definition of DT focused upon a situated activity of design (Section 1). Within this situated activity, the designer explores and develops ideas towards potential solutions. This she does in response to a design problem, that is by nature ill-defined (Dorst, 1996), or at the very least seen as ill-defined by the designer.

Iconic design representations, that is representation which attempt to approximate the form, function, or characteristics of potential design solutions, are employed in this situated activity of design. For example, a designer may start to explore possible solution candidates through representation as concept sketches. Later, higher fidelity design illustrations may begin to express material finishes, particular functional characteristics, or scenarios of use in a particular use-contexts (Figure 3).

Distributed Cognition is a means to understand lived human experience through the lens of an embodied theory of mind (Varela et al., 2016). An extended mind understands thinking as a cyclical interaction between the environment and the mind, whereby external representations are instances of embodied thinking, rather than stimuli to be experienced through the senses and understood within a skull-bound brain. Distributed Design Thinking (DDT) describes thinking between the external representation of design intent, and the designer’s interaction with representation as scaffold for thought. For example, the designer prepares an experimental prototype as representation of solution intent. The experimental prototype, as external representation, acts as means to explore the potential of a functional requirement (Figure 4). Without it, thinking towards the solution’s opportunity to meet functional requirements (i.e., as derived from user needs and technical scope and limitations) would be considerably inhibited. At least this is the assumption we make by adopting a distributed understanding of DT.
Figure 3. Scenario-of-Use concept board to represent and communicate where, how and by whom a solution may be used (Self, 2021)

Figure 4. Experimental prototype as design representation (Evans et al., 2021)
In the representation of a design solution the designer is better able to understand the solution’s potential. If our assumption is that without iconic representation, the designer would be inhibited in an
ability to think about, and evaluate, a design solution’s potential, the role and use of design representation in DT becomes clearer. So, how does design representation aid thinking? Again, applying theory on DC (Distributed Cognition), and extending DC to include design practice, design representations are locations of enhanced distributed thinking. This distributed thinking then acts as opportunity for interactions with internal representations (in the mind). These then stimulate further design representation, and/or refinement of existing representations. This is a cyclical process, wherein representation and thinking work in unison to explore and develop the potential of solution candidates.

By applying theory on Distributed Cognition to DT I have taken a step to extend understanding of why designers represent their design ideas. Design requires a distribution of cognition to engage designerly thinking (Cross, 2007). In this sense, we are in a better position to further an understanding of design thinking because we have a theoretical foundation of DC as departure point. Design Thinking as Distributed Cognition (Distributed Design Thinking, DDT) has increased explanatory power due to its scaffold of theory adopted from embodied and distributed cognition.

Now we have DDT in hand, we are better able to articulate further questions related to interactions between concepts. For example, what types of distribution occur? How and when does distribution happen? What is the interaction effect between thinking and representation? What is the influence upon perception and cognition? What implications for understanding creative thinking and its relation to making/representation? And many more.

The point is that DDT offers some hope for building general theory of design thinking, that can then account for the ubiquitous use of design representations in practice. It’s a way in to provide opportunities for further studies framed by existing understanding of the mind (as limited as it still may be). Other interesting avenues of investigation might be the relationship between DDT and other now more established theory on design (i.e., problem framing, ill-defined design problems, appositional reasoning between problem and solution, design as reflective practice). Adopting theory of design thinking as distributed cognition, the final section will suggest possibilities for future works aimed at contributing to a general theory of DT based upon a distributed.

6 Discussion & Conclusions

In this paper I have positioned Design Thinking (DT) as a type of higher-order distributed cognition. This I term Distributed Design Thinking (DDT). Drawing on work from cognitive science, cognitive psychology, and theory of mind (embodied cognition, distributed cognition, embodied mind), I have discussed the role and use of design representation as fundamental to how designers think in practice. I have touched upon a relationship between design process, fidelity of representation and the distribution of cognition between representation and the extended mind. I have also indicated how DT as distributed cognition may help explain the reflective practice paradigm for understanding design activity first introduced by Schön (1983).

However, I have merely introduced the potential of DDT as holding explanatory power to understand the role and use of design representation in DT. Many questions and further directions for research remain. For example, I have tentatively suggested that Distributed Design Thinking is described as a higher-level distribution that may support creativity. Well, what’s the evidence for this? Indeed, what is the relationship between Distributed Design Thinking and creativity? How might design expertise, or the lack thereof, inhibit Distributed Design Thinking through design representation? As mentioned in previous sections, how does the media/tool of expression (i.e., CAD vs. hand sketching, (Self, 2012) influence the distribution of cognition during Design Thinking?
Adopting Distributed Design Thinking as means to understand the role and use of design representation as expressions of intent, more empirical work can now proceed to test and validate this theoretical approach. The current article has provided a starting point for such work to commence.

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References
12 Design interventions in industry and business
Designing for change in complex socio-technical systems

Lina Rylander\textsuperscript{a,c} and Magnus Eneberg\textsuperscript{b}

\textsuperscript{a} Integrated Transport Research Lab, KTH Royal Institute of Technology, Stockholm, Sweden, linary@kth.se
\textsuperscript{b} KTH Royal Institute of Technology, Integrated Product Development and Design, Stockholm, Sweden, meneberg@kth.se
\textsuperscript{c} Scania CV AB, linary@kth.se

Abstract. The purpose of this paper is to increase our understanding of how designers perceive the development in their discipline. It explores the designer’s role in working with system transformation and transition and exemplifies how design methods and processes may contribute. The research study builds on interviews and observations in a research project at the transport solution provider Scania. To contribute strategically, designers needed to work in a multidisciplinary manner, involving other disciplines in the client firm. Furthermore, the increased attention in design thinking made the client firms ask designers to facilitate interdisciplinary workshops. Today, the design offering has become more complex, and designers are involved in activities aiming for a change in complex socio-technical systems, which has led to a shift in the designer’s role, from working in an intradisciplinary manner to becoming a stakeholder in transdisciplinary work applying methods from the system thinking field.

Keywords: Complex systems, Design thinking, System thinking, System transformation, Systemic design.

1 Introduction

The purpose of this paper is to increase our understanding of how designers perceive the past and future development in their discipline, and it is about the designer’s role in working with large-scale change in complex socio-technical systems. Furthermore, we have identified an interrelation between the level of involvement and the development in the design discipline, and we consider it a comprehensible description when discussing the shift in the designer role.

Not long-ago designers struggled to make client firms understand how they could contribute beyond being the creators of aesthetically appealing products at the end of a product development process. Instead, the designer aspired to act as a resource in strategic development within customer organizations. Since then, the design industry has moved into new domains with an expanding offering, such as service design (Eneberg, 2015) and the number of designers working in the service design field has been growing fast.

Public- and business organizations are faced with complex and ambiguous challenges, such as developing environmental, economic, and socially sustainable solutions. At the same time, possibilities arise with, for instance, digital technology. New technology and large societal changes create a need and ability to handle the transformation of complex socio-technical systems, such as the health care system and transportation system. Complex socio-technical systems exist in many different contexts, and the conversation regarding changes and challenges in such systems has been discussed within the design field (Vink, 2019; Norman & Stappers, 2015; Sangiorgi, 2009).

Designers often work with changes in different contexts, and the attitude towards changes has developed over time. For example, Irwin (2015) describes it as “Historically, change has been viewed as something that can be “managed” through centralized, top-down design processes that produce
clear, predictable outcomes.”; however, when approaching complex challenges, working with large-scale changes and complexity might need to evolve, and we believe that designers have the possibility to contribute.

Lately, the interest in system thinking in a designerly context has been emphasized for sustainable challenges (Sevaldson et al., 2010), but design and system thinking do have differences in their approaches (Pourdehnad et al., 2011). Nevertheless, designers have started to apply methods and tools from the system thinking field (Jones, 2014), and Costa et al. (2019) have identified a need to integrate design methods and processes with system thinking to manage complex system challenges. One term that can be used to describe the integration of design thinking and system thinking is systemic design (Ryan, 2014). Moreover, when designing complex systems, new approaches are needed to understand changes within such systems (Irwin, 2015), and Irwin (2015) suggests that the designer needs to be aware of its role in the system. However, as an actor in a system, you cannot experience the whole system you are part of, you can only experience your way through the system (Buchanan, 2001). Thus, the challenge in integrating system thinking with design will affect the designer, and its effects on the design field are still little explored.

2 Research methodology

2.1 Overview of the data collection process

This paper builds on two explorative studies. The first study is part of a larger project we perform at Scania in which we are involved as design researchers. Scania provides transport solutions to their customers, and the focus of the project is the development of a vehicle health management system for self-driving vehicles in the company. Our role as researchers is to apply human-centered design methodology. The curiosity and openness for design methods at the company made us interested in the expectations on design and how design could contribute in this context. Furthermore, trying to increase our understanding of the designer role in transforming large-scale socio-technical systems, such as moving towards self-driving vehicles, led us to the second study in which we interviewed designers regarding their experiences and reflection on the issue.

2.2 Interview study within the company

The research project we have been working on has taken place at Scania, offering transportation solutions. The company is undergoing a transformation, from producing heavy vehicles (trucks) to developing electrified and self-driving vehicles and delivering transportation services. In other words, the company is working on disruptive innovation. During the last years, the company has started to employ design methods to develop services and digital tools, and the company has been interested in increasing, for instance, co-creation.

The purpose of the project has been to explore how the vehicle health management system will change when the vehicles become driverless, and there is no longer a driver present in the system. The system consists of, for instance, humans, technical artifacts, social frames. Thus, a socio-technical system representation can be applied to describe the system. Our role in the project has been to apply design methodology to support and increase understanding of the socio-technical system and the interactions and relations between humans and non-human actors. An illustration of the method process applied in this study is shown in Figure 21.
Figure 21. Figure illustrating the method process.

We have performed an exploratory study where we have had the role of design process facilitators and conducted two field trips and 11 semi-structured interviews with drivers and service center personnel. Moreover, we have performed three semi-structured interviews to derive fault scenarios with internal vehicle health management experts. The faults we elaborated on from the first interviews. Later, we used the scenarios during a workshop with internal experts at Scania to understand the technological perspectives and challenges further. Additionally, we have had discussions with internal experts regarding our concepts, for example, concerning the technical aspects of self-driving vehicles.

We performed the interview analysis by identifying keywords, and the notes were coded and analyzed, and through synthesizing, we developed themes regarding the driver’s role. From the interview analysis, several fault scenarios were generated and used during the workshop. The scenarios were applied as discussion triggers concerning new system design aspects. The study has resulted in a system map describing key actors in the vehicle health management process and the information flow. The system map tool has also been used to visualize different concepts, such as one where the driver is represented and another representing a new system design concept. Moreover, we have identified social aspects important for the system, such as relations, interactions, professional experiences, and unique competencies.

From our experiences in the project when adapting a service design methodology, we have developed insights that have raised questions regarding the designer’s role and the design process. Therefore, a second study was performed to deepen the discussion.

2.3 An interview study with design consultants

In the second study, we conducted semi-structured interviews with six designers working at different firms and with varying backgrounds, as presented in Table 9. The interviews aimed to obtain perspectives on the designer’s role in the design process, the involvement of actors in the design process, and the design industry’s change. Initially, from what we learned in the design research project, we identified five core themes used to formulate a questionnaire. The themes were the following: 1.) Is design education important, 2.) Reflections about the trend design thinking, 3.) Teams practicing design, 4.) The designer’s role in the design process, and 5.) Involvement of non-designers in the design process. The interviews were conducted over Microsoft Teams and later transcribed.
Table 9. Background of the interviewees

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Years of working experience</th>
<th>Educational background</th>
<th>Current working role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 years</td>
<td>Industrial and product design</td>
<td>Design consultant, Customer Experience strategist</td>
</tr>
<tr>
<td>2</td>
<td>15 years</td>
<td>Industrial and product design</td>
<td>Design consultant, Service designer</td>
</tr>
<tr>
<td>3</td>
<td>20 years</td>
<td>Visual Communication</td>
<td>Design consultant, Senior Product Designer in UX</td>
</tr>
<tr>
<td>4</td>
<td>7 years</td>
<td>Business administration and product design</td>
<td>Design consultant, Service designer</td>
</tr>
<tr>
<td>5</td>
<td>1,5 years</td>
<td>Computer science and engineering, and interaction design</td>
<td>Scania UX designer</td>
</tr>
<tr>
<td>6</td>
<td>18 years at Scania</td>
<td>Industrial and product design</td>
<td>Scania senior product and service designer</td>
</tr>
</tbody>
</table>

A digital board called Miro was used as we clustered the data. The data analysis was inspired by the Gioia Methodology (Gioia et al., 2013), and the analysis and synthesis of the material were performed iteratively. First, we wrote quotes and keywords on digital post-it notes and created clusters to analyze the data. Then, in the synthesis, we developed themes. Later, the themes were related to literature to conceptualize the findings. An illustration of the analysis process is presented in Figure 22.

![Figure 22. Illustration of the data analysis loop inspired by Gioia (Gioia et al., 2013).](image-url)

The research method we have applied in this study has been limited by the Covid-19 pandemic, and integrative methods could have been used. Such examples are focus group interviews with designers or collaborative workshops among different stakeholders at Scania. For example, a focus group interview with designers could have been valuable to discuss the different perspectives and experiences among the respondents. However, to overcome the limitations of non-physical meetings, we decided to spend much time on the interviews and gather respondents with different backgrounds. Moreover, the literature study was an essential part of contextualizing and bringing relevant insights to the study.
3 Moving from intradisciplinarity towards transdisciplinarity

3.1 A pursuit of having a strategic impact

The application of intradisciplinary work can be described as work performed within one discipline (Stember, 1991). In a designerly context, it can be exemplified by design work that does not require a high level of involvement of other stakeholders. The designer mainly focuses on reaching out to, empathizing with, and acting as the end-user’s spokesperson. Here, visualization tools are mainly used to communicate the results of the design process.

During the industrial era, the offering of the designer was limited to a sequential value chain logic in which designers were commissioned to add value at the end of the product development process (Eneberg, 2015). Morelli (2002) argues that “Designers’ activities usually have focused on material artifacts (…) rather than on systemic solutions including services”. At the same time, the design industry struggled to move into new domains beyond working with functional and aesthetically appealing products (Eneberg, 2015). The aim was to move from an operative role and contribute to the strategic development of client firms.

When applying design in the strategic development of client firms, the client must understand how design as a process can contribute beyond the aesthetically appealing product. This was discussed by one of the design consultants:

“When you start to see design as a way of working, you can start designing anything. Design an organization, a product or a service, an information campaign, a business strategy.” (2)

Through our studies at Scania, we have identified that the main focus in the design process has been on ergonomics, functionality, and aesthetics. In addition, the truck driver has often been involved, giving input on the design process to create an environment based on the user group’s needs. During the interviews with designers at Scania, it was mentioned that there had been a shift in the design department regarding the level of involvement of end-users, which is related to different design disciplines. At several departments at Scania, the designer’s role has not changed; for example, designing the truck’s appearance is still an important task. Nevertheless, in other departments, the design tasks have changed focus, and designers work more strategically, closer to other disciplines.

3.2 Increased level of involvement

For the designer to have a greater strategic impact in client firms, the designer must be involved earlier in the product development process and work closer to other competencies inside the client firm; hence, multidisciplinary work is needed to engage several disciplines. Choi & Pak (2006) states that “Multidisciplinary draws on knowledge from different disciplines but stays within the boundaries of those fields.” In a designerly context, multidisciplinary work could be exemplified with methods like interviews, observations, and exploratory workshops with participants from different departments in the client firm. The aim is knowledge acquisition and combining different perspectives to understand the problem to be solved, such as understanding activities and interactions in client firms to add new insights to the design process (Buchanan, 2001). This was exemplified in the interviews:

“it is about getting in the statistician’s competence and perspective into the design work.” (2)

“But before these meetings, you must explain to them that everyone should go into their roles, you should not pretend to be a designer, so they feel comfortable in such a context.” (3)

“if the client has a customer service where they receive many comments about the service or product. (…) I often try to access customer service” (3)
To achieve multidisciplinary involvement in the design process, the clients need to comprehend how design can contribute beyond the product, focusing on the process and how it means working in a “designerly way” (Cross, 2006). As design thinking received increased attention in management, it also paved the way for the design industry to raise awareness among clients about how design methods and processes may enhance interpretation and collaboration between multiple stakeholders. In our study, collaboration was described as nourishing to the design process, and the design consultants described that multidisciplinary teams support innovations and give flavor to the solutions:

“Secondly, you minimize risks and solve problems to a greater extent, and solutions can be improved by becoming more ‘bulletproof’ and/or more ‘flavorful’.” (1)

Nevertheless, working in multidisciplinary teams can sometimes be challenging, and developing approaches to work together may be difficult (Choi & Pak, 2006), implying a need to find tools that facilitate the discussions. One design consultant exemplified this:

“The most challenging projects are where people with different competencies work together. And there can be tug-of-war and long discussions. But when you manage to get all the competencies together, it gets so much better.” (2)

We found that visualization is an essential tool in the design process to communicate with other disciplines participating in the design process. Furthermore, with the help of trigger material, visualization can also be used to explore new conceptual ideas and develop new knowledge and perspectives.

One design competence that has received increased attention at Scania is UX design focusing on digital support systems and technical tools that support tasks at the truck workshop. The designers involve system developers and workshop personnel in the design process to understand their perspectives and increase the understanding among developers on how technical systems can be developed to satisfy users’ needs. The UX designer we interviewed at Scania describes the collaboration as:

“If there are larger functionalities [to be implemented in the technical system], you need to involve developers, and of course, product owners to see that you have thought right when it comes to the process. (…) For us, it is quite obvious, but you have to ask those who will code it in the end so that it is feasible. So, it is much juggling between us designers but between developers and product owners as well.” (5)

Exploring end-user needs and experiences is not only a method to support the designer with knowledge, but it also mediates knowledge and perspectives among other disciplines. As UX design has gained more focus in the company, it is notable that UX designers collaborate with more disciplines within the company than designers traditionally have done at Scania. Surprisingly, even if a focus on the end-user always has been important in the design process, the study shows that the product designers working at Scania continue to work more independently with design within the design team. In contrast, UX designers are part of the development team and involve the end-users and other disciplines in the design work more frequently, or as a senior designer at Scania expressed it:

“The big change I experience, what I mentioned with UX, is how UX has grown so that all the micro-interactions have become a larger part of our interaction with the users than before.” (6)

Moreover, the UX designer at Scania pointed out that the UX designer’s role may need to increase their knowledge in business, as they work closely with the market department:
“In general, I also think, as a UX designer, I must also be able to keep track of how business works as well. Before, it may not have been so, but it is also a trait that is becoming important, as I understand it. That you have an understanding of business and not just the users.” (5)

We, as researchers, are studying systems and actors involved in the vehicle health management process of self-driving vehicles. Our study started with a multidisciplinary approach that aimed to increase our understanding of the actors involved in the system, such as truck drivers and workshop personnel. We performed interviews, and the purpose was to provide us with insights into our design process and gain different perspectives on the vehicle health management process, such as problem-solving, interactions, and the fault handling process. When analyzing the data, we realized that the vehicle health management process is much more complex than we first thought. The company offers many services, and the network surrounding the vehicle health management system consists of many actors, both human actors but also different kinds of artifacts and technical systems. Therefore, we realized a need for more integrative methods such as organizing co-creation workshops to increase our and the company’s understanding of the problem.

The increased collaboration in the UX field is one example of how designers today are involved throughout the development process and work as a glue between different disciplines. The increased level of multidisciplinary collaboration has also raised a desire among management and other disciplines in the company to know more about the design thinking process.

3.3 Management consultancies acquiring design consultancies

Lately, large-scale management firms have acquired design agencies, and design has been identified as a tool to work with a high level of complexity. Such examples are disruptive innovation and sustainability challenges. Thus, management firms have identified the design discipline’s contribution in this area. However, two of the design consultants expressed a worry about the effects the development of being part of management consultancies will have on the design industry and the designer’s role in the future.

“Innovation and new ways of working can be lost. That you continuously push the [design] industry forward. Many small independent agencies stand for what makes us unique, and they are more of pioneers. I think that will be lost.” (1)

“If the smaller studios stop existing, it will be a little more boring, if you understand what I mean. We need both. We need diversity.” (3)

In transition design, designers act as agents for change (Irwin, 2015), and management firms may have the power and resources to enable new ways of designing for change. Two examples where the support from management firms may contribute are disruptive innovation and digitalization.

“But it depends on what the future needs. But the future may need a larger holistic approach sometimes. Larger budgets so you can build bigger platforms.” (1)

Being part of a large management firm may enable designers to engage in large-scale projects with many diverse participants, which can be challenging to offer as a smaller designer agency. In addition, the “power” of belonging to a large organization may support operating design projects from the beginning to implementation. One respondent, however, questioned if belonging to a larger organization will lead to the desired effect.

“Disruptive is good, but it is difficult to establish it in the large organization” (1)
3.4 The designer as facilitator, teacher, and coach

Design has moved from being understood as a relieving service, that is, that the client outsources the aesthetics aspect of a product, to an enabling service (Eneberg, 2015). Enabling entails, in the context of service-dominant logic, shared learning activities with the aim to perform a task in a new and better way (Normann, 1992, 2001; Vargo & Lusch, 2008). Although an enabling design service may consequently result in organizational learning and change in the client company, it may also result in a need for a higher degree of involvement where participants from the client organization actively participate in the design process (Eneberg, 2015).

“They [the clients] are much more involved in the design process these days than they were 5-10 years ago when we saw ourselves as the design experts.” (2)

A service can be regarded as an interactive process that needs planning and organization where all actors in the system are considered (Morelli, 2002). Therefore, several parts of an organization may be affected by the design process, not the least due to the different touchpoints between the customer and service provider, which were exemplified by one of the design consultants:

“(…) and look into how several channels are connected. We can not only solve it on the web, but the web is connected to perhaps a physical product that is connected to a store that is connected to an information letter.” (2)

As mentioned previously, exploratory workshops in a multidisciplinary context may support the designer in defining the problem space or exploring new conceptual ideas. Workshops can also be used as a method to enable co-creation among different disciplines in the client firm. Sanders & Stappers (2008) argue that co-designing teams will increase in diversity, for instance, involving different stakeholders in the design process. This type of involvement can be described as interdisciplinary or, as Choi & Pak (2006) illustrate it: “Interdisciplinarity analyses, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole.” and design methods, such as workshops, may enhance sensemaking and collaboration between the actors involved (Eneberg, 2015; Jahnke, 2013; Verganti, 2009). By creating conditions for affordance, that is, supporting an environment that allows the individual to perform actions in shared activities (Greeno, 1994), the designer may facilitate the opportunity for different thought networks to merge and be reshaped, such as changes in mental models (Vink et al., 2019).

As the client offers more complex services to their customers, a desire to integrate the design process into their development processes has emerged. This can be exemplified by Scania, which is undergoing a transformation in the technical area, namely developing electric and self-driving vehicles, which also leads to a need to transform how they are organized and with whom they collaborate. We were asked to facilitate a design project focusing on one of the services that will be affected by the transforming technology, and service design is seen as a tool that can be useful to tackle this transformation. When the project we participate in at Scania started, we experienced a desire to learn more about service design. We were asked to arrange courses to share our design competence with engineers within the research and development department.

Designers are more often commissioned to take the role of a facilitator to enable inter-organizational collaboration, co-creation, and co-designing, such as in workshops. Besides, the designer’s role is also moving towards being a coach and teaching the design process and methods to the employees in the client organizations, as mentioned in the Scania example and the interviews with design consultants:

“I am there as a coach and say that now you should hold interviews, and then you should do this. And it is hard. I think. It is challenging.” (4)
There is a significant difference between working with aesthetics and functionality in product design and taking a facilitating, teaching, or coaching role in client firms. As in every profession, designers are individuals with different motivations and driving forces.

“Some designers work as experts, and some work as facilitators.” (2)

“A designer is, for me, someone who can collaborate and give nourishment to the collaboration.” (1)

“It is difficult to tar every designer with the same brush. Some designers do not like to work with mixing competencies.” (1)

Hence, the design profession and the different expertise designers provide are increasingly becoming more heterogeneous as the clients have become aware of the strength of the design process and its methods.

A possible effect of introducing design thinking in the management field is that people that do not have formal design education start practicing design. Respondents in our study had different opinions regarding this development. One positive consequence is that it may create a cumulative understanding of design. However, it can be challenging to learn the design mindset, which two design consultants discussed:

“It cannot be done by someone who does not have any kind of experience or background or education or understanding or has practiced any kind of design.” (4)

“It has been a great challenge with people who do not have design skills, not always, but idea generation often has higher quality with those who are trained in it. To be careless and to be daring. It is sometimes challenging to focus on ‘the new’ with people who are in a comfort zone.” (1)

Another issue raised by the designers was that when educating others in design, the designer will need to compromise on the design process and the results.

“If it is to be both a learning project and the result is important. Then there will be a huge conflict within me (…) if you have a person who has done 40 projects, design projects, and if you have three people who have never heard of design before, it will not be as good.” (4)

“It takes more time to include non-designers. It is a higher investment. It will be a compromise on which results you want.” (1)

Design offerings have moved from physical and digital artifacts to experiences, environments, and systems. Here, visualization is still an essential competence used by the designer; however, its application has widened when used to facilitate co-creation and co-design in an interdisciplinary context. Visualization tools are used as mediating artifacts that support intra- and inter-organizational collaboration and explore different perspectives, combinations of problems, contexts, and solutions.

“You may have prototypes and visualizations that you engage with and facilitate the discussion with.” (4)

“To visualize and create a shared image was very important in order to unite the organization and focus their skills or expertise around a common goal; It was all about the visitor’s perspective.” (2)

“The visualization supports us in communication. It gives consensus on what one can create.” (1)

We have identified a need for a systemic approach in the Scania project. Today, when performing fault handling and troubleshooting of trucks, many actors participate in the process, and several parts of the organization are involved in developing tools, instructions, and technical functionalities on the
vehicles. In addition, the system’s complexity has increased with developing self-driving vehicles, and the system will need to adapt to new needs when the system is changed. As discussed in the interviews with the design consultants, visualizations are used as a communication tool to enhance discussions, create reactions, and present insights. In our research project at Scania, visualization has been a vital tool to co-create and get a common understanding of the system and the actors involved. For example, a system map may include an organizational presentation of actors and their interactions. However, a significant contribution by the designer is adding and illustrating the experience, needs, driving forces, and motives among participating actors. Different scenarios have been used to illustrate current needs in the research project. During a workshop, these scenarios were used to trigger discussions and enhance understanding among different disciplines.

3.5 Ever-increasing complexity

Not many years ago, companies stated that self-driving vehicles, such as trucks or taxis, would soon be a reality. However, it has been obvious that it will take a much longer time than they first thought. The industry has realized a need for collaboration between system actors, such as policymakers and companies. Two examples of such collaborations are Scania and TuSimple or Volvo with Aurora. The need to extend partnership collaboration beyond industry is an essential strategy and to evolve from being a provider of products to being a service provider within integrated mobility (McKinsey, 2016). As more complex functionalities are added in driverless and self-driving vehicles, troubleshooting becomes more challenging (Lanigan et al., 2011). Also, business models and services will change according to new business solutions and customer needs. Consequently, complexity increases with new touchpoints, and more actors are involved, for instance, policymakers. A holistic view is needed since the change will transform the transportation system with immense effects on society.

The concept of socio-technical system highlights the need to consider both technical and social aspects of the system. With inspiration from (Geels, 2005), the socio-technical system of goods-delivery transportation can be described as a system that consists of technology, such as technical systems and vehicles; regulations, policies and working regulations for drivers; user-practices and markets, as requirements from the driver and haulage contractor; maintenance networks including workshops and service network, and cultural aspects as working culture, norms, and institutional arrangements. Furthermore, understanding and supporting large-scale system changes the different contexts and perspectives affected by the change need to be considered, which can be exemplified by taking ethical consideration in disruptive innovation, such as self-driving vehicles (Sparrow & Howard, 2020).

The increased complexity in designing systems may need a new approach, where the level of collaboration, co-creation, and co-designing changes from that of being interdisciplinary to transdisciplinary. Transdisciplinarity is a key concept eliciting non-traditional perspectives, cross-fertilizing assumptions, and forming new holistic approaches. For example, Choi & Pak (2006) describe transdisciplinary as “In transdisciplinary teams, not only goals but skills are shared (…) through role release and role expansion, transcends (hence “trans”) the disciplinary boundaries to look at the dynamics of whole systems in a holistic way.”

In a design context, this could be described as disciplines working beyond existing boundaries.

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“But in the future, maybe design thinking, or this thing to involve users and customers continuously in the development process is done by more people. Not just those who are educated designers. I hope it will be a natural part of any development process.” (2)

The concepts transition and transformation are often used to describe a large-scale change in complex socio-technical systems, and in both cases, the agency is described as a multi-actor process enabling innovation, learning, collaboration, and knowledge integration (Hölscher et al., 2018). However, there are contextual differences in which the two concepts are used, and Hölscher et al. (2018) propose a description of the differences regarding how the concepts are applied.

Transformation as a concept is often used when the focus is on change processes in society, intending to identify emergent change patterns and their consequences. Individuals’ motives, driving forces, and values supporting a transformation focus on avoiding undesirable system change.

On the other hand, transition is used when describing how changes in complex adaptive systems occur with a stronger focus on change in socio-technical aspects and disruptive innovation to enable a sustainable transition in the subsystem.

3.6 Design enabling transition and transformation

In the study, we identified that the system focus has been accentuated in importance for the design industry and applying a system approach in design might influence how the designer work. One design consultant discussed how the involvement of actors outside the organization might be one way of handling the complexity and avoiding the development of unsustainable products and services:

“I think it is very important to include other actors outside the organization. (…) it can be other companies or public organizations (…) if you just stare blindly at user needs, you can create quite unsustainable solutions (…) So, this is where systems thinking comes in more and more.” (4)

Irwin (2015) argues that new approaches are needed to understand changes within complex systems. Inspired by the work of Hölscher et al. (2018), we have identified essential aspects in the design competence that may support transition and transformation in complex socio-technical systems.

Designing for transformation would imply a need to identify emergent change patterns. Bottom-up approaches targeting the micro-level perspectives are often used in design practices, not the least to understand the end-user. Searching for patterns is an essential tool when working with conceptualization (Vink, 2019). Hence, using a micro-level perspective would support our understanding of motives, driving forces, and values of individuals and emergent patterns which may lead to undesirable changes when the system is transformed.

However, only focusing on the micro-level could lead to a loss of a holistic perspective and overview of the socio-technical system. Users in a system cannot experience the whole system they are part of; they only experience their pathway in the system (Buchanan, 2001). A proposal is a framework that includes methods and tools that support designers both from a micro and a macro perspective (Vink et al., 2020). The design of socio-technical systems demands multi-directional processes, which often are conflicting, and the different perspectives must be zoomed in and out (ibid). Disruptive design interventions involving actors affected by large-scale system changes may also lead to changes in the mental models among the individuals and teams participating in the joint activity (Vink et al., 2019). This may also result in new transdisciplinary knowledge in the sense that assumptions are cross-fertilized and form new holistic approaches that can lead to disruptive innovation. The design intervention itself is essential; therefore, we argue that the designer performs actions in the design process that correlate with the characteristics of working with transition and may enable a sustainable transition in a subsystem.
The designer’s future role is difficult to anticipate. However, in the study, we identified a desire among designers to work with disruptive innovation and sustainable transitions:

“We have to start adjusting. We may not have to produce new ones all the time. Look at removing or replacing. This can be difficult to convince sometimes.” (1)

“I think it is good if the tools and methods can help organizations as forward and create better experiences and sustainable experiences.” (4)

The sustainable aspect is vital as the long-term effects of the design process influence a sustainable mindset, not only from an environmental perspective but also from the system effects of new designs. Moreover, there are still many areas where design is not applied today, enabling further exploration of the design approach and design applications related to system thinking. One respondent said that:

“Where we are not is in policymaking, politics, and laws, or agriculture. There is still a lot of unexplored lands.” (1)

The design discipline will need to collaborate with other disciplines not previously involved in the design process, such as system engineers. Combining design methods with methods used in other disciplines may support the designer in their pursuit to contribute to a sustainable transition in society. Sustainable challenges have enhanced interest in system thinking within the design context (Sevaldson et al., 2010) and designers have borrowed tools and methods from system thinking, for example, integrated methods and meta-design frameworks (Jones, 2014). In a sense, it can be deliberated upon if the process and methods used in transforming large-scale transitions should be called design thinking or if it is even relevant.

“Design is a collective name for something you do. If you have a word for it, you can talk about it. Maybe it is good that there is a name for it. You can put an epithet on the activity. But if it should be called design or user-centered development or design doing or design thinking… I do not know…” (2)

In literature, the integration of system thinking and design thinking has been termed systemic design, and it has also been discussed if systemic design should be its own field (Ryan, 2014). Another point of view could be to understand systemic design as an offering or problem space where the designer’s competence can contribute to system changes. Also, the integration of system thinking and design thinking might affect the designer’s role, and Pourdehnad et al. (2011) accentuate a difference in system thinking and design thinking, where stakeholders in design thinking are involved in enabling the designers to learn from the stakeholders when in systems thinking, the designer is a stakeholder. Being a stakeholder rather than understanding other actors may contribute to a search for identity within the design discipline.

4 Conclusion

The designer role has evolved, and today designers are also engaged in facilitating, teaching, and coaching the design process in client firms. This shift is in many ways related to an increased need for sharing perspectives and methods between disciplines and the importance of collaboration, co-creation, and co-designing of new knowledge to solve ambiguous problems.

One field that is receiving much interest from the design discipline is system thinking. We argue that designers would benefit from collaborating with disciplines as system engineers. Combined methods used by designers and system engineers may have the capacity to support and reach for change in complex socio-technical systems. Besides, the need for a system perspective in design relates to system change and how it is described in transformation and transition literature. There are methods
in the design process that are relevant for both systemic transformation and transition, and it has been accentuated that designers need to iterate between macro and micro perspectives. In the context of system transformation, the designer may contribute by identifying patterns in the interaction among the actors involved in a system and their relations, motives, experiences, and driving forces. This may contribute to avoiding undesirable change. The designer’s focus is then identifying patterns. Further on, disruptive design interventions may be used to provoke reactions and open up for a sensemaking process. Here, the aim is to increase the understanding of mental models that may hinder a sustainable system transition on a macro level.

Today, designers work with tasks that demand different levels of involvement and collaboration, which can be put on a scale extending from intradisciplinarity to transdisciplinarity. Moreover, the emergence of systemic design has shown a search for an identity in the design discipline, and as system thinking has received more attention in the design discipline, the designer’s role has changed. In intra- multi- and interdisciplinary involvement, the designer engages with others to understand them, but when engaging in transdisciplinary work, the designer’s role change from engaging with others to becoming a part of the system themselves. The relevance of the search for identity should not be diminished or disregarded; on the contrary, we need to continue the discussion about how the design discipline can or should evolve. Questions such as “Who is a designer?” and “What is design?” are highly significant as the designer becomes an agent and co-creator in complex socio-technical systems. However, the focus needs to be broadened and also include how design can contribute to sustainable system transformations and transitions, which the study has shown that the designer both wants to and already participates in today.

Acknowledgment
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References


Design thinking and innovation in SMEs: A systematic literature review in terms of barriers and best practices

Fatma Demir, Irina Saur-Amaral and Daniel Ferreira Polónia
University of Aveiro, fatma.demir@ua.pt, isaur@ua.pt, dpolonia@ua.pt

Abstract. All over the world, SMEs are considered as a key part of the economic fabric. Once limited to their domestic markets, since the late 1990’s they have been exposed to a globalized marketplace, with more demanding customers and fierce competition. This exposure has become a significant challenge to SMEs, since most of them have limited resources and capabilities that frequently lack the ability to create and maintain a structured innovation management system. In that context, the paper performs a systematic literature review on the relationship between the Design Thinking, innovation, and competitiveness in SMEs. 308 papers published between 1998-2021 were obtained after searching Web of Science, and they were analyzed from the bibliometric and content perspective. 70 papers were obtained after applying all exclusion criteria. Results point to the need to develop an innovation framework for SMEs, integrating DT processes and aligned with corporate strategy.

Keywords: Design Thinking, Innovation, SME, Systematic literature review

1 Introduction

New technologies and changing markets are creating new challenges and opportunities for companies (Goerge & Schoemaker, 2016). In the search for new solutions, the importance of corporate innovation management is increasing - even for small and medium-sized enterprises (SMEs), that often lack resources to face these new challenges, even though they play a key role in the economic fabric of nations and will remain so in the expected near future (van de Vrande, de Jong, Vanhaverbeek, & de Rochemont, 2009). Especially for SMEs, the standard tools or approaches for innovation management are unsuitable and outdated (Assink, 2006). Design thinking meets the needs of SMEs in terms of innovation capacity by promoting user-centricity and creativity, as well as uncovering unknown potential. For SMEs, a creative approach to innovation development, such as Design Thinking, is therefore even more important and profitable (Assink, 2006).

There are three main motivations for choosing a literature review: the kind of research interest, the characteristics and coverage of previous reviews, and the information explosion (Williams, Clark, Clark, & Raffo, 2020). Maintaining an overview in specialized fields proves difficult given today's information explosion; necessary information is often hard to find. The identified research gap addresses a growing interest but a lack of overview of the field of Design Thinking in SMEs, as well as the innovation capacity (van de Vrande, de Jong, Vanhaverbeek, & de Rochemont, 2009). A research interest in this regard can in principle be answered with literature reviews, as they create an orientation service, show connections and disputes of previous works, and create an understanding of theoretical phenomena and terminology of the field (Williams, Clark, Clark, & Raffo, 2020). Previous literature reviews do not adequately fill the research gap, as demonstrated by the corresponding systematic literature review results in the following section.
The selection of a specific systematic review methodology, especially in terms of its complexity, depends on the principal research objective and the general restrictions of the research context (Crossan & Apaydin, 2010).

This insight will help researchers to have more realistic expectations of Design Thinking and innovation processes in SMEs through the systematic approach and will help mentors to guide newcomers through the phases of planning, implementation, and documentation (Carver J. C., 2013). The most important initial considerations for the preparation of the systematic literature review relate to the formulation of a clear, focused research question, as all subsequent processes depend directly on its formulation (Okoli & Schabram, 2010). A broad research question can be chosen for the review, which corresponds to the overall aim of the review (Wardati & M., 2019). Since this work is interested in capturing the full scope of the research field, as well as specifically the developments in innovation strategy, the research questions are intentionally broad.

− Which external sources of knowledge in research papers contribute to the definition of a Design Thinking innovation strategy and how can they be systematized?
− Which obstacles and barriers lead to the failure of implementing systematized innovation management systems in companies?
− How has the scientific output of the Design Thinking innovation strategy evolved in relation to SMEs?

To answer the questions posed, the paper is structured as follows. First, we introduce the concept of Design Thinking in SMEs. Next, we present the methodology and results of the systematic literature review. Finally, we discuss the results and present the conclusions.

2 Design Thinking as a creative development approach in SMEs

In SMEs, the support of the entrepreneur(s) is the basis for the implementation of Design Thinking. This point is more crucial than in large companies or corporations, because it can be assumed that in SMEs the chance is smaller than Design Thinking can be introduced in a single department without the knowledge and approval of the entrepreneur. The entrepreneur in an SME is responsible for the successful implementation of innovation strategies, like Design Thinking (Mortati & Cruickshank, 2011).

This is not possible without any assistance and responsibility from the entrepreneur. While in a large company an implementation, especially at the beginning of the project, can be done on a small scale and with first project results the support of top management can be gained (Judy & Savatore, 2011), in SMEs the strong focus and involvement of the entrepreneur in operations is a prerequisite for the implementation of Design Thinking (Geldermann, Lerche, & Sepulveda, 2018).

If, in addition to the operational business, there is little time for the creation and use of reflective Design Spaces (e.g., as a relocation of the Design Thinking space, into a cloud-based virtual space) (Lim, Kim, Kim, & Kim, 2019), it can be assumed that the willingness to deal with an approach that is probably unknown to the entrepreneur and does not correspond to regular business thinking is rather small (Moultrie, Clarkson, & Probert, 2006).

For the successful implementation of Design Thinking in SMEs, further success factors specifically tailored to SMEs are required. Time resources and budget are essential for successful innovation implementation (Acklin, 2013). But here, too, the prerequisites of SMEs and large companies differ: In large enterprises, there are often specific research and development departments (also creative spaces) as well as innovation managers or Design Thinking experts and thus places and people whose tasks include evaluating new approaches such as Design Thinking (Acklin, 2013). In SMEs, employees usually do this at most besides their daily activities at work, and there are fewer specialized departments with experts. Also, SMEs are usually very cautious about implementing
innovative strategies such as Design Thinking without knowing the exact benefits beforehand (Acklin, 2013). Large companies, on the other hand, are more likely to give the search for optimization and innovation the necessary space.

3 Systematic literature review: Innovation strategy Design Thinking in SMEs

3.1 Research design

The basis for this work is a systematic literature review, a methodology that differs from classical reviews in that it aims to synthesize research in a systematic, transparent and in an iterative process (Crossan & Apaydin, 2010). The idea behind systematic reviews is characterized as follows: they are transparent, focused, equal, and accessible, provide concreteness, perform homogeneity of research and practice communities. These lead wholly to a synthesis. It provides a manifesto for science and for practice, as the compilation of knowledge research is systematically managed.

The goal of our systematic review is to structure the field of research on Design Thinking and innovations in the context of SMEs, to identify researched topics, to list the most important research gaps and thus to contribute to theory development.

A systematic review includes both a quantitative, bibliographic analysis and a more qualitative, thematic analysis (Saur-Amaral, Reis Soares, & Proenca, 2018). Although systematic reviews can include other types of publications, we followed other researchers and focused on peer-reviewed academic journal articles in English to ensure quality and reduce the sample to a manageable amount.

In terms of the time frame covered, we argue that Design Thinking has received considerable attention and strong interest in implementation from practitioners and international researchers since Brown published "Design Thinking" in the Harvard Business Review (Brown, 2008). To illustrate this trend, data from previous years was included in the analysis. Therefore, the review covers academic papers from 1998 to 2021.

3.2 Data collection

To identify the relevant innovation literature on Design Thinking in SMEs, a systematic literature review was conducted. The first step was to define the search terms for this literature abstract and keywords. The exact search terms are listed in a structured review. The large database Web of Science for the years 1998 - 2021 is searched with the linked search term from the exact word sequences “Design Thinking” AND “Innov*” in title (see Table 1). The language "English" is selected for the search. To ensure the quality of the literature contributions, only ISI/WoS indexed journals are included in the analysis.

Table 10. Exact search term for the systematic literature review

<table>
<thead>
<tr>
<th>Database</th>
<th>Exact search term</th>
<th>Number of articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web of Science – Current</td>
<td>“Design Thinking” AND “Innov*” in Topic</td>
<td>308</td>
</tr>
<tr>
<td>Contents Connect</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All searches were conducted on April 4, 2021

Search queries to the Web of Science database and initial hit lists were used to refine or, if necessary, extend the search terms used (see Table 2). This initially served to obtain a rough overview of the amount of literature available. Central works in the selected subject area and specific journals with complete table of contents and bibliographic information were then used as points of reference. Consequently, the search terms were evaluated based on a cursory scan of the results.
Table 11. Preliminary search terms for the systematic literature review

<table>
<thead>
<tr>
<th>Search term</th>
<th>Results</th>
<th>Purpose</th>
<th>Criticism</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Innov*&quot; (Current Contents Connect)</td>
<td>169,307</td>
<td>Edition of all works that contain a combination of words all about &quot;innovation&quot;, &quot;innovate&quot;, &quot;innovative&quot; etc. included</td>
<td>Too many hits, not very specific, usually wrong context</td>
</tr>
<tr>
<td>&quot;Innov*&quot; AND &quot;SME*&quot; (Current Contents Connect)</td>
<td>2,804</td>
<td>Restriction of the works from the first query to those containing the term &quot;SME*&quot;</td>
<td>Too general, context continues to vary greatly</td>
</tr>
<tr>
<td>&quot;Design Thinking&quot; (Current Contents Connect)</td>
<td>602</td>
<td>Overview of the hits on the topic Design thinking in general</td>
<td>Consolidation of the topic of Design Thinking without direct reference to the topic of innovation</td>
</tr>
<tr>
<td>&quot;Design Thinking&quot; AND &quot;Innov*&quot; (Current Contents Connect)</td>
<td>308</td>
<td>Specification of the previously made request. Limitations to works that are explicit engage in Design Thinking in the field of innovation management.</td>
<td>Strongly limited search space</td>
</tr>
<tr>
<td>&quot;Design Thinking&quot; AND &quot;Innov*&quot; – related to specific research areas</td>
<td>70</td>
<td>Sample of selected articles to analyse and import to NVivo</td>
<td>Very Strongly limited search space, for importing it to NVivo</td>
</tr>
</tbody>
</table>

It turned out that with a sufficient specification of the search queries, the result area could already be narrowed down to a manageable scope. However, the results still proved to be too general, which is why the queries were subsequently specified again. The investigation was finally limited to the results obtained by linking the terms "Design Thinking" and "Innov*". After eliminating the duplicates, 308 articles remained.

In the following analysis phase, the collected works were exported to Endnote and NVivo and examined them. In addition to extracting potential knowledge sources, specific content for SMEs was filtered out. Likewise, barriers or failures of innovation were selected to show a powerful tool for elimination through failure analysis. These instruments were extracted from the articles using content-based data analysis.

The aim of this systematization was to synthesise the results and to identify differences, similarities and failure factors of the innovations and its need for research. This was used to identify all 308 literature entries and transfer them to Endnote and create an Excel list. Afterward, the entries in Endnote were searched for duplicates and removed. Of the 308 papers, the title and abstract were checked for their content relevance and relevance to Design Thinking and innovation, and entries that did not match were removed.

The following exclusion criteria were applied: (1) contributions that considered Design ashuman-centered problem solving; (2) those that dealt with the specific design of things, methods, or products; (3) those that were purely located in Design Science, for example, advancing specific methods or dealing with the mindset of designers, and thus not concerned with the application of Design Methods for innovation; and (4) those that applied the term "Design Thinking" generically and especially in SMEs. It left us with a final sample of 70 literature entries that were included in the analysis.
3.3 Descriptive data analysis

A descriptive analysis of the 308 articles revealed that the first article from the sample that linked Design Thinking and innovation appeared in 2007 (see Figure 1). From 2008 onwards, an increase in the number of articles can be observed, which might be attributed, among other things, to the Special Issue of the Harvard Business Review from 2008 with the much-cited (1,060 citations) article "Design Thinking: Thinking like a designer can transform the way you develop products, services, processes - and even strategy" by IDEO’s CEO Tim Brown and the resulting increased interest in the topic (Brown, 2008). In 2020, there was a peak of 77 contributions.

![Year of publication](image)

**Figure 23.** Publications per year

Figure 2 considers the 152 most frequently occurring journals. The journal with more publications is Design Journal, by far a regular in the publications associated to Design Thinking and innovation, followed by International Journal of Engineering Education, Creativity and Innovation Management, Journal of Cleaner Production and Sustainability. As the year 2021 is not yet complete with research and its publications, the data in the graph is decreasing.
3.4 Content analysis

We read a total of 308 abstracts and excluded 238 papers that included the topics used in the search but did not address the innovation approach in terms of feasibility in different sizes of firms as a central topic area or as part of their theoretical innovation aspects. For a better illustration, an Excel file was created for the 308 articles and a graphical representation was realized for a better analysis (see Figure 2).

The elaborated final selection contains 70 articles published between 1998 and 2021. Detailed content analysis in NVivo was conducted based on the final sample, which directly related to Design Thinking and innovation. The process included thematic coding to determine the main attributes of Design Thinking, looking in detail at the SMEs.

We chose the Design Thinking criteria for the development of the framework. First, we assessed the criteria and how they related to the topic, based on ambiguity. Our research team came to a common understanding that there was little or no talk about failure factors or failure of general innovation and Design Thinking projects. Therefore, criteria related to these aspects were further considered. We then identified two groups: failure of Design Thinking interventions as a parameter related to direct and indirect shortcomings in the articles (e.g., lack of understanding, lack of flexibility) and those that can be crystallized by notable successes (e.g., management support, customer-centric).

The factors for the analysis were specifically adapted to SME characteristics. Attention was paid to the following SME-typical characteristics.

1. SMEs are characterized by the personality of the entrepreneur or the entrepreneurial family, who often combines management and entrepreneurship. Accordingly, SMEs are more dependent on the leader or the management body than a large company is on the board of executives (Kammerlander, Burger, Fust, & Fueglistaller, 2015).
(2) In SMEs, it can be observed more frequently than in large companies that the managing directors carry out operational activities and are thus less able to concentrate on management activities. Strategic instruments are rarely used in SMEs compared to corporations. The less intensive involvement with strategic activities is not necessarily a conscious choice. This poses a major challenge, as time is found for innovative topics or the intensive examination of the future of the company in addition to the varied tasks in day-to-day business (Gasda & Fueglistaller, 2015).

(3) Many employees in SMEs are skilled workers who are trained within the company itself. Both entrepreneurs and employees in SMEs are highly involved and often busy with their own work. Accordingly, innovations require additional capacities, which are rarely available in SMEs. But Design Thinking, which ideally involves people from several departments due to its interdisciplinarity and also challenges the usual analytical business thinking, could be particularly difficult to implement due to this SME characteristic (Liedtka & Ogilvie, 2011).

(4) Faster product lifecycles and constantly changing technologies require an agile approach that sometimes exceeds the flexibility that SMEs are granted. As a result, there is little time for implementing ideas alongside day-to-day business (Sarooghi, Sunny, Hornsby, & Fernhaber, 2019).

(5) In most cases, small and medium-sized enterprises are more limited in their financial possibilities than large companies, which is especially noticeable in investment projects. SMEs are heavily dependent on the invested capital of the business owner (Kammerlander, Burger, Fust, & Fueglistaller, 2015).

(6) In SMEs, the entrepreneur often knows all employees personally. The company structure is lean, the hierarchy levels are usually flat, and the degree of formalization is low (Durst & Edvardsson, 2012).

From this selection of SME characteristics, the criteria of Design Thinking in SMEs are formed and extracted in research papers.

<table>
<thead>
<tr>
<th>N.°</th>
<th>Mandatory Necessary</th>
<th>Explanation</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Management support for the DT team</td>
<td>In SMEs, the chances are smaller that Design Thinking can be introduced in a single department without the knowledge and approval of the entrepreneur. It is imperative to have the commitment and support of the entrepreneur for the project to be successful.</td>
<td>Appleyard, Enders, and Velazquez (2020) (Bason &amp; Austin, 2019) (Crites &amp; Rye, 2020) (Eppler &amp; Kernbach, 2016; Lee &amp; Ma, 2020; Snyder, Ingelsson, &amp; Bäckström, 2018) (Vagal et al., 2020)</td>
</tr>
<tr>
<td>2.</td>
<td>Time Resources</td>
<td>In SMEs, employee involvement in the innovative process is usually developed on the side at most. There are fewer specialized departments. SMEs have to think twice whether they start a Design Thinking project without being able to calculate the exact benefits in advance.</td>
<td>(Agogino et al., 2016) (Ahn, Rundall, Shortell, Blodgett, &amp; Reponen, 2021; Beltagui, 2018) (Bicen &amp; Johnson, 2015) (Cagnin, 2018) (Carlgren, Elmquist, &amp; Rauth, 2014) (Coco, Calcagno, &amp; Lusiani, 2020) (Crites &amp; Rye, 2020; de Carvalho, da Hora, &amp; Fernandes, 2021) (Ghajargar, Mangano, De Marco, &amp; Giannantonio, 2017)</td>
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<td>Beneficial</td>
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</tr>
<tr>
<td>3</td>
<td>Budget for Design Thinking projects</td>
<td>Here the statement for Budget is the same as in “time resources.”</td>
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<td></td>
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<td>(Kimbell, 2011; Nagaraj, Berente, Lyytinen, &amp; Gaskin, 2020; Yu, Qu, &amp; Hu, 2015)</td>
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<td></td>
<td></td>
<td>(Baldassarre et al., 2020)</td>
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<tr>
<td>4</td>
<td>Small projects and small teams</td>
<td>In SMEs, the implementation of innovations looks different than in large companies. Here, even small projects can achieve greater success.</td>
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<td></td>
<td></td>
<td>(Baldassarre et al., 2020)</td>
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<td></td>
<td></td>
<td>(Manzini &amp; Rizzo, 2011)</td>
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<tr>
<td>5</td>
<td>DT team strategically well positioned (team selection)</td>
<td>SMEs are less able to give the search for optimization and innovation the necessary space.</td>
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<tr>
<td></td>
<td></td>
<td>(Beckman &amp; Barry, 2007)</td>
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<tr>
<td></td>
<td></td>
<td>(Brown, 2008)</td>
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<td></td>
<td></td>
<td>(Fleury, Stabile, &amp; Carvalho, 2016)</td>
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<td></td>
<td>(Hölzle &amp; Rhinow, 2019)</td>
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<td>(Kurtmollai, Pedersen, Fjuk, &amp; Kvale, 2018)</td>
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<td>(Nagaraj et al., 2020)</td>
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<td>(Seidel &amp; Fixson, 2013)</td>
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<td>(Vagal et al., 2020)</td>
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<td>(Yang &amp; Hsu, 2020)</td>
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<td>(Yeoman &amp; Carvalho, 2019)</td>
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<tr>
<td>6</td>
<td>Customer or benefit orientation is strategically anchored</td>
<td>SMEs will think twice before starting a Design Thinking project without knowing the exact benefits beforehand.</td>
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<tr>
<td></td>
<td></td>
<td>(Diepenmaat, Kemp, &amp; Velter, 2020)</td>
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<td></td>
<td></td>
<td>(Hankammer, Brenk, Fabry, Nordemann, &amp; Pill, 2019)</td>
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<td>(Hölzle &amp; Rhinow, 2019)</td>
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<td>(E. Knight, Daymond, &amp; Paroutis, 2020)</td>
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<td>(Vetterli, Uebriickel, Brenner, Petrie, &amp; Stermann, 2016)</td>
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<td>(Yan, 2018)</td>
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<td></td>
<td></td>
<td>(Carlgren et al., 2014)</td>
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<tr>
<td>7</td>
<td>Potential benefits of DT project known in advance</td>
<td>Only if it can be seen early on that the initial investment has paid off will others follow.</td>
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<td></td>
<td></td>
<td>(Bairaktarova, Bernstein, Reid, &amp; Ramani, 2016)</td>
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<td>(Carmel-Gilfilen &amp; Portillo, 2016)</td>
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<td>(Hookway, Johansson, Svensson, &amp; Heiden, 2019)</td>
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<td>(Pluchinotta, Kazakci, Giordano, &amp; Tsoukias, 2019)</td>
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<td></td>
<td>(Shafiee, Haug, Kristensen, &amp; Hvam, 2021)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Design thinking steps well defined</td>
<td>SMEs lack the financial resources to take bigger risks. Therefore, the steps for innovation should be taken in smaller but safe steps.</td>
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<tr>
<td></td>
<td></td>
<td>(Brassett &amp; O’Reilly, 2015)</td>
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<td>(Chandler &amp; Ward, 2019)</td>
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<td></td>
<td></td>
<td>(Conforto, Amaral, da Silva, Di Felippo, &amp;</td>
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</tbody>
</table>

<p>|   | Specific to SME                                                           |                                                                 |
| 9 | External Design Thinking experts to support the project                   | Due to the high involvement of employees in day-to-day business, it is usually unrealistic for SMEs to have the time, space and knowledge to implement Design Thinking internally, without external coaches. |
|   |                                                                            | (Ghajargar et al., 2017)                                         |
|   |                                                                            | (Jun, Morrison, &amp; Clarkson, 2014)                                |
|   |                                                                            | (Kozlowski, Searcy, &amp; Bardecki, 2018)                           |
|   |                                                                            | (Kulick, 2017)                                                   |
|   |                                                                            | (Na, Choi, &amp; Harrison, 2017)                                     |
|   |                                                                            | (Shapira, Ketchie, &amp; Nehe, 2017)                                 |
| 10| Design Thinking success is measured                                       | Small steps lead to greater success.                             |
|   |                                                                            | (Brassett &amp; O’Reilly, 2015)                                      |
|   |                                                                            | (Chandler &amp; Ward, 2019)                                          |
|   |                                                                            | (Conforto, Amaral, da Silva, Di Felippo, &amp;                       |</p>
<table>
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</table>
| differently | Kamikawachi, 2016)  
(J. Knight, Fitton, Phillips, & Price, 2019) |   |
| 11. Cross-departmental projects with DT | Due to the flat hierarchical levels in SMEs, communication within the team is much faster than in others.  
(Seidel & Fixson, 2013) |   |
| 12. DT is also integrated and applied to existing projects | In SMEs, innovation approaches are often unconsciously applied in projects without being defined as such.  
(Liem & Brangier, 2012)  
(Shafiee et al., 2021) |   |
| 13. First application to design affinity areas | The advantage for SMEs is that DT can be introduced even with a small budget.  
(Aagogino et al., 2016)  
(Beckman & Barry, 2007)  
(Chandler & Ward, 2019)  
(Lande, 2016)  
(Lim, Kim, Kim, & Kim, 2019) |   |
| 14. External experts are involved (almost indispensable for SMEs, but professionals may be available for corporations) | Outsourcing allows employees to focus on their own day-to-day work.  
(Buhl et al., 2019)  
(Carlgren, Elmquist, & Rauth, 2016)  
(Eppler & Kernbach, 2016)  
(Fleury et al., 2016)  
(Glen, Suciu, & Baughn, 2014)  
(Kim & Strimel, 2020)  
(Liem & Brangier, 2012)  
(Olsen, 2015)  
(Yu et al., 2015) |   |
| General success factors independent of SMEs |   |   |
| 15. DT is visually represented and communicated | Visual representation of DT is possible in both SMEs and large enterprises.  
(Na et al., 2017) |   |
| 16. DT involved persons are professionally trained | Professional coaches can also be applied to all sizes of enterprises. However, this factor makes more sense and is more effective in SMEs.  
(Na et al., 2017)  
(Shapira et al., 2017) |   |
| 17. Physical space for DT projects is available | This area appeals more to large companies than to SMEs.  
(McGann, Blomkamp, & Lewis, 2018)  
(McGann, Wells, & Blomkamp, 2021) |   |
| 18. DT is easy to learn and use for company employees | DT is more practical to use and remains straightforward if you stick to the core steps. It is feasible in all sizes of companies.  
(Souza et al., 2020) |   |
| 19. Internal employees involved in the project. Usually, no external experts necessary. | Large companies have their own innovation departments, so outsiders tend to be less represented.  
(Brown, 2008)  
(Carlgren et al., 2014)  
(Roberts & Palmer, 2012)  
(Snyder et al., 2018) |   |

In the context of the study, the specific key factors in Table 3 are divided into "Mandatory components”, “Beneficial components”, “Specific to SME” and “General factors”.

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500
As part of the systematic literature review, content-related criteria that can be specifically tailored to SMEs were analysed. Therefore, these benefit criteria were again weighted and divided. The first criteria under the category "Mandatory Necessary" are directly related and are more difficult to apply in SMEs due to their context than in larger companies.

The supporting or beneficial factors are assumed to be directly related to their underlying SME characteristics. They also have an SME-specific background.

The third category contains those benefits that do not seem to be influenced by SME characteristics and are generally applicable in all company sizes. Finally, some general factors that are independent of SMEs but also interesting were developed.

However, this is only one perspective of successfully introducing innovations into SMEs using different approaches.

But it is hard to guess how many SMEs are doomed to fail. Innovative products, processes or services often fail before their "inventors" can even think about entering the market. Even products, for example, that meet customer needs in a completely new way often remain only in the shadow of their possibilities.

When developing an innovation, its developers and teams often face extreme challenges. A multitude of potential mistakes lurk in the innovation process that should be avoided. Only when you start pointing out situations about failures can you draw lessons from them. Every mistake can become a costly lesson for a company. However, such costs can be reduced enormously by avoiding things that others have failed at before. Therefore, Table 4 aims to present the failures of innovation in companies. These could be filtered out from the selected research papers.

Table 4. Failure factors based on the nature of SMEs

<table>
<thead>
<tr>
<th>N.º</th>
<th>Failure factors</th>
<th>Explanation (based on the nature of the SMEs)</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lack of customer input in customer analysis (customer goals, personas, customer journeys, etc.) and prevalent misconceptions of already knowing customer needs and expectations</td>
<td>Understanding customer goals and the current customer experience as perceived by the customer form the central basis for the subsequent active design of the customer experience. Companies must develop a deep understanding of the customer's goals, needs, perceptions, and interactions.</td>
<td>(Liu &amp; Lu, 2020) (Rau, Zbiek, &amp; Jonas, 2017) (Sohaib, Solanki, Dhaliwa, Hussain, &amp; Asif, 2019) (Snyder, Ingelsson, &amp; Backstrom, 2018)</td>
</tr>
<tr>
<td>2.</td>
<td>No comprehensive or incorrect survey of actual customer needs and expectations</td>
<td>A holistic and correct recording of the customer's needs and expectations require comprehensive ethnographic, qualitative and quantitative data collection and evaluation of internal and external information sources. Personal points of contact should be used for in-depth insights and feedback.</td>
<td>(Hankammer, Brenk, Fabry, Nordemann, &amp; Piller, 2019)</td>
</tr>
<tr>
<td>3.</td>
<td>Qualitative survey methods with the customer (surveys, interviews, etc.) are designed to create negative customer experiences</td>
<td>The instrument of direct collection of customers input is overused or misused. Data collection must be prevented from provoking negative reactions from the customer and creating survey fatigue, which undermines the willingness to provide critical feedback.</td>
<td>(Andreasan, Kristensson, Lervik-Olsen, Parasuraman, McColl-Kennedy, &amp; Edvardsson, 2016) (Lim, Kim, Kim, &amp; Kim, 2019) (Pande &amp; Bharathi, 2020)</td>
</tr>
<tr>
<td>4.</td>
<td>No complete coverage of all</td>
<td>The identification of relevant touchpoints for</td>
<td>(Hankammer, Brenk, Fabry, Nordemann, &amp; Piller, 2019)</td>
</tr>
<tr>
<td>N.°</td>
<td>Failure factors</td>
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<td>Literature</td>
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<tr>
<td>5.</td>
<td>No linkage of the assessment of relevant touchpoints with entrepreneurial significance</td>
<td>The touchpoints deemed relevant by customers must also be assessed in terms of their economic significance for the company so that design priorities can be defined later.</td>
<td>(Martin, 2011)</td>
</tr>
<tr>
<td>6.</td>
<td>Insufficient analysis (resulting in a lack of understanding) of the customer's value-adding processes</td>
<td>Capturing the value creating processes are a key step for the subsequent alignment of the company's own processes and value proposition. A deep understanding of how the customer creates value for its own customers are therefore needed.</td>
<td>(Appleyard, Enders, &amp; Velazquez, 2020) (Holzle &amp; Rhinow, 2019)</td>
</tr>
<tr>
<td>7.</td>
<td>No identification of relevant stakeholders and decision makers as well as their holistic customer journeys, goals and pain points</td>
<td>To create optimal experiences for all relevant customer stakeholder groups, the individual goals, pain points, and customer journeys must be captured holistically from start to finish.</td>
<td>(Bas &amp; Guillo, 2015) (Geldermann, Lerche, &amp; Sepulveda, 2018) (Magistretti, Dell’Era, &amp; Doppio, 2020) (Pluchinotta, Kazakci, Giordano, &amp; Tsoukias, 2019)</td>
</tr>
<tr>
<td>8.</td>
<td>Insufficient analysis of a customer's interactions with other service providers in the ecosystem as well as with other customers</td>
<td>A holistic understanding of the customer experience requires capturing the value creating ecosystem. Companies should analyse the experience ecosystem and understand how it generates added value and usage value for customers and how it shapes their expectations of the customer.</td>
<td>(Sorice &amp; Donlan, 2015)</td>
</tr>
<tr>
<td>9.</td>
<td>No adequate recording of own value-adding processes as well as the current value proposition to customers</td>
<td>A shared understanding of the current value proposition and internal processes form the basis for subsequent design decisions and for aligning processes to deliver value for use to customers.</td>
<td>(Hankammer, Brenk, Fabry, Nordemann, &amp; Piller, 2019) (Hirano, Ishizuka, &amp; Sakaguchi, 2013)</td>
</tr>
<tr>
<td>10.</td>
<td>No situation analysis of the competencies and resources currently available in the company, related to customer experience and organizational performance</td>
<td>The subsequent implementation, monitoring and control of the customer experiences requires dedicated competencies and resources. Only based on an analysis can any gaps be closed.</td>
<td>(Nagaraj, Berente, Lyytinen, &amp; Gaskin, 2020)</td>
</tr>
</tbody>
</table>

Failures that are not accepted and shared lose their importance in the innovation world. As a result, you lose oodles of time, money, and health to repeatedly making the same mistakes - because no one talks about them (Rhaiem & Nabil, 2019). Interest in failure of innovation projects is shown by entrepreneurs and managers to bring about the prevention of the problems and risks. Table 4 shows the failures elaborated from the articles. These were listed from direct and indirect context. Since, for reasons already mentioned, SMEs cannot afford to make mistakes when implementing innovations in projects, it is advisable to take smaller steps and smaller projects.
It should also be kept in mind that SMEs often apply innovation approaches without labelling them as such. The integration of direct innovation strategies will lead to greater success.

4 Findings & discussion

The results are divided into several sections: First, we provided an overview of the research agenda and literature on Design Thinking and innovation. Next, the papers were analysed descriptively and the availability of Design Thinking and innovation in the scientific field was examined. The analysis has shown that Design Thinking research in the innovation context is still a relatively young field that has shown a steady development based on publications for about 15 years. A thematic analysis was then conducted to present an overview of the Design Thinking parameter in relation to SME innovation practices.

Overall, the results show that our sample on Design Thinking and innovation is powerful, with 308 filtered articles explicitly addressing the topic. Narrowing it down even further, 70 articles deal directly with the topic of Design Thinking and innovation and its key figures.

The most important articles for Design Thinking research and innovation are those with a design focus, with the Design Journal playing a dominant role, as already mentioned. In addition, there are articles in mainstream innovation journals such as International Journal of Engineering Education, Creativity and Innovation Management, Journal of Cleaner Production, Sustainability and California Management Review, which are also well represented in this analysed topic area. This shows which subject areas also deal intensively with the innovation approach Design Thinking.

The purpose of the thematic content analysis was to identify essential elements and dimensions of Design Thinking practices in an SME context (focus on needs and failures – Tables 3 and 4). These are concrete measures of the success and failure of Design Thinking and innovation approaches to increase innovation capability. As can also be seen in the previous Tables, the identified two essential building blocks (needs and failures) of Design Thinking in companies have been identified and explained.

The analysis shows that science has dealt with the implementation of thinking approaches in SMEs, but not enough. Therefore, the topic is consequently not very well known even in small and medium-sized enterprises (Gasda & Fueglistaller, 2015). Because SMEs are not frequent users of Design Thinking and the academia is very little interested in analysing the subject (Kammerlander, Burger, Fust, & Fueglistaller, 2015). Only a few SMEs do not encounter this approach. Moreover, SMEs are preoccupied with everyday business, which is why they are slow to integrate new approaches (Magistretti, Dell’Era, & Doppio, 2020). For this reason, SMEs do not provide themselves with the capacity to develop “new things” and thus run the risk of losing some of their competitive advantages in the medium to long term. It seems that Design Thinking is not suitable for SMEs because of their characteristics (Magistretti, Dell’Era, & Doppio, 2020). However, as already mentioned, there are also characteristics that indicate a sensitivity of SMEs to Design Thinking elements. The receptiveness for Design Thinking in small and medium-sized enterprises is greater than in large companies (Shapira, Ketchie, & Nehe, 2017), and due to flat hierarchies, SMEs can adapt changes more quickly than large companies.

As a basis for further research approaches, these factors can be used to further expand and strengthen the strategic sustainability behaviour of SMEs and the innovation approaches Design Thinking is pursuing (Magistretti, Dell’Era, & Doppio, 2020).
5 Conclusions

The aim of the study is to identify the needs and failures of Design Thinking and innovation approaches in SMEs by conducting a systematic literature review. Here, we focused on positive and negative implementation competencies. We contribute to the literature by showing that innovation approaches are, in principle, built on some unique Design Thinking parameters to deal with uncertainty at management level, adaptability, flexibility and understanding, speed, and integration. Our contribution implies that Design Thinking approaches related to well-known innovation approaches in our literature list and associated company size can be used to also test and improve innovation approaches in SMEs to respond to uncertainty and risks. The study can show companies the limitations in exploring and comparing different solutions with a well-defined list of design approaches and principles. It is a guideline and the comparative first step for companies to learn from others' mistakes and work more efficiently in terms of time to implement innovations. It could also be a crucial research step in the current literature and practice in Design Thinking.

Our findings suggest a different theoretical path for the field. Stakeholders can now merge theoretical insight by using our categorized Design Thinking needs not only to develop new solutions, but also to compare different solutions in terms of performance in managing uncertainty in SMEs.

In addition, our paper provides a fundamental comparison of management practices to advance the research field. In developing and elaborating solutions, researchers and practitioners can now use our research as an initial and preliminary reference. The theoretical way to design new hybrid approaches can provide more options for dealing with uncertainty. Researchers and scientists can test, continuously elaborate, and improve our Design Thinking solution approaches for SMEs in different business situations (e.g., small, and medium-sized enterprises and start-ups). They can also apply such Design Thinking criteria and principles in different phases of the Design Thinking approach, with different practices and techniques, and study the impact on innovation performance.

One promising avenue of research is to examine the design principles in the innovation management literature, in relation to SMEs. Based on this, further studies and research can address other resource opportunities and their complexities. The research team notes, as well, that the presence of failures is seldom referenced in the literature.

The study has some limitations. First, we provide a preliminary list of failures and needs (link Tables 3 and 4 tailored to SMEs, however we did not test these elements empirically, which is a future research direction.

Second, as this is a systematic literature review, the inherent limitation is related to the impossibility to generalize the results, or to provide managerial or policy implications.

Third, the definition of SME encompasses a wide type of firms, from start-ups to incumbent firms, and failures and needs for these firms can be quite different. A specific analysis considering as control variables the size, the age, the industry, and other characteristics that may account for the differences between SMEs is recommendable in future studies.

Also, the failure factors, based on indirect and direct representations regarding the Design Thinking criteria were identified. Furthermore, we realized that the developed list based on the systematic literature review is not exhaustive. To the end, there is an opportunity to elaborate and investigate further research and additional Design Thinking criteria and principles tailored to SMEs in the future. Ultimately, further research can be prepared, continuously improved, and supplemented in further studies, in implementation of the Design Thinking project. That leads to an iterative process, which is also typical for Design Thinking.
References


Understanding gender and diversity sensitive smart mobility needs without access to users: The impact of COVID-19 pandemic on TInnGO design outcomes

Paul Magee, Andree Woodcock and Katarzyna Gut
Coventry University, UK, arx218@coventry.ac.uk; adx974@coventry.ac.uk; katarzyna.p.gut@gmail.com

Abstract. The COVID-19 pandemic has required us to work in new ways. This paper addresses issues around the co-design of gender sensitive, smart mobility products undertaken as part of the three year, H2020, EU funded TInnGO project (Transport Innovation Gender Observatory, https://www.tinngo.eu/). The project aimed to create a paradigm shift in transport employment, education, design and transport usage, which would break the male domination of the sector. A core theme of the project employed design and design thinking to address issues around the lack of engagement of women and those from excluded groups around their transport and mobility needs. With the UK team having to act as proxies due to Covid restrictions, we use our experiences over the last 18 months to discuss the management and challenges of design at a distance, when undertaking gender sensitive smart mobility design briefs for the EU and the reception of these by the project team.

Keywords: Transport, gender, design pedagogy, design research, design visualization, covid

1 Introduction

Transport is a male dominated sector (ONS, 2018) in terms of transport design, employment and service provision. The continued gender imbalance in STEM education, means that fewer women have the qualifications needed to enter the profession (Smith et al., 2013). This is reflected in figures which show that women form only 22-27% of those employed in transport, with most occupying lower grade positions in administration (Ortega et al., 2019) and experiencing both gender and pay discrimination (Turnbull, 2013; Pillinger, 2017). The lack of women (and those from diverse backgrounds) in organisations which operate transport services means that little empathy or understanding is shown towards female transport users (Bakran, 2018). For example, women make different, longer and more complicated journeys than men, as they make take on the dual role of carer/housekeeper and employee (Pasaoglu et al., 2012). Despite known differences in travel patterns, such journeys have not, until recently been taken into account in the planning of transport services (Ng and Acker, 2018; Grosso et al., 2019) leading to transport services which do not meet the needs of all groups.

This is beginning to slowly change as, for example, automotive CEOs recognise the power of the female consumer and the value of women as leaders of design studios (Hewlett et al., 2013). Where women can act as role models, they attract and mentor women into the industry (Turnbull, 2013).
Additionally, transport planning has seen a paradigm shift away from private vehicle ownership which led to unsafe, congested and polluted cities, to sustainable forms of transport which can lead to more habitable and fairer cities (Polk, 2013). Mobility is a key component to delivering a smart city, defined by the BSI (2014) as “the effective integration of physical, digital and human systems in the built environment to deliver sustainable, prosperous and inclusive future for its citizens.” The H2020 TInnGO project was designed to create a paradigm shift in Europe in women’s engagement in and by the transport sector as it moves towards smart mobility. Consortium members have worked collaboratively to understand and address gaps in employment and education. The work of the Coventry University team, and the focus of this paper, has been to use design to understand and showcase women’s requirements of, and barriers to, smart mobility products. These products can include, for example, new sustainable, inclusive transport vehicles or parts, services, or the technology which links the user to those services.

Across the European consortium, the 10 national hubs were coordinated to discover gender and diversity transport inequalities in collaboration with transport users. Each hub was responsible for generating a series of problems, from which design concepts could be co-created with student design interns. To do this, it was planned that each hub would invite women and those from diverse, under-represented groups into their hubs to discuss mobility related issues, which could be used to inform design briefs. Here, elements of participatory or co-design were expected to be introduced as a ‘different’ way of starting conversations with such groups, leading to design briefs, and concepts which would reveal specific, unmet, and unrecognised needs and provoke further conversation.

To facilitate communication, collaboration, and empathy, it was planned for members of the Coventry team to travel to the hubs, to train colleagues, provide citizen science training and lead co-design sessions according to living lab principles. Mature design concepts would then be shared and discussed widely on the project’s Open Innovation Platform to lead to greater awareness and understanding of gender and diversity related issues in transport usage, both amongst the design team and the wider community.

Each national hub was expected to work for 12 -18 months with women, minority and transport excluded groups to understand local issues and barriers to mobility (for example the UK hub looked at BME groups; the Scandinavian hub at bike design).

This part of the project was due to commence in Spring 2020 and run until November 2021; as such COVID-19 significantly and negatively impacted on our plans. For example, the Hubs could not meet hard-to-reach groups (either over social media or face to face), designers were unable to travel to the hubs to lead design sessions and co-create with end users. Instead, technical partners acted as proxies for end users, tentatively developing design briefs based on their knowledge of the sector and lived experiences (e.g., as older women, women with children and dependents). The shortcomings of such an approach have been previously discussed (e.g., Herriott, 2015). Communication was mediated through TInnGO’s Open Innovation Platform64, Teams65 and Mural66.

Although many researchers and designers are familiar with location independent and asynchronous working, the speed of lockdown and the need to move to total online working proved challenging with,

64 https://transportgenderobservatory.eu/national-hubs/uk-hub/
Open Innovation Platform was created by TInnGO to bring together designers, researchers, stakeholders, and general public to co-create mobility solutions.
65 https://www.microsoft.com/en-gb/microsoft-teams/log-in
Microsoft Teams is a communication platform developed by Microsoft; during pandemic TInnGO team would meet online using the platform.
66 Mural is a digital workspace facilitating workshops and visual co-creation. https://www.mural.co/
for example, inflexible deadlines which fail to consider the added mental, emotional and physical strains of teleworking, or the need to ‘personally manage’ hardware and software which may have limited functionality when compared to design offices.

With travel embargoes and lockdowns for nearly 18 months causing major disruption to the project plan, the focus of our paper has shifted away from codesign with transport impoverished groups to a discussion of how we adapted our practices to deliver design outcomes and the effects of distance working on the wider goal of using design as a means of increasing empathy and understanding of vulnerable and excluded groups. Therefore, this paper discusses:

- the challenges the COVID-19 pandemic brought and how these were overcome;
- the experience of working with student interns;
- the appropriateness of design visualizations as a means of communicating with non-design audiences and the comments they elicited from the group;
- the role of design in uncovering deeper discussion/new insights with different audiences;
- the extent to which these could be embodied in the final designs.

2 The role of design in TInnGO

Woodcock (2012) has previously asserted that design and (macro) ergonomics have an important role in the design of transport futures, by:

- championing and understanding the needs of transport users, especially those who may be excluded or considered vulnerable transport users,
- taking an integrative, systems orientated approach,
- taking on a mediating and managing role between users and stakeholders.

Loewy, architect of the Industrial Design movement in mid-century USA explained that ‘Design’ is, “a simple exercise; a little logic, a little taste, and the will to co-operate,” (Anderson, p23, 1979). Anyone can be a designer – developing potential solutions to real world problems, but trained designers can push this further by flipping between analytic and creative thinking to visualise, communicate and construct a concept that can be built in the real world. The physicality of a design is inherently linked to the meaning of the product, and to an extent the meaning that a viewer associates with the same, nostalgia for instance. Yet the meaning can be intrinsically variable and lead to miscommunication.

Despite the potential of design thinking and design research to engage with wicked problems, and the slow impact of purely technology approaches to behavioural changes, it is not usual for design to feature prominently in EU funded Research and Innovation Actions (RIA), such as TInnGO. Therefore, despite the problems with lockdown it was important to carry on with this stream of activity. The role of design in TInnGO was to:

- illustrate how the process of design could be used as another way of engaging with excluded transport user groups (such as ethnic and migrant groups, older transport users, those with disabilities as well as women), who are still regarded as difficult to reach, e.g., they may be disillusioned with planning processes, feel they lack empowerment, unwilling or unable to attend traditional meetings and answer surveys. Communication around a design may draw people into conversations about their lived experiences, providing more insights into barriers and requirements;
• show the added value of design when applied to transport as a whole, not just the design of vehicles;
• increase empathy and understanding of traditionally excluded groups amongst design interns, project team and wider stakeholders;
• illustrate how empathic user-centred design could create more inclusive design;
• demonstrate the value of understanding the lived experience of transport users to more technical partners, and breakdown their reticence in engaging directly with end users;
• facilitate discussion of intersectionality, and the multidimensionality of people

To this end, each of the 10 national hubs was expected to draw people physically into their hubs – especially those who had not participated in discussions of transport – to discuss issues of local concern, such as safety of members of the LGBTQI+ on buses at night, and safety of older people at bus stops. A number of approaches could have been used to capture the authentic experience of transport users such as observation, walking interviews, focus groups, conversations with purpose, surveys or citizen scientists/expert informants.

From these rich, context specific narratives, hub leaders could build an understanding of the most pressing problems for local transport users, which could be shared across the consortium and presented as design briefs along with sufficient information to enable the Coventry team to base their designs on an empathic understanding of users.

If lockdown had not happened, the design team would have presented initial concepts (provocations) to or co-created them in person with the original research participants, to elicit further requirements and a more detailed understanding of inclusivity issues. Embodying these in concept designs provides a rapid means of transmitting ideas to the wider consortium, thereby providing a more nuanced and detailed understanding of barriers to the uptake of smart mobility and develop more inclusive solutions. The final designs provocations and their accompanying narrative/notes from design critiques, provide examples of the value of design as a research method in general, and in particular in contributing to future transport scenarios and drawing out detailed insights into the mobility problems of hard-to-reach groups.

The more technical partners initially experienced problems in understanding the role of design to furthering understanding of the lived experience and how they could contribute to this process. Design is non-linear, fuzzy, untidy, organic, and yet systematic and process led. Partners did not understand that working through the ‘design solutions space’ involves a series of moves, before arriving at one that ‘touches the heart of the problem’, which can be used to engage further conversations. As we could not work directly with partners or transport users, many of the design moves became invisible, i.e., they were seen and discussed only by the Coventry team.

Final concept design visualisations were uploaded as provocations on the Open Innovation Platform – where it was hoped that they would elicit further insights into the user experience and recommendations for change – which after some prompts members of the wider project started to do.

The emotional payload associated with subjective meanings encourages an empathic approach, based on observation, if not full ethnographic approaches, in which the world is seen or experienced through the perspective of end users, without preconceived misconceptions or prejudices. However, it is not easy to understand context and subjective meanings if they arise in an unfamiliar environment or from different socio-cultural group. In terms of transport design and planning, because there has been such a persistent gender and diversity bias, there is little in-depth understanding of the needs of
women and vulnerable and excluded groups. In order to meaningfully design gender and diversity sensitive smart mobility solutions designers need to observe, work and communicate with overlooked groups, to create a paradigm shift, which leads to mobility for all. Communication however does not offer perfect insight as meanings are filtered through the ethnographer’s perception (Geertz, 1973). As a result, communication may be seen as a horizontal, iterative process of meaning-sharing and meaning-making, creating a ‘thick description’ (Boyle, 1994). For designers, design provocations and co-creation are ways to exchange experiences, meaning, and symbolic visuals from different contexts and challenge the top-down approach perpetuated by traditional industrial design. The strong connection between design process and ethnographic research calls for more empathic conversations between people, and documenting those experiences in visual, accessible ways. The research activities and materials need to be well designed, in order to get people involved and elicit useful and inspiring results. Yet ironically, the better designed the solution, the less likely the viewers are to objectively feedback. Designers tend to have a highly sophisticated form of visual language but when working with people who have not had the opportunity to experiment with marking making and visual language, this can introduce another barrier to communication. Designers/facilitators must have strong communication skills, a sensitive attitude, high cultural and social awareness and emotional intelligence alongside a strong, visually engaging approach, which could help to explain their ideas. These are the qualities we tried to instill in our designers to make them effective in this context. The next section briefly touches on the challenges of COVID-19 before providing examples of the design activities and the comments they elicited.

3 Challenges of COVID-19

3.1 For the project

From March 2020 until December 2021, most hubs have had little or no opportunity to work as planned with vulnerable transport users, either face to face or remotely, even if staff were allowed to work from their offices. This seriously compromised design activities. Without input in the form of user insights, requirements and design briefs, the UK hub and project members generated their own briefs based on previous data and their experiences or used Mural to discuss design ideas with other partners. Mural was not very satisfactory in this context, with many of the online participants spending time learning to use the system rather than contributing ideas and to wider debates. The design team was not allowed to meet face-to-face, use design studios or travel out of the UK to work with the hubs. Indeed, because of the situation in the UK our three design interns returned to their native homes, meaning all communication with them was computer mediated. The COVID-19 period caused us to re-think how a paradigm shift might be achieved now, and in the future. Whilst the COVID-19 pandemic caused mass disruption, the methods employed to continue to work within the widespread restrictions have served to highlight the advantages and disadvantages of working away from each other. Personal liberty was so inhibited during 2020 that the notion of personal mobility may have changed but working from home and travel restrictions led for some, to a better quality of life, fitness and well-being, as sustainable transport measures were fast tracked in many cities and the need to commute to the office was removed. Importantly COVID-19 also highlighted the need for more nuanced understanding, using intersectional approaches to reveal the effects of multiple levels of deprivation on certain groups. For example, the higher risks of exposure for key workers who were reliant on public transport.
3.2 For co-design practice

Extended and exclusive remote working has had a major impact on interaction, productivity, and external engagement – particularly so in design education which relies on more traditional face to face interactions in the design studio. We have seen a number of ways that engagement has either flourished or stumbled. We have already published our experience of stealth tele-presence (Magee et al., 2021), where users have switched off their remote cameras (in some instances genuinely to save bandwidth) and the resulting impact this has on the creative endeavor. Telepresence in which people may select whether, or how much of their authentic selves to show makes it difficult to judge the mood of the room or the rest of the group, and even how engaged they are in the current meeting. We address a void.

Interns engaged on the project, worked from homes in different timezones, and were supported in 1-1 or 1-many tutorials and a weekly show and tell session. During this time, we saw the effects of ‘semi-formal’ working from home studios, or quickly constructed workstations on creativity, group dynamics and learning. For example, creativity was hampered by the lack of essential tools/design ephemera, and the added difficulties and changes on practice required to present online e.g., transfer of sketches into digital formats which were visible on screen. Additionally, the lack of digital design skills caused continued issues, as did the shift from semi-formal ‘tutorial mode’ to addressing clients online e.g., in terms of dress code and particularly in business language.

Our design interns chose to move back to their parent’s homes rather than remain at Coventry in lockdown. Therefore, we had also to deal with different time zones (spanning Indonesia, Spain, UK, and India), time of day effects leading to different levels of readiness and alertness, the semi-formal nature of home working, the need to disguise working spaces which may not be ideal, and domestic distraction.

Group dynamics changed over time. The interns, design tutors and project staff did not know each other at the start of the placement. Without non-verbal cues, voice distortion and delays, and the ability to share a whiteboard, developing a collegiate and co-operative atmosphere in which students were not afraid to express their ideas was difficult. Once they got to know each other the students buddied up, natural leaders emerged and defended each other from criticism. The hierarchy of the team remained flat as we were all facing similar problems working with the technology and understanding design briefs, in some cases generated from countries for which we had no direct reference.

In terms of design pedagogy, the project and the students learnt a lot. The non-design project members had to understand how to construct a usable design brief, how to interpret the students’ work and give feedback in a constructive manner and understand how the designs responded to the emergent mobility problems – their knowledge of the mobility experiences of different groups was therefore increased – for example the amount of journey planning needed when travelling with someone with autism and dementia, the need to create safe spaces during travel. The students learnt new digital and drawing skills, developing their own styles, how to present their work, and the need for essential design cues to be included – such as scale and annotation, how to deal with criticism and use this to rethink their design ideas. They also learnt to be more empathic and careful in their assumptions about users.

4. The experience of working with student interns

The rate of design outputs was severely impeded by the COVID-19 restrictions and occurred at a much slower pace than had been anticipated. It was expected that intense “design sprints” could...
occur with detailed designs emerging every 2 weeks. With no control over the amount of time the interns worked on the project and lack of everyday contact with them in a studio, each design took around 4 – 6 weeks to complete, at which time it was shared on the Open Innovation Platform (OIP) to act as a provocation, stimulation or a conversational piece (see below) with the hub that had set the design challenge, and the wider project team. In this way a richer and deeper understanding could be generated amongst all project participants and visitors to the site.

The idea that co-design could be used to engage in deeper conversation, leading to greater empathy and insight of excluded and vulnerable transport users was a central part of the project. Discussions with the interns was wide ranging and captured in notes and mind maps that would document early-stage ideas and communication process between designers/students and non-designers/users. Below we share an example mind map taken during a design review meeting. Discussions ranged from talking about the design concepts and representations to the level of understanding/empathy for the end users and their experiences, and more pragmatic issues such as context, cost, maintenance and systems thinking. Only UK hub members took part in these meetings, which meant that other members of the consortium could not participate or benefit from the insights. Although we attempted to capture some of the discussion in visual representations and mind maps, these are only surface descriptions.

Figure 1. Mind Map Design Review Meeting 30.10.2020

The issues of how to record design discussions so that they may be of wider benefit, especially amongst distributed teams who may have limited connection/not able to attend is difficult. It was hoped that co-design could have both tangible and intangible benefits for the direct participants, the end users, design interns, hub members and wider stakeholders. Not having any ability to transmit or translate these discussions to the wider group was detrimental to the wider project. It was possible to record these sessions, and in the normal course of activities many students do record feedback on their iPhones, but it was felt unlikely that our two-to-three-hour meetings would have been of sufficient interest or intensity to have engaged partners in passive listening. Representation of design discussions/process remains a problem for design research in general (e.g., Subasi and Fitzpatrick,
2012: Black et al., 2013).
Mind maps (Figure 1) from meetings combined textual and visual information attempting to capture information, see and draw new connections and visualise complexity of issues. Some of the maps (as above) exemplify how discussions started from a single concept, drawn image or word shown in the middle of the page to evolve into a map of associated meanings or problems added as the meeting unfolded and new concepts were discussed. Mind maps helped to retain information from the meetings and allow personal creative space to reflect on concepts and raised issues (Wheeldon and Ahlberg, 2019).
Although Mural was used to support brainstorming across the hubs it was not used in the design review meetings where discussion was prompted by the interns’ designs presented over teams. As notetakers, the authors found it faster and more flexible to create handwritten/drawn notes without worrying about the position of notes and typographical mistakes. Nevertheless, a lot of information could not be captured owing to the rapid flow of ideas. As attested in previous research mind maps hold a lot of potential and would have been something we would have liked to have explored with the TInnGOIdLAbs where physical constructs or digital mind maps (e.g., Faste and Lin 2012) could have been developed and discussed over time as collaborative tools and experiential records.

5. Design visualisations as a means of communicating with non-design audiences

Whilst a highly creative discipline, design has a number of stages that form an overall system, and hence a taxonomy of tools is a useful way to communicate how each stage progresses. The purpose of the taxonomy is not to compress the process into a limited number of stages but rather to acknowledge that the process is necessarily systematic in order to make meaningful progress. The starting point is often a barrier for stakeholders to communicate their priorities. To alleviate this, a collage of examples is often used to illustrate a user journey and to begin to find pinch points.

In this section, we provide examples of the type of visualisations the interns produced to show their final design provocations to the consortium. These were uploaded onto the Open Innovation Platform along with a short (100-word+) description for each. The provocations are available for anyone registered at the website to view and comment upon; indeed, there is no expectation that those viewers should agree with the ‘solution’, hence the provocation framework.
Method 1 uses a visual narrative style to describe a particular circumstance in a visual storyboard. The image shown in Figure 2 is a stylized version of a storyboard used to explain how a design idea might work in the context of a user’s general journey, such as retail purposes, commuting or broadly looking at recreation. The cartoon storyboard format is familiar to many, easily followed and allows the observer to apply the design idea, in the footsteps of a given user. The storyboard creates multiple, overlapping narratives that encompass the experience of many users and highlight the common areas to be addressed. The storyboard is perhaps one of the easiest of the representations for non-designers to understand.
Progressing from the insight found in a user journey, Method 2 is derived from the traditional napkin-sketch, or colloquially referred to as the ‘back of envelope’ sketch. It shows an overall volume shape, not a distinct design, nor a specific location and is not constrained by physical dimensions (although proportions will still be evident). The technical sketch (Figure 5) places a number of elements in relation to each other and explores how this might result in a designed solution, around the user – who is generally illustrated as a stick figure or sketch silhouette. The technical sketch is not detailed and is one of many, rapidly produced sketches that are produced to illustrate a point or an idea. As so many of the sketches are produced, they are often tidied and briefly annotated.
Some instances require more than a basic volume to illustrate an idea. Method 3 is a way to put the art into the science of the design process. It may explore forms and intersecting shapes, creating overlaps, shadows and silhouettes (Figure 5). When shown in this way it is possible to judge how the feeling of the idea works for the place, in relation to the criteria established in the design brief and the type of emotion or feeling it invokes from observers. This is the opportunity for the designers’ flair for the dramatic, or for simplicity to shine, potentially captivating the imagination and giving them scope to push their concept forward.
Figure 4 depicts a 3D face that can change in form or shape when spoken to, for example when a passenger asks for directions or details of the next bus. This was developed as part of a series of designs addressing the need to provide more human interactions at bus stops, and to create bus stops which were of more interest to the community – see also Figure 4 and note the emergence of different drawing styles. Such a visualisation is very difficult for non-designers to interpret as it depicts just part of the bus stop and may not be at all similar to a solution they might have envisaged.

Method 4 is digitally rendered with semi-realism using a combination of reasonably detailed form and shape, constrained to world dimensions and proportion. The method then integrates a cartoon-like of expression of other elements outside of the design, so as to afford the concept some reality.

The effect is intentionally semi-real, partially with material or surface finish colour for example, but not so real that the image appears to be the photograph of a final, finished piece of work (Figure 5). This is the ‘work-in-progress’ illustration, with additional approximation of the environment to visualise how the concept fits in its place. As such, the intention is that an observer can cast a critical eye over the elements and still feel as though the design can be developed, tuned and reframed according to the user need – rather than merely being asked to comment on a finished article, which has gone so far along that path already, that any new revisions are likely to be tokenistic.

At the latter end of a project, Method 5 presents a final solution in a degree of reality, with realistic colour, material finish and relationship to an environment (Figure 6). This is very much a final view of the idea and not one that is useful during the development stage, since it can be time-consuming to produce and not an efficient use of time whilst a design is being developed. Where this method becomes invaluable is at the design sign-off stage, and transfer to an engineering process, where the overall aesthetic must be maintained.
Method 4 can actually be slotted in at any stage, with the intention of encouraging observers to interact with the idea on display and challenge the idea based on their experience, or frequently that of a co-creative group (Figure 7). By reviewing the proposed design, it can then be reconsidered with respect to the variety of feedback and a subsequent iteration produced. This process can continue until the feedback and iteration loop reaches saturation and there are few meaningful
aspects to resolve. Figure 7 shows an idealised version of the way in which the sketches could provoke deeper insights into the user experience e.g., that mothers are concerned about hygiene and may have other children to look after. Also, the comments show that the images raise a number of questions about a wide range of issues – in this case relating to size, balance, cleaning and materials. Working in this manner even allows us to address complex problems related to perception within the safety of the framework. On the OIP we looked at the idea of drones used in retail and subsequently proposed a number of different ways of looking at the service but fundamentally, whenever we asked for comments or advice around consumer use of a drone, the common perception reverts back to military and geo-political aspects of drone use, rather than the capacity of the ‘device; to be of assistance. We realized that few observers wanted to get into a discussion about a potentially sensitive discussion and started a design review discussion in ways to increase the sense of trust in such a service. By framing the provocation in this way, we were able to introduce autonomous, self-propelled devices with a friendly, more approachable demeanor and even a naming strategy that avoided the term drone altogether. The results of the OIP feedback were positive and resulted in considerable engagement.

![Diagram](image_url)

**Figure 7. Method 6. Debate, scribble, annotate on the sketches**

### 6. Use of the Open Innovation Platform

To communicate design provocations and the development of ideas we used Open Innovation Platform (OIP). The OIP created by TInnGO is a digital space that aims to bring together the TInnGO national hubs, stakeholders and citizens in order to address local issues of gender and diversity in smart mobility. The platform is free and open to the public and everyone can leave comments or ask designers questions. It has three sections: Ideas Lab, Discussion, and Initiatives (Figure 8).

The Ideas Lab is the space where students post development sketches and their final work, presented in one of the formats discussed in the previous section. Each student was proficient in, or preferred to use one or more of the above visualisation methods. Their abilities significantly developed during their internship bearing in mind that their designs would have to be comprehensible to a wide audience unfamiliar with design conventions using different devices/browsers. In all cases the
emphasis was on user centred design for transport excluded groups.

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**Figure 8.** Open Innovation Platform’s Home page\(^7\).

Owing to COVID-19 restrictions, communication over the final concept designs was mediated over an asynchronous discussion board requiring the commentators to understand the sketches and the thinking behind the sketches, from what was presented on the Open Innovation Platform and summary text.

This led to a number of difficulties. Firstly, the limited functionality of the OIP meant that designs could not be drawn on or annotated; the designers did not get alerts as to when a comment had been made on their design, and in many cases did not know how to respond to the statements. Secondly, most of the project partners from a technical background may not have known how to read the sketches or understand the motivation behind them. Lastly, and most importantly, the whole process was supposed to increase empathy and greater understanding amongst the team and the hub communities about gender and diversity sensitive smart mobility. Extensive discussions did occur over the designs between the UK hub members and the student interns, but much of this was lost and did not benefit the wider group. This section provides examples of responses the designs generated on the OIP, including comments from the public, partners, and TItnnGO Team.

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\(^7\) [https://oip.transportgenderobservatory.eu/home](https://oip.transportgenderobservatory.eu/home)
Feedback from the Ideas lab section about Figure 9:

A nice well thought-through idea. I like the protection for the child’s legs but need to think about the dimensions as their legs can get very thick when all wrapped up in padded trousers or onesuits. The only thing I find impractical is the ‘staircase’ for fun and independent climbing. I am fairly sure that with the weight of a child it would simply fall over as soon as they start to climb. With a VERY heavy base it would be more stable but then way too heavy to carry on the bike. It is a nice idea to provide something fun and make the child independent but would only work if there can be a special ‘step’ as a fixed part of the bike, so parent holds the bike while child climbs up. It is probably easiest for parent to lift child onto bike without having additional worry of the staircase stability. [User 1]

The value of comments referring to personal observations is description of a problem from the perspective of a ‘lived experience’, highlighting that developing and improving design concepts thrive on ‘lived experiences’ of users. Comments about real life experiences can help stimulate discussion, inform new directions of design and shed the light on new problems, which were hitherto overlooked by the designer or weakly defined in the original design brief. In the child seating solution for shared bicycles example (Figure 9), the commentator highlighted the need to take into account children’s clothes as well as anthropometric measurements, especially as the design solution was for colder European countries. The ‘staircase’ was introduced as a fun element, which would engage the child more in the cycle journey and introduce them to the concept of cycling.

Figure 9. Child Seating Solution for Shared Bicycles. Designed for the TInnGO project by Ronald Jurianto
Pink Corner emerged initially from an idea for a women-only safe, waiting space at bus stops or stations (Figure 10). This idea was suggested by the Romanian hub. However, when scoping out the design the students quickly decided that this idea would not lead to an increase in respect for women, and they may in fact be more singled out by this. Instead, they looked at different ways in which a bus stop could be used to promote diversity and equality. The brainstorming process and early assessment of design concepts was chaotic and uneven, without a clear idea of the problem. It proves that the design process starts with the conversation and exchange of ideas that can shift direction from initial design brief, something that could be expected of design provocations which are untested, future-thinking or even unfeasible. The final idea was more of a systems approach in which a bus stop could be adopted by a local school, working with a charity. Artwork would be created by students to celebrate diversity and equality themes as part of their schoolwork. A sustainable system was developed by which the drawings could be quickly mounted on the bus stops and replaced. Adoption of a bus stop by a school would increase their sense of ownership and responsibility in the community and they could share their philosophy and interests with other transport users and different schools etc. This design illustrates the need for system approaches and the range of ideas that are used to create just one design.

The above examples show that the OIP provided a digital space for communicating design ideas under development and facilitated designer-audience interactions. Examples from OIP present the challenges in communication process, both textual and visual, and document barriers that impede the communication of design ideas. Developing design concepts in this way can be a co-creative, iterative activity. One of the challenges is to understand what to capture from design discussions and put on the OIP. The designs did provoke critical reflection and new insights and led to new design ideas.
7. The role of design in uncovering deeper discussion and new insights

Because it is often difficult to explain real need, it is difficult to understand the needs of others. And so, if we ask what should be created next, the response can either be highly personal (and potentially niche), or can be so saturated to be acceptable by as many as possible, that the result is equally ineffective for many others. Designs need to be tuned, framed around the knowledge of experience – which is why it is so valuable to witness experience in someone else’s shoes. The design process needs to be hinged on the context of its core values, which could mean:

- User aspiration
- Manufacturing suitability
- Market readiness
- Value (economic, spiritual, functional)
- Effectiveness

So, whilst TInnGO aims to demonstrate usefulness of ‘design’ in engaging hard to reach groups in conversations about smart mobility, the purpose of a design provocation, is to encourage a response – positive or negative; the more the provocation is engaged with, the more it becomes shaped towards its Resolution, Realization and Completion (RRC)(Figure 11). The design provocation is a tool to stimulate debate, encourage lively experience-focused discourse. It is not intended to propose a final solution.

![Figure 11. Design Provocation (DP) purpose](image-url)
The design provocation is defined (Woodcock, 2021) as a visual response to a comment, design brief, or idea – the response an exploration whilst also being a less than perfect solution, designed to raise ‘tension’. The tension raised by provocation results in consternation, surprise, even delight; which can then be resolved through engagement leading to new knowledge, understanding and reframing; mediated by, and through design. It is not intended to propose a final solution.

The DP method is universal, in that it seeks insight from user experience to better understand how to solve big picture problems. The specific cyclical nature we envisaged was hindered by the COVID-19 lockdown restrictions but the method is all about offering design as a way to engage in deeper conversation for which we developed our term of ‘design provocations’, to contextualise Experience Highlights (EH)(Callari et al., 2019) and stimulate contribution of the hub’s experience of the issue being addressed.

The presented design provocations may be naive, conceptual or mis-aligned to the end result because of a mismatch of thinking but they may provoke observers to express nascent/unexpressed needs or emotions of excitement and delight. Engaging with the visual prompt results in becoming more than merely an observer, but part of the act of shaping and transforming. Whilst it seems parochial to think back to group meets over tea and cake, it remains clear that chatting around a drawing is less confrontational than an online presentation and easier to thread together as a narrative.

In short, to get this kind of response we created a design provocation, a visual metaphor, a contextual prompt. We show this visually to get an objective response from stimuli that can be seen, in context, and perceived relative to an observer’s experience, and for the written response to occur at a convenient time, thus opening the door to anyone who might struggle to respond under pressure but for whom the solution on offer may propose great significance and value.

8. Discussion

Gathering knowledge is fundamental to self-conduct in daily living; it stems from education, experience and influence; it governs the way we perceive our environment, culturally, socially, and professionally. The gathering of knowledge that leads to identification of an opportunity, application of new technology and materials, but not necessarily ‘need’ is fundamental to the act of design. The process is complex and can take considerable time to achieve. Yet, to the external observer, the annual refresh of products happens almost invisibly, right up to the orchestrated launch event, and the magical reveal. The same might be levied at transport provision; upon first encounter, the new transport system introduces new thinking and possibly hope. But all too often the poor on-board experience of UX, the shift to a single ‘universal’ platform or the wider implications of restrictive hardware, dissipate that potential. How many times must we download yet another app before service providers realise this method is sub-optimal, at best? The process used seems to focus so much on what can be done, technically, rather than what should be done, compassionately.

In a time of high consumption of FMCG (fast-moving consumer goods), electronics, brand competition and self-assembly furniture overload, knowledge of the language of design remains shrouded in mystery. Or perhaps magnified because of it? It seems unlikely that the impact of design is not appreciated, nor that of the value that design brings to the marketplace and for business growth (Design Council, 2012). Yet the artistry is unseen, such as the skill behind making the perfect surface, the grace of an object in the hand, the touch of a screen and the physicality of the haptic feedback in a button. These features mean little in isolation, but the value that their invisible combination can bring to the user is highly prized. These factors make a single object stand above the crowds of similarity - infused with the desirability factor that ensures success and longevity. It is perhaps, the shrouded nature of product development that prevents wider understanding of how such a solution becomes real. And consequently then, the inevitable barrier emerges which inhibits truly
deep insight.
Perhaps use of the terminology such as ‘ergonomics’, ‘prototyping’ and ‘rendering’ remain unknown concepts, since the words have minimal usage outside of New Product Development (NPD); terms seldom used in daily life, thus gaining little familiarity.
Working remotely on unfamiliar subjects, has clearly had an impact on the extent to which our interns were able to expand their thinking horizon, gathering new knowledge that enhances capability. To some extent we as a project team have seen a wealth of different creative proposals and have encouraged development of narratives in which to clarify meaning. But therein we have the dichotomy. As a project we must ensure high quality external communication, as formally represented by a digital presence and to do so, we have had to edit the ideas, constrain the thinking and the result is actually a small percentage of the endeavor. The final outputs are the ‘cleaned up’ versions, with the best intention of providing clarity to ensure that those outside of the design team would understand what is being ‘provoked’. Yet had we been in the studio all together, we would have talked at length, presented the rough cardboard sketch models, the pieces of sample material, the general mood boards and all of the other, well known design studio tools. When working remotely, the creative leap, that moment when everything comes together in context, is diffused and with it the jubilant sense of completion is reduced.
Perhaps this really teaches us that meaningful design has deeper meaning when hinged about a conversation, with overlapping ambition. When context is key to understanding a problem, empathy is vital to understand the emotional impact of an issue not just a mechanistic evaluation of performance or ability to satisfy a potentially mis-guided early intention. Rather, design for the future (as for the past) can be poetic and beautiful; meaningful and ambitious, imbued with responsibility, respect and purpose. But right now, it needs more genuine insight, and importantly, the motivation to make this a new normal practice; design needs a model to not only formalize this method but to actively endorse a new paradigm that comprises resolution, realization and completion (RRC) and to provide it with the recognition and value it richly deserves. The new paradigm would signify the designer’s method of choice at the outset, much as an if™ award might signal success of a designed outcome.
So, designers of our shared futures – those trained and those not, gather knowledge by practicing the art of conversation; it can put ideas into the hands of billions of people. TInnGo has highlighted the importance of learning from the needs of those frequently excluded, whose insight will open eyes and provide focus when thinking about responsible design. TInnGO also shows us that this is all the more difficult to achieve when we work in isolation. But then, triumph over adversity; as a collective we have had good ideas, respectful of experience and guided by unseen insight - jubilant moments for us all to share, even from a distance.

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References


13  Design contributes to transformations
The design entrepreneur: How adaptive cognition and formal design training create entrepreneurial self-efficacy and entrepreneurial intention

Bo T. Christensen, Kasper M. Arendt, Paul McElheron and Linden J. Ball

Abstract. Why are design students more likely than other students to become entrepreneurs? The cognitive mechanisms underpinning design- and entrepreneurial thinking have been argued to be similar, suggesting relevance to business venturing. On the other hand, differential formal training in design vs business education suggests distinct types of “entrepreneurial self-efficacy”. We report a survey (N = 296) of design versus business students that assessed how adaptive cognition and formal training drive distinct types of entrepreneurial self-efficacy and entrepreneurial intention. The study finds that design versus business students possess different types of entrepreneurial self-efficacy that are positively predicted by adaptive cognition, but differentially affected by type of education. Both types of entrepreneurial self-efficacy positively predict entrepreneurial intention to start up a new business. These findings advance an understanding of how design cognition overlap with other fields.

Keywords: adaptive cognition, design training, entrepreneurial intention, entrepreneurial self-efficacy

1 Introduction

Over the past few decades, the meaning of the term “design” has slowly shifted from pertaining mainly to the practice of a certain type of profession, which is primarily the preserve of formally trained architects, engineers and designers, to now denoting a special kind of thinking, which people from any profession can engage in. Research into the former has sometimes been labelled “designerly thinking” (Cross, 1982), and relates centrally to the study of how trained, expert designers reason, while the latter is often termed “design thinking” (Johansson-Sköldberg et al., 2013), and relates especially to the study of how a prescriptive set of user-centered tools and process steps can be applied by any profession to improve on designed outcomes.

With their shared focus on cognitive processes, the designerly thinking and design thinking approaches have become somewhat entangled, leading to a degree of conceptual confusion as well as attempts to demarcate clearer distinctions regarding how to define design. As a case in point, consider the profession of business entrepreneurship, which has sometimes been compared to design and is claimed to require thinking much like that of designers. Past research, which we will review below, does indeed appear to show that designers and entrepreneurs generate ideas in similar ways by deploying similar types of problem-solving strategies and metacognitive monitoring and control mechanisms. But to what extent are entrepreneurship and design truly underpinned by equivalent cognitive and metacognitive processes and to what extent do important distinctions prevail that speak to the unique aspects of the causal determinants of outcomes in these two domains? The present paper
sets out to disentangle some of these issues, in close alignment with the theme of DTRS13, which likewise seeks to explore such conceptual confusion and to debate the demarcation between domains. We recognize that the entanglement between the notions of designerly thinking and design thinking may well worry many trained designers. With the conceptual expansion of design into other professions, are we not losing sight of core aspects of what it means to design as a designer? Should designers not be aiming to keep other professions off their design turf? On the other hand, the conceptual expansion also potentially brings new opportunities for trained designers. If design thinking is now something that can be meaningfully applied in management, marketing, innovation, human resources and the like, then might this capture new turf for designers and new professional roles for them to appropriate? In these respects, we are clearly dealing with contested issues that potentially have both negative and positive ramifications for design practitioners.

In the present paper, we aim to contribute to the exploration of the existing conceptual confusion relating to designerly thinking and design thinking by presenting an empirical study contrasting design students with business students, both in terms of how they are trained to think as well as in terms of how their different formal, professional training leads to distinct skills and competencies. Crucially, too, we are also interested in how such skills and competencies have downstream effects on what such students believe they are capable of, that is, their perceived self-efficacy. A particularly interesting outcome measure of what design versus business students believe they are capable of pertains to their intention to start a new business venture. Design graduates choose to start their own businesses much more frequently than most other professional graduates. In Denmark, for example, approximately 30% of design school graduates become entrepreneurs within their first 10 years after graduation, exceeding most other cultural and artistic educational programs as well as business school graduates (~11%), with the average level in higher education being ~7% (Uddannelseszoom; Statistics Denmark).

There are several possible explanations for this observation. First, the structure of the labor market for professional designers is dominated by, and invites for, small-scale venturing. Second, graduate unemployment rates force trained designers to start their own ventures to maintain a living. Third, design graduates are trained with skills and ways of thinking that they believe are useful in business venturing, hence lowering the barriers to enter into business start-ups. In the present article, we investigate the latter explanation, whereby it is perhaps the case that design training positively affects graduate start-up activity through the acquisition of skills and ways of thinking believed to be relevant for starting a business. By exploring how the differential training of design versus business students leads to competencies and ways of thinking that in turn affect what the students believe they can do, and intend to do, in their subsequent careers, we aim to inform the debate about how design overlaps with other domains (such as business and entrepreneurship), and with what consequences.

1.1 Linking design to entrepreneurship

More than 50 years ago, Herbert Simon (1969) advocated the teaching of applied disciplines through design-based curricula, asserting that professional schools, including schools of business, engineering, law, medicine and architecture, are all concerned primarily with the process of design. Simon (1969, p. 130) famously defined design as “devising courses of action aimed at changing existing situations into preferred ones”. Simon’s definition of design could well pass as a definition of the entrepreneurial process, and it is clear that both design and entrepreneurship aim to change living conditions to produce better situations or new value. Thus entrepreneurship, when viewed through a design lens, might help students identify and act on unique venture opportunities (Neck & Greene, 2011).

Business models are now theorized as basic organizational frameworks to be “artfully” generated
through design processes (Teece, 2010), utilizing visualization methods such as the Business Model Canvas (Osterwalder et al., 2010). There has also been a recent surge in training entrepreneurship by means of pedagogical approaches such as studio-based learning, which are well known to design education (Barry & Meisiek, 2015; Christensen et al., under review). Lackéus (2015) has described experiential entrepreneurship education as pedagogically similar to traditional design education: it is problem- and opportunity-oriented; features long-term projects; delivers value to external stakeholders; involves iterative experimentation; and demands team-based, real-world interactions with stakeholders and users.

It is not just entrepreneurial and design education that share similarities, but also entrepreneurial cognition and design cognition. Entrepreneurial cognition is defined as the knowledge structures that people use to make assessments, judgments and decisions involving opportunity evaluation, venture creation and growth (Mitchel et al., 2002). As noted by Ward (2004), novel and useful ideas are the lifeblood of entrepreneurs. To become successful, entrepreneurs need to generate valuable ideas for new products or services that will appeal to a market, identify new business opportunities and ensure that ventures are brought to fruition. Entrepreneurial cognitive processes play a key role in understanding how new ideas for ventures are recognized, generated or discovered, and how cognitive processes aid in transforming ideas to fully-fledged business models. In entrepreneurship research several generative cognitive processes seem to underpin the pursuit of new business opportunities, including intuition (Baldacchino, 2015), ideation (Gemmel, 2011), improvisation (Hmieleski, 2013), counterfactual thinking (Baron, 1998, 2000) and conceptual combination and analogy (Ward, 2004). A particularly influential stream of entrepreneurial research stems from Sarasvathy (2001), who developed the concept of “effectuation” when working under the guidance of Herbert Simon. Effectuation has emerged as one of the key cognitive concepts argued to separate entrepreneurial thinking from cognitive processes arising in the domain of general economics. Sarasvathy (2001) suggests that entrepreneurs engage with distinct “logics”, or cognitive processes, when pursuing entrepreneurial opportunities. She distinguishes between a “causation” logic, typically used in entrepreneurial situations associated with lower degrees of uncertainty, and an “effectuation” logic, which pertains to the early stages of venture creation in contexts involving greater levels of uncertainty. A causation logic entails beginning the process with a given goal, focusing on expected returns, emphasizing competitive analyses, exploiting existing knowledge and trying to predict an uncertain future. An effectuation logic, on the other hand, begins with a given set of means, focuses on affordable returns, emphasizes strategic alliances, exploits contingencies and seeks to control an unpredictable future (Perry et al., 2012). Entrepreneurs (much like designers) operate in environments that may be characterized as radically dynamic and uncertain, and in such contexts expert entrepreneurs have been argued to operate less in accordance with goal-directed, pre-planning behaviors, instead focusing on exploring how to mobilize available resources for some possible (but not pre-specified) value creation. This effectuation logic turns business creation into a design problem as opposed to an optimization problem. A recent study by Klenner et al. (in press) provides empirical insights from interviews with designer-founders on how design thinking and effectuation inform each other in practice, illustrating how design thinking can function as an approach for entrepreneurial innovation and new venture creation.

### 1.2 Entrepreneurial self-efficacy and entrepreneurial intention

Why do design students frequently start their own businesses? To explore the possibility that design education (like business or entrepreneurship education) helps develop students’ self-efficacy in starting and running a business, we set out to test empirically for the existence of a link between entrepreneurial self-efficacy (ESE) and entrepreneurial intention (EI). ESE refers to an individual’s
belief in their capability to perform tasks and roles related to entrepreneurial outcomes and is crucial in determining whether individuals choose to pursue entrepreneurial careers (Newman et al., 2019). Self-efficacy denotes a mechanism of agency, motivation and behavior, with theorists agreeing that it is domain specific (e.g., Bandura, 1997, 2006). According to the social-cognitive theory of career and academic interest, occupation-specific self-efficacy, as opposed to generalized self-efficacy, is linked to effects on career development and performance (Lent et al., 1994). In entrepreneurship research, ESE has emerged as a central psychological construct, with growing evidence indicating that entrepreneurial education enhances ESE in both undergraduate and graduate students (Newman et al., 2019). In addition, ESE is affected by individual differences (e.g., gender, personality, need for achievement) and exposure to mentors and role models (e.g., having entrepreneurs in the family).

EI may be defined as a state of mind directing a person’s attention and actions towards self-employment (Souitaris et al., 2007). EI may concern either the initiation of a new business venture (generating a start-up) or the acquisition and scaling of an existing company. We focus here mainly on the former type of EI (i.e., initiating a start-up) (Zhao et al., 2005).

In relation to the outcomes of ESE, past research has frequently drawn upon the Theory of Planned Behavior (Ajzen, 1991) to explain the emergence of entrepreneurial intention (EI) and actual business venturing activities. According to the theory of planned behavior (Ajzen, 1991), planned behaviors are intentional and thus predicted by attitudes and perceived behavioral control. Here, ESE is believed to capture an individual’s perceived behavioral control, which is a key element in their intention to engage in entrepreneurial behavior (Chen et al., 1998; Miao et al., 2017). Significant positive effects of ESE on EI have been found for both undergraduate and graduate students, as well as in the population at large (Newman et al., 2019). In past literature, EI has proved to be the best predictor of planned behavior towards self-employment, especially when behavior is rare, or involve unpredictable timelags (Bird, 1988). Research on EI has shown that university entrepreneurship programs raise EI (Souitaris et al., 2007; Chen et al., 1998; Liñán & Fayolle, 2015), with some of the important educational factors being educational and structural support systems (Turker & Selcuk, 2009).

ESE is a multi-dimensional construct (Newman et al., 2019), consisting of a number of sub-factors (e.g., Barakat et al., 2014; Barbosa et al., 2007; Chen et al., 1998; Denoble et al., 1999; McGee et al., 2009). Although several studies treat ESE as a global, higher-order construct, research on the effects of education on ESE has identified differential educational effects on the sub-factors that underpin it (Chen et al., 1998). In the present study, we focus on the two entrepreneurial self-efficacy sub-factors of new product development and opportunity identification and commercialization. Our first hypothesis replicates past research on ESE and EI, extending it to formal design education contexts:

**Hypothesis 1:** The ESE sub-factors of new product development, and opportunity identification and commercialization both positively predict EI.

### 1.3 The Effects of Adaptive Cognition on Entrepreneurship

Both the design and business domains emphasize the need for practitioners to be attuned to environmental changes and to have the metacognitive ability to identify and apply strategies in flexible and “adaptive” ways that are appropriate to the prevailing situation or task (see Feltovich et al., 1997, and Klein, 2011, 2017, for important views on adaptive expertise). Sixty years of design cognition research has shown that expert designers employ adaptive strategies such as framing (Dorst, 2015), analogical reasoning (Christensen & Schunn, 2007), abductive reasoning (Dong et al., 2016), mental simulation (Ball & Christensen, 2009; Christensen & Schunn, 2009) and problem–solution co-evolution (Crilly, 2021; Dorst, 2019; Dorst & Cross, 2001; Wilschnig et al., 2013). The strategies allow designers to learn from experimentation, to create hypotheses and to manage the epistemic
uncertainty associated with ambiguous situations (Ball et al., 2010). Through metacognitive awareness of ongoing progress and challenges, expert designers selectively and adaptively engage in cognitive operations (Ball & Christensen, 2019; Christensen & Ball, 2018) and switch away from unproductive cognitive patterns through reflection with peers and more experienced designers (Schön, 1983).

Although research into entrepreneurship education focuses primarily on action, scholars have also debated the roles of reflection, metacognition and adaptive thinking in entrepreneurial knowledge production (Kassean et al. 2015; Lindh & Thorgren, 2016; Pittaway & Cope, 2007). Indeed, evidence suggests that adaptive strategies similar to those deployed in design are likewise associated with entrepreneurship (Garbuio et al., 2018; McMullen & Shepherd, 2006). For example, it has been found that metacognitive awareness can engender the application of adaptive cognitive strategies in entrepreneurial contexts, underpinning an “entrepreneurial mindset”, which consists of the ability to be flexible and to self-regulate cognition in complex, dynamic and uncertain task environments (Haynie et al. 2010). Such metacognitive awareness and the resulting entrepreneurial strategies also appear to be enhanced through training (Mevarech, 1999; Schmidt & Ford, 2003). Furthermore, the importance of being able to detect those possessing an entrepreneurial mindset led Haynie et al. (2009) to construct a measure of adaptive cognition in entrepreneurship, with this measure being defined as an individual’s ability to be dynamic, flexible and self-regulating in their cognitions given dynamic and uncertain task environments. We used this measure in the present study to assess adaptive cognitive abilities in both design and business students.

Following the entrepreneurship literature, we hypothesize that entrepreneurship education should help to train adaptive cognition, which should subsequently lead to elevated levels of ESE. Given the arguments for the importance of adaptive cognition in both the design and entrepreneurship literatures, we do not predict a difference in the level of adaptive cognition between design versus business students. It does follow, however, that elevated levels of adaptive cognition in design students should lead to increased ESE, much like for entrepreneurship students. This leads to the second hypothesis:

Hypothesis 2: For both business and design students, adaptive cognition positively predicts the ESE sub-factors of new product development and opportunity identification and commercialization.

1.4 The effects of design versus business education on entrepreneurship

In arguing that designers and entrepreneurs may be thinking alike in many ways (e.g., by having similar mindsets and applying similar adaptive cognitive strategies), it is easy to lose sight of the fact that trained designers and business managers have, in fact, passed through very different educational systems, affecting their competencies, their identities and their ways of thinking. Thus, although design education may be linked to particular kinds of thinking, it is nevertheless the case that educational outcomes of formal design training are not simply reducible to these kinds of thinking. What trained designers can do – what roles they may fill in organizations, what type of value they may produce and what skills they have – extend beyond what may be described as “ways of thinking”.

Higher education aims to train a range of program-specific competencies and skills, with student progression guided by domain-specific pedagogic approaches. Students on a university’s business tracks are trained in core subjects and methods that are markedly different to those of students on design tracks. The labor-market (i.e., the receivers of the outcomes of university education) expect that specific program content will feed through to graduates’ competencies, allowing them to take up
specialized organizational positions related to their education. As such, education is specialization; the trained business graduate is expected to be able to fill a very different role in an organization to the trained design graduate. Although none of this is surprising, it does highlight the need to maintain a keen eye on how business versus design students are educated, if the aim is to understand what roles they will be able to take up within or outside their chosen professions. What occupies us here is the extent to which a specific type of education (design vs. business) instills a degree of belief and self-efficacy in students that they have skills and competencies to stretch beyond narrow, specialized roles in business or design, allowing them to become successful business or design entrepreneurs.

ESE encompasses several sub-factors such as marketing, management, financial control, planning, opportunity identification, product development and creativity (Newman et al., 2019). Given the specialization of higher education, design versus business students should differ in terms of these ESE sub-factors. For example, previous research has documented program-specific differences on ESE sub-factors between students on different programs, with Chen et al. (1998) finding that entrepreneurship students had higher self-efficacy in marketing, management and financial control than either management or psychology students. Across the three types of students, ESE was positively related to the intention to set up one’s own business.

Here we focus on how business versus designs students differ on the two ESE sub-factors of new product development, and opportunity identification and commercialization. We note that business education is a social science, with an emphasis on the social aspects of organizing, financing and marketing new business ideas, whereas design education is a material or technical science, with an emphasis on product development and reflective training in material interaction (Schön, 1983). Given that design programs train for the iterative, hands-on development of newly designed outcomes within certain areas of design specialization, it may be expected that design education should increase a student’s self-efficacy within new product development. Conversely, business programs usually do not train skills within new product development, and students usually receive no training in hands-on material interaction. Business programs do, however, focus on managerial aspects of innovation, including strategy and process steps, often through case-based learning, which should not translate to the same degree into new product development self-efficacy as would be the case with designers.

Business programs typically focus on management aspects of organizational life, including specialized organizational functions within strategy, marketing, operations, finance, innovation and human resources. This organizational overview is often taught using lectures and casework. As such, business programs maintain an encompassing focus on the entire value-chain and the full spectrum of organizational life, maintaining a broader management overview compared to design education. While design programs often focus on aspects of user and market needs (i.e., one aspect of business-opportunity recognition) as a starting point for product development, business programs maintain a broader view of what constitutes an attractive business opportunity, extending into finance, pricing and cost structures, organizational scaling and management, marketing and business operations.

Baron and Ensley (2006) contrasted the knowledge structures driving pattern recognition for novice and experienced entrepreneurs, finding that the latter had richer and more clearly defined mental conceptions of what characterized a good business opportunity. Experienced entrepreneurs (in contrast to novice entrepreneurs) who were seeking to recognize business opportunities were found to focus on whether a business idea solves the customer’s problems (which both design and business education typically focus on). However, they also focused on other concerns, including: the ability to generate positive cash flow and quickly generate revenue; the capacity to have a manageable risk; and the nature of the business organization pertaining to teaming and networking (which usually only business education focuses on). Consequently, business education should translate into a broader set of student competencies, and higher student self-efficacy, within business opportunity recognition and commercialization, compared to design education. This leads to the third hypothesis:
**Hypothesis 3:** Business students (vs. design students) will have more entrepreneurial self-efficacy pertaining to business opportunity identification and commercialization, whereas design students (vs. business students) will have more entrepreneurial self-efficacy in relation to new product development.

According to the preceding line of argumentation, EI concerns the starting up and running of a new business (e.g., based on the commercialization of a newly designed product line). However, EI can also come in the form of a distinct set of venturing activities pertaining to the acquisition and scaling of an existing company. Given the education-specific training in design versus business programs reviewed above, we hypothesize that venturing intentions may differ for design versus business students. Although design students may seek to start their own business with the purpose of producing and selling designed artifacts that they developed themselves, business students are more likely to have the intention of acquiring and scaling a company started by someone else (and where the main product sold was developed by someone else). Such an acquisition-oriented EI may be partially mediated by self-efficacy within business opportunity identification and commercialization, rather than self-efficacy within new product development. This led to the fourth hypothesis:

**Hypothesis 4:** Business students (vs. design students) will have a higher entrepreneurial intention to acquire and scale an established company, mediated by the students’ entrepreneurial self-efficacy within business opportunity identification and commercialization.

## 2 Methods

We conducted structural equation modeling (SEM) to assess how design cognition and education-specific skills create entrepreneurial self-efficacy and, in turn, entrepreneurial intentions. SEM is used to investigate the significance level and direction of correlations in the hypothesized model. Standardization of correlation estimates allows for interpreting the output of SEM as path coefficients like in traditional OLS regression. Furthermore, SEM allows for the estimation of direct and indirect effects which are preferable when testing mediation hypotheses (Acock, 2013).

### 2.1 Sample

Data for this study came from a survey of second and fourth semester students at a large design and business university college in Denmark offering a two-year Academy Professions degree program on design, technology and business with two different sets of educational specializations (design vs. business). Testing students from the same program at the same institution allowed us to home in on specialization-specific effects of design versus business education, while holding institutional and cultural factors constant. The Academy Professions degree program starts with a joint semester of courses for all students, including an introduction to general aspects of entrepreneurship such as the Business Model Canvas. Students then separate into their design or business programs for three semesters of specialist courses, internships, electives and a final exam project. Links for the survey were distributed in-class during the start of the semester and were followed up in-person at a campus-wide meeting where students were specifically allocated time to answer the survey. The vast majority of surveys (78.7%) were filled out within the last month of the semester, with the remaining surveys filled out across the remaining parts of the semester. Of 554 students surveyed, 296 provided full answers to the survey (a response rate of 53.34%), with 75.68% of responses coming from second semester students and 24.32% coming from fourth semester students. Given the small sample of
fourth semester students responding, we do not report results split by semester. The proportion of
students responding in their second vs fourth semester did not differ between programs ($\chi^2(1) = .96, p = .33$).

2.2 Measures

Entrepreneurial Intention (EI). We adopted the global measure of EI used by Zhao et al. (2005), but
we split it into two separate 2-item measures. The first measure (EI-Start) covers aspects of starting a
new business, while the second measure (EI-Acquire) covers the acquisition of an existing business.
More specifically, for the first measure, respondents were asked to assess how interested they were in
starting a business and in starting and building a high-growth business in the next 5-10 years. For the
second measure, respondents were asked how interested they were in acquiring a small business and
in acquiring and building a company into a high-growth business. Responses were given on a 5-point
Likert scale ranging from “very little” (1) to “a great deal” (5).
The measure of intention to start a new business had a high internal consistency, Cronbach’s $\alpha = .81$,
while the measure of intention to acquire a business had a slightly lower but nevertheless very good
internal consistency, Cronbach’s $\alpha = .73$. Confirmatory factor analysis with oblique rotation
confirmed the decision to split the global measure into two separate ones. In the analyses, each
measure was recoded into a dummy variable for respondents in the two top categories ($4 + 5$). Respondents
with a high intention to start a new business account for 39.86% of the sample ($n = 118$), while respondents with a high intention to acquire an existing business account for 22.97% of the sample ($n = 68$).

Education (Design vs. Business). The university college offers four design specializations, covering
fashion design, furniture design, pattern design and visual fashion. The three business specializations
offered cover branding and marketing management, purchasing management and retail design and
management. Distinguishing between enrolments into business or design specializations allows for an
assessment to be made into education-specific effects on entrepreneurial intentions.
For the design students, the product (e.g., an item of fashion or furniture) is the focus of the specialty
programs and the final exam. Emphasis is placed upon documenting the design process, idea
generation tools, materials and hands-on “making”, with competencies being developed through the
production of a product. Knowledge is gained on the design process and methods, materials,
aesthetics and sustainability, with key competencies developing within the implementation of design
from an idea to a finished product, as well as describing and analyzing user needs, and taking part in
product development processes. For business students, the focus of teaching sessions is on identifying
and solving a business problem, often based on a case study. For the final exam, the output is a
written report that proposes a strategic solution to solve a business problem that the student has
identified. Knowledge is gained on marketing, organizing, management and communication, with key
competencies developing in relation to the introduction of new products to the market, project
management, planning and implementation, and optimizing operations.
The two types of specialty programs also differ in their pedagogy. For business students, the
pedagogy is comprised of lectures, casework and discussions where students work in groups and
receive group-based guidance. Business projects are formulated as a report, and tend to progress
through a set of steps, from selecting an approach, through problem formulation, to literature review,
research design and on to analysis and conclusions. For design students, studio-based learning is the
predominant form of instruction, with visualization and prototyping encouraged and with lectures
mainly used to support studio work. Design projects materialize as a product (in support of a concept)
considered as a design solution, which progress through a series of iterations from concept
development through refinement to the building of a prototype. We note that 45.27% of students in
the sample were enrolled in a design specialization, while the remaining 54.73% were enrolled in a business specialization. In the SEM analysis, education was coded as Business = 0 and Design = 1.

As a validation check that formal training had an impact on student competences across time in our sample, we tested whether the fourth semester cohort of students differed from second semester students in Entrepreneurial Self-Efficacy. For both ESE-NPD (Cohen’s $d = .17$) and ESE-OIC (Cohen’s $d = .27$) we found small positive effect sizes, indicating increased self-efficacy across time. Given the small sample size of fourth semester students, this was only significant for ESE-OIC, but does illustrate effects of formal training in our sample.

**Entrepreneurial Self-Efficacy (ESE).** We included a four-item measure of ESE developed by Zhao et al. (2005). This measure was devised to measure self-efficacy regarding a general set of entrepreneurial tasks, covering how confident students feel they are in successfully identifying new business opportunities, creating new products, thinking creatively and commercializing an idea or development. The measure has been reported to have a strong correlation to other dominant measures of ESE, such as that developed by Chen et al. (1998). The Zhao et al. (2005) measure was developed as a global measure of ESE, aggregating across entrepreneurial task domains (Zhao et al., 2005, p. 1268).

To test for differential educational effects on ESE sub-factors, we separated the Zhao et al. (2005) ESE measure into two 2-item sub-factors pertaining to new product development and opportunity identification and commercialization, respectively. Similar ESE sub-factors have been applied in past research, with creativity and new product development being used in several measures (e.g., Barakat et al., 2014; Chen et al., 1998; DeNoble et al., 1999). Similarly, opportunity identification (Barbosa et al., 2004) and aspects of commercialization have been applied in several measures (Barakat et al., 2014; Chen et al., 1998; McGee et al., 2009).

The global ESE measure had an acceptable internal consistency, $M = .70$, $SD = .17$, Cronbach’s $\alpha = .67$, as did the sub-factors relating to new product development (NPD), $M = .74$, $SD = .19$, Cronbach’s $\alpha = .62$, and opportunity identification and commercialization (OIC), $M = .67$, $SD = .20$, Cronbach’s $\alpha = .59$. While internal consistencies are acceptable (albeit at the lower end), confirmatory factor analysis using oblique rotation revealed that items load onto two factors, validating the decision to divide ESE into sub-factors.

**Measure of Adaptive Cognition.** To measure respondents’ entrepreneurial mindset we used the measure of adaptive cognition (MAC; Haynie & Shepherd, 2009). MAC is a generalized measure of metacognitive awareness in an entrepreneurial context and includes 54 items divided across five dimensions of metacognitive awareness. Responses are given on an 11-point semantic differential scale, which is anchored on the left with the statement “not very much like me” and on the right with the statement “very much like me”. The MAC showed a very high level of internal validity, $M = .72$, $SD = .10$, Cronbach’s $\alpha = .92$.

**Control Variables.** The analyses included control variables for socio-demographic characteristics such as gender, age and number of children as well as if any family member was an entrepreneur (Table 1). These control variables were included: (1) to account for any potential self-selection into design or business programs; and (2) because these indicators have previously been found to be influential in predicting entrepreneurship (Walter & Heinrichs, 2015) and entrepreneurial self-efficacy (Newman et al., 2019).
Table 1: Socio-demographic characteristics of the design and business students in the sample

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneur in the family</td>
<td>0.50</td>
<td>0.58</td>
</tr>
<tr>
<td>Age (in years)*</td>
<td>24.87</td>
<td>22.54</td>
</tr>
<tr>
<td>Has children (1+)</td>
<td>0.16</td>
<td>0.09</td>
</tr>
<tr>
<td>Gender (female = 1)</td>
<td>0.88</td>
<td>0.91</td>
</tr>
<tr>
<td>Number of observations</td>
<td>134</td>
<td>162</td>
</tr>
</tbody>
</table>

Note: *Difference is statistically significant using a t-test, p < .05

3 Results

Means, standard deviations and correlations for all measures that were included in the analyses are shown in Table 2. Both of the self-efficacy measures (ESE-NPD and ESE-OIC), the MAC, and the indicator of an entrepreneur in the family have a direct and significant relationship with the entrepreneurial intention to start a new business (EI-Start). Both of the self-efficacy measures (ESE-NPD and ESE-OIC) also have a direct and significant relationship with enrolment in design/business specializations (the education variable). Furthermore, MAC also correlates significantly with the entrepreneurial intention to acquire a business (EI-Acquire).

The results of the structural equation modelling analysis are presented below (Table 3), with two models being tested for their goodness of fit to the data: one involving EI-Start as the outcome measure and one involving EI-Acquire as the outcome measure. Both models fit the data well: Model 1 (outcome EI-Start), $\chi^2(4, N = 284) = 2.92, p = .57$; and Model 2 (outcome EI-Acquire), $\chi^2(4, N = 284) = 2.45, p = .65$. The remaining goodness-of-fit statistics shown in Table 3 indicate a reasonably good fit, meeting the criteria suggested by Hu and Bentler (1999) and Acock (2013). Standardized path estimates are presented in Figure 1.

Table 2: Means, standard deviations and correlation for included variables and measures

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>EI-Start</th>
<th>EI-Acquire</th>
<th>Education</th>
<th>ESE-NPD</th>
<th>ESE-OIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI-Start</td>
<td>0.40</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EI-Acquire</td>
<td>0.23</td>
<td>0.42</td>
<td>0.49**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>0.45</td>
<td>0.50</td>
<td>-0.05</td>
<td>0.14</td>
<td>0.30**</td>
<td>0.41**</td>
<td></td>
</tr>
<tr>
<td>ESE-NPD</td>
<td>0.75</td>
<td>0.20</td>
<td>0.23**</td>
<td>0.14</td>
<td>-0.12</td>
<td>0.41**</td>
<td></td>
</tr>
<tr>
<td>ESE-OIC</td>
<td>0.68</td>
<td>0.20</td>
<td>0.27**</td>
<td>0.20**</td>
<td>-0.02</td>
<td>0.26**</td>
<td>0.36**</td>
</tr>
<tr>
<td>MAC</td>
<td>0.72</td>
<td>0.10</td>
<td>0.19**</td>
<td>0.23**</td>
<td>-0.02</td>
<td>0.26**</td>
<td>0.36**</td>
</tr>
</tbody>
</table>

Note: EI-Start = Entrepreneurial Intention to start a business; EI-Acquire = Entrepreneurial Intention to acquire and grow; ESE = Entrepreneurial Self-Efficacy; ESE-NPD = New Product Development; ESE-OIC = Opportunity Identification and Commercialization; MAC = Measure of Adaptive Cognition. Control variables not included. *p<0.05; **p<0.01
Table 3: Goodness-of-fit statistics for structural equation models.

<table>
<thead>
<tr>
<th></th>
<th>M1: EI-Start</th>
<th>M2: EI-Acquire</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2(df)$</td>
<td>2.92(4)</td>
<td>2.45(4)</td>
</tr>
<tr>
<td>CFI</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>SRMR</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Note: EI-Start = Entrepreneurial Intention to start a business; EI-Acquire = Entrepreneurial Intention to acquire and grow; CFI = Comparative fit index; SRMR = Standardized root-mean-square residual; RMSEA = root-mean-square error of approximation.*

The results shown in Figure 1 provide support of Hypotheses 1, 2 and 3. More specifically, the results from Model 1 indicate that self-efficacy sub-factor measures of ESE-NPD, $\gamma = .17, p < .01$, and ESE-OIC, $\gamma = .15, p < .05$, both positively predict the entrepreneurial intention to start a new business (EI-Start), thereby supporting Hypotheses 1. In other words, students with higher levels of each of the two ESE sub-factors also demonstrate higher levels of EI-Start. Hypothesis 2, which relates to the effects of adaptive cognition on ESE while controlling for design versus business education, is also supported, with standardized coefficients of .25 ($p < .01$) for ESE-NPD and .35 ($p < .01$) for ESE-OIC. This means that students with higher levels of adaptive cognition have correspondingly higher levels of each of the two ESE sub-factors, regardless of their education specialization. In relation to Hypothesis 3, the model confirms that business students have higher ESE-OIC levels compared to design students, $\gamma = -.11, p < .05$, whereas design students have higher levels of ESE-NPD compared to business students, $\gamma = .33, p < .01$. We note, however, that the results from Model 2, with EI-Acquire as the outcome measure, lead to a partial rejection of Hypothesis 4. While business students have, as predicted, a higher level of EI-Acquire, $\gamma = -.18, p < .01$, there is no evidence to support mediation by the level of ESE-OIC ($p = .47$). Instead, the level of ESE-NPD is found to mediate the effects (following the mediation approach advanced by Baron & Kenny, 1986), accounting for 34.63% of the effect of the education factor.

The part of Model 1 that links the education factor to EI-Start can be described as a double-opposing mediation model, with ESE-NPD and ESE-OIC serving as opposing mediators. Although not hypothesized, we tested for the direct and indirect effects of the education factor on EI-Start. Mediation analysis reveals that the inclusion of both of the self-efficacy sub-factors (ESE-NPD and ESE-OIC) fully mediates the effect of design versus business education on EI-Start. Furthermore, the effect of the adaptive cognition measure on EI-Start is partially mediated by the ESE sub-factors (ESE-NPD and ESE-OIC), with these sub-factors accounting, respectively, for 23.95% and 54.26% of the effect of the adaptive cognition measure.
Figure 1. Structural Equation Model with the outcome Entrepreneurial Intentions to start a business. Parameter estimates are fully standardized. Solid arrows represent hypothesized paths; a dotted arrow represents a path that was not hypothesized. H = Hypothesis; ESE = Entrepreneurial Self-Efficacy. The model visualization does not display control variables. *p < .05; **p < .01

4 Discussion

We tested four hypotheses pertaining to whether adaptive cognition and formal design training predict entrepreneurial self-efficacy and entrepreneurial intention in design and business students. In support of the hypotheses, we found that: (1) entrepreneurial self-efficacy predicts entrepreneurial intention to start a new business in both business and design student samples; (2) the level of students’ adaptive cognition predicts entrepreneurial self-efficacy in both business and design student samples; (3) formal, specialized training in design versus business leads to differential effects on the two entrepreneurial self-efficacy sub-factors, that is, trained designers believe they are more capable at achieving new product development, whereas business students believe they are more capable at achieving business opportunity identification and commercialization; and (4) formal business training (vs. design training) leads to entrepreneurial intentions to acquire and scale an existing company.

The results inform the design literature in several ways. First, in comparing design students and business students, the findings indicate that adaptive cognition may be considered a domain-general skill that both kinds of students display to an equal degree, and with the same types and levels of positive effects on students’ self-efficacy beliefs in their abilities to perform entrepreneurial tasks. At the same time, formal educational specializations relating to design versus business were found to have differential effects on the entrepreneurial tasks that students believed they could perform, illustrating that formal education led to domain-specific skills. The data thus illustrate that both domain-general (adaptive cognition, e.g., Klein, 2011, 2017) and domain-specific (formal education) conceptions of design co-exist in the same dataset, and that the two conceptions cannot be reduced to each other since they exert differential effects on entrepreneurial outcomes. Moreover, either focusing on design primarily as a kind of thinking (e.g., Johansson-Sköldberg et al., 2013) or as a kind of
domain-specific formal training that leads to practitioners engaging in designerly thinking (e.g., Cross, 1982), will miss part of the story in relation to a designer’s self-efficacy and behavioral intentions.

Second, the results support arguments in the literature that design thinking (measured in terms of an individual’s level of adaptive cognition) positively predicts designers’ self-efficacy beliefs and their behavioral intentions in areas that go beyond design tasks. Here we found that the level of adaptive cognition positively predicted entrepreneurial self-efficacy and entrepreneurial intention for both designers and business students.

Third, formal design training (vs. business training) was positively linked to a student’s belief in their ability to engage in new product development, but negatively linked to business opportunity identification and commercialization. This indicates that the specialization of formal design education exerts an education-specific effect on a student’s self-efficacy beliefs within entrepreneurship tasks. These results underscore the point that to explain designers’ self-efficacy beliefs and behavioral intentions in entrepreneurship there are at least two different pieces to the puzzle, whereby both domain-general cognitive abilities and domain-specific formal training of skills and competencies independently explain why so many designers start their own business.

Finally, the results help to inform the entrepreneurship literature, by highlighting that while formal design and business training may aid in producing higher levels of entrepreneurial self-efficacy, it remains the case that specific educational contents can lead to distinct types of self-efficacy. Thus, while the design-trained students believed in their abilities to produce new products and to start their own ventures on the basis thereof, the business-trained students believed in their abilities to identify business opportunities and engage in commercialization, and in their abilities to either start their own business, or to acquire and grow a business started by someone else. The two groups, however, showed no difference in their overall level of entrepreneurial intention to start a new business. In sum, the designer entrepreneur is likely to possess a different kind of entrepreneurial self-efficacy to the business entrepreneur, even though they may both think adaptively in similar ways.

Returning to the general issue of the shifting meaning of the term “design” from a type of profession to a kind of thinking, our results strongly suggest that to predict designers’ self-efficacies and behavioral outcomes we need both domain-general theories of cognition and domain-specific theories of skills and competencies acquired through formal design education. Only by understanding how trained designers have both skills and abilities that stand out from other professions, as well as having skills and abilities that are found in other professions, will we be able to understand fully the roles that designers believe they can play – and intend to play – in design and elsewhere.

The present study found similar levels of adaptive cognition amongst business and design students but hypothesized that both groups should have higher levels of adaptive cognition than other student groups not working within dynamic and uncertain task environments. Our sample, however, did not include a control group, and thus more research is needed to test this hypothesis directly. We also note that most business venturing takes place in teams. The present study did not explore the type of team composition sought or preferred by design versus the business entrepreneurs. It may be hypothesized that a heterogeneous skillset in a start-up team might lead to higher overall levels of team self-efficacy, and therefore team tendencies to start-up. Indeed, anecdotal evidence from our sample institutions suggests that graduate start-ups often employ a mix of design and business graduates. It is possible that the lack of formal training in management and organizational aspects may mean that the design entrepreneur may be less attentive to the importance of a heterogeneous skillset when building a start-up venture. Further research is again needed to unpack this issue. Finally, given that the students in the present sample were in their first or second year of their study, they may be considered either novices or early beginners in their educational domains of choice. With this limited time for formal professional training, it is possible that student self-selection into their educational programs
may have partially influenced their levels of entrepreneurial self-efficacy. Future research should aim to deploy pre-post experimental designs in order to more firmly control for student self-selection effects.

With this study we hope to have opened up new theoretical venturing possibilities for design researchers to explore, which relate especially to the roles that designers believe they can play in entrepreneurship and other fields outside of traditional design, and the factors driving their beliefs.

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Design Thinking meets innovation management – A case study examining how Diplomatic Rebels manage design in organizations

Hanna Lena Bogner and Anna-Sophia Rabe
Copenhagen Business School, Denmark, hanna.bogner@yahoo.de, rabe.anna@gmx.net;

Abstract. This case study introduces the unique concept of the Diplomatic Rebel: An innovation manager with the mindsets and skills of a Design Thinker (the rebel) as well as a manager (the diplomat). In doing so, a practice-based approach for managing design and innovation in organizations is presented. Studying the Diplomatic Rebels through the lens of literature, shortfalls in Design Thinking are advanced with management literature. While Design Thinking’s purpose is to overcome innovation barriers and drive idea generation, agreeableness and strategic thinking are needed to manage resistance and drive successful implementation in organizational settings. This contribution bridges the gap in academia and practice and consequently calls for a new stream of literature.

Keywords: Ambidexterity, Change Management, Design Thinking, Organizational Innovation

1 Introduction
Approximately 70% of innovation initiatives in organizations fail (Bucy, Finlayson, Kelly & Moye, 2016). While Design Thinking was brought to the business world as a new way to deliver creativity and increase a firm’s level of innovativeness, its success remains unclear. In fact, empirical studies seem to indicate that there are many difficulties related to implementing Design Thinking in organizational settings (Carlgren, Rauth, Elmquist, 2016). This is where this paper takes its starting point, investigating what it takes to manage design and drive innovation in organizations. Trying to provide an answer, we studied a case company who seems to propose a different approach by introducing the concept of the Diplomatic Rebel as an innovation manager. This paper sets out to understand, how do Diplomatic Rebels manage design and innovation? What do they do differently? How can the concept be understood in the light of literature? And finally, could this be a new approach to successfully establish Design Thinking in a corporate environment?

Taking a deep dive into the case study of Diplomatic Rebels, the paper advances the conversation of driving innovation through Design Thinking in organizations. Through eight in-depth interviews with experienced innovation managers, the unique concept of the Diplomatic Rebel is introduced. Combining the characteristics of a rebel (Design Thinker) with those of a diplomat (manager), they have a unique entry for driving innovation. Studying the Diplomatic Rebel through the lens of literature, we transfer management theories into Design Thinking. In doing so, the gap in the innovation process is filled: Design Thinking reflects the idea generation phase and is complemented with aspects from management literature for the implementation stage.

The paper is structured to first give an overview of the theoretical conversation in Design Thinking, in management and ambidexterity literature. Secondly, the method including the case study is presented. The main body of the paper consists of the findings, analysis and discussion of the Diplomatic Rebel’s mindsets and skills, and how these operate in the innovation process. The paper concludes with a summary, limitations and future research.
2 Literature review

The innovation process can be understood as two main processes: idea generation and implementation (Amabile, 1988; Baer, 2012; Rosing, Frese & Bausch, 2011). Design Thinking has been brought to the business world as a new way to spark creativity in the idea generation phase and involve customers throughout the solution development. However, the implementation in the organization, defined as a socio-political process, is often neglected in Design Thinking (Carlgren, et al., 2016; Rylander, 2009; Rosing et al., 2011). To fill this gap, we turn to management theory.

![Figure 1. The innovation process: idea generation & implementation](image)

2.1 Design thinking literature

Contrary to designerly thinking, which defines the designer’s way of working, this study focuses on Design Thinking in a business context (Johansson-Sköldberg, Woodilla & Cetinkaya, 2013). While many associate Design Thinking with a workshop model (Hassi & Laakso, 2011; Brenner & Uebernickel, 2016), we build on Johansson-Sköldberg et al.’s (2013) holistic definition of Design Thinking as a general thinking style and way to approach complex innovation problems in organizations.

Taking a practice-based view, Design Thinking literature differentiates between mindsets and practices (Hassi and Laakso, 2011; Brenner, Uebernickel and Abrell, 2016). The mindset is defined through abductive reasoning (Dunne & Martin, 2006; Kimbell, 2011) and reflective reframing (Dew, 2007; Boland & Collopy, 2004). Further, Design Thinkers show an experimental and explorative mindset (Fraser, 2007; Brown, 2008; Holloway, 2009) combined with a tolerance for ambiguity (Drews, 2009; Brown, 2008; Dunne & Martin, 2006). They embrace a holistic 360° view to develop a full understanding of the customers’ needs (Hassi & Laakso, 2011; Holloway, 2009). Lastly, Design Thinkers are optimistic (Brown, 2009) and future oriented (Dunne & Martin, 2006; Drews, 2009; Kimbell, 2011). The practices are thinking by doing (Brown, 2008), a human-centred approach (Brown, 2008; Dunne & Martin, 2006), collaborative work styles (Holloway, 2009; Kimbell, 2011) and visualizing (Brown, 2008; Rylander, 2009). Thus, Design Thinkers bring the mindsets and practices to think beyond boundaries, come up with novel ideas and involve customers to validate and develop solutions.

While Design Thinking has been widely praised, some authors express critique. Most criticism is directed towards a lack of measurable success and its application in the business world. Nussbaum (2011) criticizes that Design Thinking has turned into a linear-by-the-book process to fit organizational contexts. Kolko (2015) similarly argues that when managers become aware of the power of design, they see it as a solution to all their problems. Other authors see a gap between organizational values and those of Design Thinking. For example, the playful and exploratory aspect of Design Thinking is often perceived as non-serious, and Design Thinking can cause political conflicts as it questions established business standards (Carlgren et al., 2014; Rauth et al., 2015). Overall, while critique has been expressed, few offer solutions towards successful implementation of Design Thinking in a business context.
2.2 Management literature

Large corporates often fail to innovate, and approximately 70% of all implemented change initiatives in organizations are not successful (Nikolaou, Gouras, Vakola & Bourantas, 2008; Altringer, 2013; Bucy, et al., 2016). Looking at the reasons why large firms fail to develop disruptive innovation, Assink (2006) focuses on innovation barriers within organizations. The adoption barrier is seen in “organizational rigidity and the existence of a dominant design carried on through successful concepts from the past” (Assink, 2006, p. 227), which results in organizations being unable to adapt to new structures and introduce disruptive innovation. The mindset barrier reflects a firm’s inability to unlearn, the lack of distinctive competencies necessary for disruptive innovation, and obsolete mental models (Assink, 2006; Carlgren et al., 2016). Closely linked is the risk barrier, which describes a general risk averse corporate attitude. Sandberg and Aarikka-Stenroos (2012) find the mindset barrier to have the biggest impact on implementing innovation. Due to a fear of change and failure, conservative decision-making, and restricted organizational culture, employees are averse towards change. These negative feelings often lead to resistance (ibid.).

Maurer (2009) identifies three different levels of resistance. The first level, I don’t get it, stems from a lack of relevant information or knowledge, disagreement over the interpretation of data, or confusion over what it all means. The second level, I don’t like it, is rooted in employees' fear of losing face, status, control, or the job through the initiated change. Lastly, the third level, I don’t like you, reflects a lack of trust or confidence in the leader. Maurer (2009) further points out that many companies treat all resistance as first level resistance, whereas more than often the cause is emotional. To deal with resistance, diverse streams in management literature acknowledge that a one-sided competence set is not sufficient and call for a change manager’s mindset in two realms, spanning managerial aspects and social competences (Rezvani et al., 2016; Fisher, 2011; London, 1999). Building on that, Vakola et al. (2004) define that the personality traits of a manager should be strategic, achievement-oriented, orderly and persistent (conscientiousness) as well as emotional-diplomatic, cooperative, trustful and likeable (agreeableness) to better cope with change. Across several studies it was shown that extraversion and openness to experiment are not enough to manage change and that agreeableness and conscientiousness build a positive correlation with successful change implementation (Judge, Thoresen, Pucik & Welbourne, 1999; Vakola, 2004; Nikolaou et al., 2008).

Regarding the skills of a change manager, Van der Walt, du Plessis and Barker (2006) differentiate between rational intelligence (the ability to base decisions on a determinate logic), emotional intelligence (the ability to listen to employees, adapt and learn from each other) and spiritual intelligence. The latter can be linked to cultural awareness (Fisher, 2011), as it describes the ability to understand the values and meaning seeking needs of team members to create a unified culture of change. Rezvani et al. (2016) and Vakola et al. (2004) find that emotional intelligence is particularly crucial in situations of change. Managers, who are able to perceive, understand and manage emotions of oneself and others, can turn these emotions into positive directions, and foster motivation for creativity and change (ibid.). Further, Fisher (2011) emphasizes that leading and influencing others, creating trust, being able to manage conflict as well as understand others’ behaviour and cultural beliefs are crucial skills. Overall, communication skills are a key element in change management literature to educate and convince reluctant employees of why change is needed (Kotter & Schlesinger, 2008; Ford & Ford, 2009; Maurer, 2009; Turell & Earle, 2018).

2.3 Ambidexterity literature

Ambidexterity is widely discussed in the context of change and innovation, describing a manager’s ability to combine both exploration and exploitation (Paliokaite & Pacesa, 2015; Rosing et al., 2011). Exploitation is the ability to deploy already existing competencies and structures in an organization,
whereas exploration captures the discovery of new concepts (Paliokaite & Pacesa, 2015). Both competencies are needed for organizations aiming to change. Exploitation abilities are required to sustain efficiency, whereas exploration skills are essential for novelty (ibid.). Ambidexterity literature does not find common ground whether exploration and exploitation are to be embodied in one manager-person: Hunter, Cushmanber and Jayne (2017) claim that exploration and exploitation are a fundamental paradox and can thus not be incorporated in one person. Other authors find that these two personalities can co-exist as they come into play for different situational and personal factors (Bodwell & Chermack, 2010; Rosing et al., 2011; Keller & Weibler, 2014). While exploration is mostly encompassed in the idea generation phase, exploitation is mainly evident in the implementation process (Rosing et al., 2011).

3 Method

Studying the management of innovation processes in organizations, this research is based on a qualitative case study. As a case, the network-like company Diplomatic Rebels was chosen for two reasons. One, the case provided insights into different innovation processes in various large companies. Two, wanting to investigate Design Thinking, the company’s term for an innovation manager, the Diplomatic Rebel68, seemed a promising and novel concept to research. The company Diplomatic Rebels was founded in 2017 in Copenhagen to support intrapreneurs - individuals who drive innovation in large international organizations (1000+ employees). The company’s concept is a fellowship program, where intrapreneurs from different organizations and industries meet on a regular basis and exchange the challenges they face in their work as innovation managers. In group sessions, they discuss challenging topics and support each other. In addition, they get consultation and sparring from professional advisors. The fellows of the program are called Diplomatic Rebels. They are selected for the program based on having a position in innovation within a big corporation, as well as bringing a certain way of thinking and doing that is diplomatic and rebellious.

Following an inductive research approach, we started out by exploring the context of innovation managers, where diverse perspectives were narrowed down as the research progressed (Saunders, Lewis & Thornhill, 2009; Qu & Dumay, 2011). Therefore, we conducted an unstructured group interview to explore diverse open-ended questions as a first step. The concept of the Diplomatic Rebel was subsequently set as the focus of the research, which was further narrowed down throughout seven individual semi-structured interviews with each innovation manager. Here it is important to highlight that we did not start out knowing what constitutes a Diplomatic Rebel. Rather we saw it as an interesting concept to explore and research Design Thinking empirically and theoretically. Throughout the research process we then uncovered the systems and characteristics of the Diplomatic Rebel. Aiming to contribute to the field with new understandings of a social phenomenon, the focus was set on the interviewees’ perceptions of their social interactions and their way of working. More specifically, we researched factors for driving innovation through the real-life experiences of Diplomatic Rebels.

Table 1 provides an overview of all interviews. As far as possible, the interviews were held in person to observe behaviour, attitudes and environmental settings. However, three interviews were conducted via Skype, given the geological distance. The primary data collected through these eight interviews builds the empirical foundation of the study. Besides interviews, the research is influenced by secondary data consisting of documents published by the case company as well as non-text materials such as photos and artefacts used by the case company.

68 We indicate the company named Diplomatic Rebels in non-italic font and introduce the concept of Diplomatic Rebels in italic font.
Table 1. Overview of conducted interviews

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Matthew &amp; Benjamin</th>
<th>Matthew</th>
<th>Benjamin</th>
<th>Greg</th>
<th>William</th>
<th>Lincoln</th>
<th>Alex</th>
<th>Thomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Diplomatic Rebels</td>
<td>Diplomatic Rebels</td>
<td>Diplomatic Rebels</td>
<td>Spiel</td>
<td>News</td>
<td>Medant</td>
<td>E.G.</td>
<td>Flux</td>
</tr>
<tr>
<td>Position during time of interview</td>
<td>Managing Partner</td>
<td>Country Manager, Germany</td>
<td>Head of Capital Venture</td>
<td>Head of Analytics</td>
<td>Discovery Lead</td>
<td>Head of Innovation</td>
<td>Head of Global Quality</td>
<td></td>
</tr>
<tr>
<td>Conduction</td>
<td>Unstructured Group Interview (Personal)</td>
<td>Semi-structured Interview (Personal)</td>
<td>Semi-structured Interview (Skype)</td>
<td>Semi-structured Interview (Personal)</td>
<td>Semi-structured Interview (Skype)</td>
<td>Semi-structured (Skype)</td>
<td>Semi-structured (Skype)</td>
<td></td>
</tr>
<tr>
<td>Duration of interview</td>
<td>2:22:00 h</td>
<td>1:31:02 h</td>
<td>1:00:17 h</td>
<td>1:07:27 h</td>
<td>1:19:58 h</td>
<td>01:33:02</td>
<td>00:59:14 h</td>
<td>1:13:44 h</td>
</tr>
</tbody>
</table>

In a second step, an iterative data analysis was performed, alternating between empirical findings and literature. To mitigate bias and misinterpretations, we conducted and coded all interviews as a team. Following the inductive approach, all interviews were analysed through open coding. Thus, codes were formulated unsystematically at first and emerged progressively throughout the data analysis (Emerson, Fretz & Shaw, 2011; Miles, Huberman & Saldana, 2013). In the first coding cycle, interviewees’ direct answers and behaviour were analysed line-by-line and assigned with predominantly descriptive and in-vivo coding, in some cases process coding (Miles et al., 2013). From the first coding cycle a list of unstructured codes emerged, which were again clustered and summarized into themes through second cycle codes. Guided by literature, higher cycles were developed, completing the final coding tree.

It is important to mention that we used a hybrid form, where empirical findings and literature findings are directly connected in the data analysis. Lastly, our inductive research approach proves particularly suitable for constructing new theory by studying contextual aspects of small samples (Saunders et al., 2009).

4 Findings

As intrapreneurs whose job is to challenge status quo and drive innovation, all interviewees faced several challenges in their companies. To study these challenges and how Diplomatic Rebels deal with them, their cases are presented here:

Thomas transformed Flux, an international analytics company, from an internal process-focused into a customer-centric organization. He introduced a front-end innovation board and implemented entrepreneurial principles into the core culture. That new way of thinking triggered resistance amongst employees: “We do things ourselves. [...] We design ourselves. It's much better. So, we don't want to let too many people in. This whole notion about open innovation and strategic partnerships is very alien to us” (Thomas, Interview). Likewise, C-management did not buy into Thomas’ idea at first, as they didn’t understand the urgency of the innovation project over other company matters. Through the fellowship program, Thomas learned to pitch the idea better by applying empathy and selling it at the right time to C-level and colleagues: “Maybe I didn't pitch it well enough [...] but it seemed they had other things on their plate. [...] At least I've become more mindful of sometimes you have a window of opportunity, because things are going on behind the scenes where they are up to here with worries” (Thomas, Interview).

Alex changed the overall structure of E.G., a large international holding company. Like Thomas, Alex recognized that even though innovation is important, it is a lot of times not the most urgent matter in

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69 Both the interviewees’ names and their respective companies are anonymised.
an organization. In the holding, all sub-companies previously ran innovation individually and in parallel with product development efforts. Alex broke those silos down. Instead, she introduced a holding-wide innovation board to focus on radical innovation, while the sub-companies were to focus on continuous development. Introducing this new structure, Alex faced a lot of resistance, which stemmed from directors not feeling comfortable with the high risk associated with restructuring. To overcome that resistance, Alex called for one change manager with a mandate to drive change as well as the sensemaking skills to address the strategic goals of the company.

**Greg** initiated a radical innovation project in Spiel, a traditional toy company. His goal was to revolutionise the toy industry by transforming traditional toy bricks into digital worlds. As he didn’t get the buy-in from top management, Greg started to strategically build a “tribe” around him with colleagues who - in their free time - would develop the project. Greg emphasized the resistance his team faced from colleagues who did not accept the company change; “This is not Spiel. Spiel would never do this” (Greg, Interview). Greg understood it was important to counteract that conformity. “For people in big corporations, what happens is that they grow up through the system. [...] And then slowly they fall asleep, and they start getting more and more conform and they start thinking like everybody else ‘oh we can't do this because the system says we can't’” (Greg, Interview). His team continued the project and eventually succeeded. They started making T-shirts with the project’s slogan and learned to provide more information about the project, so people would understand “what it is all about”. Greg also emphasized the importance of being kind, empathic and approachable when talking to people about change. Over time, colleagues started getting curious and eventually, a hype was created bottom-up until C-level buy-in was achieved.

**William** wanted to change the culture and people dynamics at News, a nation-wide newspaper company. He stressed, that to succeed with new future strategies, the organization and its employees would need to become comfortable with change. “You have to figure out how to get people to change. And you will figure out that people hate change, and they only like change if it doesn’t affect them” (William, Interview). With resistance being a natural human response to disliking change, William applied different competences to convince people. He pursued a tailor-made approach and talked to people individually to meet their personal meaning seeking needs; “You cannot go in and try to create a culture in an organization. Culture stems from the people, and you need one person to do that, and then that could influence others” (William, Interview). For some people he used numbers and statistics, for others he explained empathically how they could benefit from change.

**Lincoln** led a digitization process in Medant – a world-leading healthcare group – by implementing a machine learning model. Lincoln was fully backed by C-level support, including necessary time, money and manpower to develop the project. Just before go-to-market, Lincoln got a new supervisor. The new boss had little knowledge of the project and saw no value in it. In the end, the new supervisor did not support the launch of the project. Lincoln changed position internally, and the digitization process was never implemented. Lincoln was the only case who was not successful with his project as he failed to gain the final supervisor support. Lincoln mentioned two reasons: Lack of ownership of his boss and clashing mindsets. First, Lincoln said, he would have needed to involve his boss more and bring him onboard from the beginning. Second, Lincoln’s experimental, trial-and-error mindset conflicted with his supervisor’s conventional theoretical approach. “I mean to be very honest; it's never going to work with him. [...] He is a different school” (Lincoln, Interview). Thus, in comparison to the other **Diplomatic Rebels**, the findings show a lack of empathy and communication for Lincoln towards his supervisor.

Amongst all five cases, the key challenge of resistance is observed – either from colleagues or supervisors. Two common reasons are found: Firstly, employees do not understand the need for change as it does not fit into the existing organizational traditions. As Greg exemplified: “[Even]
many of the lead designers […] were telling us ‘No, no, no, this is not Spiel. Spiel would never do that.’ So, we had a lot of resistance there” (Greg, Interview). Alex was challenged by a management board who didn’t understand the urgency for change; “[I was] facing a lot of resistance, having a hard time making people understand what we were doing and why we were doing it” (Alex, Interview). Secondly, employees fear the consequences of change, as it could threaten their jobs or competences. “All of them [the employees] they were a little bit afraid. Because it’s innovation projects, or let’s call it radical innovation, that maybe could disrupt the company or our products. Or new things that are too far from what they’re working on” (Alex, Interview). William highlights that fear is a natural response to change; “There will be some people that […] are afraid of the change to a degree where they just hate everything you are doing. It will feel like it’s personal but it’s just because they are super afraid. So, you will figure out that people hate change […] It’s a very natural thing.” The findings reveal that resistance is one of the most difficult challenges when introducing change in organizations. Therefore, the key fundamental principle of Diplomatic Rebels is to acknowledge that resistance always occurs in corporate innovation. Thomas explained: “it is about empathy. Sort of understanding that resistance is typically due to fear of the unknown and maybe not understanding or having been heard. I would always start with that, figuring that out. You have a responsibility to at least understand people are not doing this to be cruel to you but because they don't understand.” As a main finding of the paper, we observe that innovation cannot be implemented successfully without the organization’s support. Supervisor support is inevitable to get the required resources for the project and gain the final go for implementation. Colleagues’ support is crucial as they are the ones delivering and implementing the change initiatives.

5 Data analysis

In line with the inductive research approach, the data analysis interlinks findings from the cases and literature directly. Hence, this section aims to dive deeper into the mindsets and skills of the Diplomatic Rebels and how these can be understood through existing theory. As summarized in Figure 2, the analysis shows that the principles represented by Design Thinking fall in line with those of the rebel. The diplomat extends those mindsets and skills with people-understanding and a strategic focus. The grey-highlighted fields represent a gap in the respective literature field where management (diplomat) complements Design Thinking literature (rebel) and vice versa.
Figure 2. Overview of the Diplomatic Rebel’s mindset and skills, reflected through academia, incl. differences and gaps between literature streams. Grey areas are aspects not covered in the opposite literature.

### Mindset

Like Design Thinkers, the findings show the rebel to have a mindset of **abductive reasoning**. Instead of accepting norms (What is?), the rebel inherently questions the status quo and breaks up existing structures to come up with new ideas (What could be?) (Hassi & Laakso, 2011). Alex exemplified she “didn’t want to follow the same path as others” and showed out-of-the-box thinking by claiming she “was very curious about finding ways [...]**. Through their **experimental and explorative** mindset, the rebels pursue unknown fields and try out new things. The interviewees often referred to this as a trial-and-error and “try early, fail fast” mindset. Rather than viewing challenges as limitations, the rebel **embraces risks** and dares to disrupt existing thinking models (Fraser, 2007; Brown, 2008). This was reflected in comments such as “You don’t ask permission; you just try to do things” and “willing to go the full way and if you get fired then be it” (Lincoln, Interview). For example, Lincoln and Greg dared to proceed with their project and introduced radical digitization processes in their companies, even though they did not get management support at first. This mindset enables the rebel to solve wicked problems and arrive at radical innovation (Dunne & Martin, 2006; Brown, 2008; Kimbell, 2011). Same as a Design Thinker, the rebel exhibits a **future-oriented mindset** that aims to truly “change [the company] for the better” (Drews, 2009). The Diplomatic Rebels explain it as: “We are all the time looking into ‘How can we develop it better or how can we do things that might have a bigger impact?’” (Matthew, Interview). In addition, the rebels present a **holistic view** towards customer understanding (Hassi & Laakso, 2011). For example, Thomas restructured the company towards a customer-centric organization. Other interviewees expressed that the “mindset is about understanding, [...] have empathy basically to read a situation, understand what is going on here” (Greg, Interview). Lastly, an **optimistic mindset** was found. Optimism relates to passion and the intrinsic motivation and drive to keep going where others would give up (Dunne & Martin, 2006; Brown, 2008).

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<thead>
<tr>
<th>Skills</th>
<th>Rational Intelligence</th>
<th>Communication Skills</th>
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<tr>
<td></td>
<td>Collaborative Workstyles</td>
<td>Emotional Intelligence &amp; Culture Awareness</td>
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<td></td>
<td>(towards external stakeholders, e.g., consumers)</td>
<td>(towards internal stakeholders)</td>
</tr>
</tbody>
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<tr>
<th>Mindsets</th>
<th>Re却l</th>
<th>Diplomat</th>
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<td></td>
<td>Design Thinking Literature</td>
<td>Management Literature</td>
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### a. The Rebel

As one key result, we found the rebel’s mindsets and skills to fall in line with the key principles of Design Thinking. Thus, the rebel “embodies” the Design Thinker below.
Gloppen, 2009). But optimism is also reflected in a strong self-confidence and self-determinism; “[T]he rebel type, they love to shine themselves. [...] someone who can be a little dominating, who wants to fill out the room” (Greg, Interview).

Two mindsets postulated in Design Thinking are not found in the cases, namely ambiguity tolerance and reflective reframing. Most Diplomatic Rebels stuck to their innovation idea and pushed through to the end, instead of accepting outside opinions that might prompt them to diverge in other directions; “I have to push against the resistance, because I believe it” (Benjamin, Interview). Thereby, the rebels can create dislike and stir resistance amongst colleagues; “If they stay in the rebel, then people will find [...] them hard to work with, annoying. They will be people that you want to avoid” (Thomas, Interview).

Skills
Based on the findings, four dominant skills emerged for the rebel, in parallel to the Design Thinker. Firstly, the skill of thinking by doing is found in the rebel’s proactive way of working, recognizing trends early on and staying ahead in the innovative field. The rebel’s actions seem to be led by intuition, a practice of “first doing, then thinking”. Interviewees referred to it as “thinking in prototyping, thinking in testing” before extensive investments have been made (Bohemia, Liedtka & Rieple, 2012, p.157; Brenner & Uebernickel, 2016, p.8). Lincoln stressed the need to launch the digitization project as soon as possible to test it on the market: “it needed to go to market so I launched that” (Lincoln, Interview). Secondly, rebels are skilled in a human-centred approach. Having a dialogue with users from early on is a core skill mentioned frequently by our interviewees. Especially Thomas highlighted this: “So instead of these developers being half-time product developers, I wanted them to have more strategic focus on the customer needs and pains, being out there with the customers”. This highlights a crucial finding: Whereas Design Thinking mainly focuses on the external user view (Hassi & Laakso, 2011), the Diplomatic Rebels’ understanding of human-centeredness also includes internal stakeholders, how they perceive the project and how to get them onboard. Thirdly, the findings confirm collaborative work styles as a key skill (Hassi & Laakso, 2011; Holloway, 2009; Kimbell, 2011). The interviewees showed strong collaboration skills. However, working across departments likewise brings certain challenges; As Lincoln highlighted: “[I]magine 10 people that have different calendars and you have to figure out how to get the right people to meet together and bring a project forward”. These points of strategic stakeholder management and project planning are neglected in Design Thinking literature. Lastly, the interviewees were found to express their ideas through visualising, for example by using artefacts, LEGO Serious Play, or prototyping tools.

b. The Diplomat
The results show that the diplomat’s mindsets and skills are described in management literature.

Mindset
The data analysis derives two core mindsets of the diplomat, being strategic and agreeable. The findings show that the strategic diplomat would approach tasks analytically in a holistic and long-term manner to find the most efficient and realistic solutions. These features can be linked to conscientiousness and orderliness, characterizing a person as being planful and organized (Judge et al., 1999b). The interviewees had a clear goal in mind while being aware of “the strategic targets of the company: where we’re going, how to make money”, as well as the internal values and meaning-seeking needs: “If you want to take an organization in a direction, [...] you need to create change that goes along those values” (Matthew, Interview). The findings further show that the diplomat has a very people-focused mindset, coined as agreeableness – a mindset based on emotional intelligence that is
deeply rooted in empathy (Judge et al., 1999b). The agreeable diplomat is a likeable person, who is “very patient [and] a good-people-person. So preferably someone who's able to have a conversation with colleagues on their level, so that they feel comfortable” (Greg, Interview). This element of “whole-hearted openness”, “soft approach” and “trusted leadership” is a topic much discussed in the fellow group. It constitutes a core principle of Diplomatic Rebels, described as “writing love letters” and as “making other people shine”. As William put it: “Writing love letters is a great one. You have to make sure that people are encouraged and acknowledged because that’s what drives human behaviour”. Literature supports these findings with agreeableness and sociological understanding being the core competencies of a project manager to create trust and bond with others (Meng & Boyd, 2017; Fisher, 2011).

Skills
In line with the strategic mindset above, the diplomat has the skill of rational intelligence, the ability to think and act analytically (Van der Walt et al., 2006). In the interviews this was reflected in presenting precise action plans, charts and numbers to convince stakeholders; “I made a project plan, and I actually did it sometime prior to the project start”, “I had just presented my findings that show that we could potentially improve our sales rep’s revenue for somewhere between 30-40%.” (Lincoln, Interview). Beyond that, all interviewees demonstrated strong skills in emotional intelligence and cultural awareness (ibid., Fisher, 2011). Here, the diplomat is analysed as understanding and supportive towards their innovation teams. Diplomatic Rebels booked frequent touchpoints with their teams to understand their points of departure and feelings towards the organizational change; “You really need to make sure that everybody is feeling comfortable. If someone gets stuck, you need to maybe help them” (Benjamin, Interview). Being able to understand one’s own as well as others’ behaviours, emotions and values proves to be a crucial basis to create a culture of change (Rezvani et al., 2016). In addition, the interviewees highlighted the need to involve and empower team members from early on, which is reflected in the concept of “building a tribe” – a crucial skill of Diplomatic Rebels. Despite many colleagues being hesitant towards the project, Diplomatic Rebels started out with people who believed in the project and then scaled it by engaging more and more colleagues. “You have to make sure that people are encouraged and acknowledged from early on because [...] then they are more willing to change”. This goes back to empathy and speaking to colleagues on an “eye-to-eye level”. As Matthew said: “You need to be able to tell a story that people can relate to, and they want to be part of. Because that's how you get people behind you”. Engaging and involving is a crucial leadership skill to motivate and inspire others for the innovation project (Fisher, 2011). Therefore, strong communication skills are needed to bring people onboard (Kotter & Schlesinger, 2008; Maurer, 2009; Ford & Ford, 2009). The interviewees emphasized the importance of being able to influence and convince others through storytelling and explaining why change is needed. William for example emphasized how he persuaded colleagues for the innovation project by tailoring his communication approach to individual’s needs. He would present different charts and statistics to strategically convince different stakeholders. Explaining the importance of a project, its benefit for individuals and why they should change, can unblock people’s resistance towards change (Fisher, 2011).

c. The interreletion of Diplomatic Rebels
All interviewees referred to the Diplomatic Rebel as a unique concept and an equilibrated combination of competences; “I was amazed by this combination […] I felt very connected with it because I went through that process – being too much rebel that wasn't that good, but when I was too diplomatic, it didn't work either” (Alex, Interview). Throughout the fellowship, they learned that both competences of the rebel and the diplomat were needed to drive organizational change: “If you're only
a diplomat, [...] radical innovation projects don't get approved because you're not pushing hard enough [...] because you don't have the power—though, the will of the rebel for radical change, to go the extra-mile” (Thomas, Interview). On the other side, being merely a rebel, one would oftentimes be disliked in the organization and stir resistance. For example, Alex realized she couldn't bring change forward in the E.G., holding group if her approach was too innovative for the board of managers; “I was a rebel, you know. So, I was very, very pushy, and in the process, I harmed a lot of relationships. [...] It was very hard in the company, because [...] their investments were big, so they were very reluctant of creating different things [...] so I realized I needed to be more diplomatic.” Analysing the interrelation of the two, the findings show that the rebel and diplomat are no antonyms; “I don't think they need to be opposing in any way. [...] Because that would make it a bit schizophrenic [...]” (Greg, Interview). Instead, the rebel and diplomat emerge interactively - depending on the situation and the person being addressed; “You need those two to go hand in hand. So even when you're doing something very rebellious, like getting up on stage and telling everybody that we need to think differently... We know the company is about to be disrupted and needs to do something. Then you need the diplomat at the same time, telling the story in a way that makes everybody believe in it and makes everybody understand that they can be part of it” (Greg, Interview).

6 Discussion
In the following section we discuss in depth how Diplomatic Rebels manage the two stages of innovation processes: ideation and implementation (Amabile, 1988; Baer, 2012; Rosing et al., 2011). As outlined in the findings, we argue for the rebel (Design Thinking) to come up with ideas and introduce new thinking models. For successful implementation, we point to the diplomat (management literature) to overcome resistance and manage stakeholders. For simplicity reasons we play with the stereotypes of the rebel as the Design Thinker and the diplomat as a strategic and agreeable manager. We however want to highlight that this should not be seen black and white. The two sides are part of one person with overlaps occurring.

a. Innovation barriers
Literature has vastly shown that large organizations fail to innovate as they struggle to overcome adoption, mindset and risk barriers (Assink, 2006; Bucy et al., 2016). After all, that is the exact reason why Design Thinking has been brought to the business field: To help organizations innovate. We underline the argument that it is the rebel-side that helps organizations to break out of obsolete systems (Carlgren et al., 2016). In the following, we discuss how the rebel manages the adoption barrier, mindset barrier and risk barrier (Assink, 2006).

Wanting to drive organizations forward in a future-oriented way, rebels strive to create change for the better (Lockwood, 2010). Through abductive reasoning and an “what if”-approach, the rebel questions existing norms and triggers disruptive thinking (Hassi & Laakso, 2011). Thereby, the rebel has the capabilities to overcome adoption barriers and break out of obsolete systems. That was demonstrated by all interviewees aiming to “stir things up and shake everybody up” in their elsewise traditional companies (Benjamin, Interview). Lincoln expressed the strive for disruption as “You don’t ask for permission; you just try to do new things”. Based on their designerly way of thinking, rebels do not only challenge existing norms, but also help companies find new ideas and solutions (Dunne & Martin, 2006). Through their creative vision, rebels come up with solutions that “break new ground, develop new models, and pioneer new approaches” (Turell & Earle, 2018, p. 173). The rebel’s experimental and explorative mindset is a key capability to overcome the mindset barrier and come up with new solutions, where other employees would stay within existing mental frameworks such as “This is not Spiel. Spiel would never do this” (Greg, Interview). This was presented in all
interviewees introducing radically new approaches in their companies, from digitization, restructuring and introducing customer-centric thinking models. The rebel type pushes radical ideas forward as well as the process of testing them from an early stage and improving them in iterations (Hassi & Laakso, 2011), reflected in the interviewees’ “try early, fail fast” approach. Closely connected to the mindset barrier is the risk barrier. Perceiving ambiguous situations as desirable and feeling comfortable with taking risks, the rebel is set to cope better with change and thereby overcome the risk barrier (Judge et al., 1999a; Vakola et al., 2004). While their organizations fear the risks of innovation, the rebels accept the possibility of failing (Holloway, 2009; Plattner & Meinel, 2014). Both Lincoln and Greg proceeded with their projects in their free time, despite the explicit refusal from C-level, going as far as risking their jobs.

While the rebel is a key enabler to break through these barriers and drive forward new solutions, there are drawbacks. By pursuing novelty and innovation in organizations, the rebel naturally stirs resistance in the company – as “people hate change” (William, Interview). Through their risk-taking mindset and willingness to drive change, the rebel can appear “too pushy, and harm a lot of relationships” (Alex, Interview). Thus, the rebel’s disruptive capacity can come at the cost of sensitivity and empathy towards others. Introducing radical change without being mindful about internal stakeholder perceptions, the intrapreneur might not be able to implement the innovation project successfully. It was especially Lincoln, who struggled to build trust with his new supervisor and ultimately failed to gain buy-in. This is an aspect neglected in Design Thinking theory, and where this paper adds to the conversation: Reviewing Design Thinking literature, some authors do acknowledge the importance to function as a visionary leader (Boland et al., 2008; Bohemia et al., 2012; Johansson-Sköldberg et al., 2012) and build a safe culture for employees (Kolko, 2015). In addition, most Design Thinking literature emphasises team collaboration and orchestrating diverse inputs from team members (Hassi & Laakso, 2011). However, there is little conversation on how to lead teams, manage people and their emotions and fear against change, an aspect essential to get people’s buy-in for innovation projects. Accordingly, we bring the diplomat into play as a novel contribution to Design Thinking – a main contribution of this paper (see Figure 2).

b. Resistance

The previous findings show that resistance is one of the most prevalent challenges in innovation (Assink, 2006; Kotter & Schlesinger, 2008; Maurer, 2009). In the following, we discuss how the Diplomatic Rebels manage resistance through their unique competences in agreeableness and strategic thinking.

Agreeableness

Agreeableness, being cooperative, trustful, and likeable to others, is an essential competence of the diplomat to help employees cope with change (Judge et al., 1999b; Vakola et al., 2004). While the rebel often creates friction with people, it is the diplomat who resonates well with people by understanding human behaviour (London, 1999). Based on the skill of emotional intelligence, Diplomatic Rebels understand their colleagues’ standpoint and are able to bring them onboard for the project; “You need to be able to tell a story that people can relate to, and they want to be part of. And that again has to do with values: [...] to connect to something that they truly believe is important” (Matthew, Interview). The interviewees expressed how they first struggled to bring people onboard, as they faced two different types of resistance. Either people not understanding why change was needed (I don’t get it) or people being afraid of the consequences of change (I don’t like it) (Maurer, 2009). By involving their colleagues from early on and engaging them from the start and explaining why change is needed, the diplomat can overcome first-level resistance (I don’t get it) (Maurer, 2009).

For example, Lincoln and Greg “built a tribe”, starting out by seeking support from few people and
then scaling the team through followership. As Greg described; “You have to make sure that people are encouraged and acknowledged from early on because that’s what drives human behaviour [...] then they are more willing to change”. Here customized communication and rhetoric prove successful, to be responsive to multiple audiences (Kotter & Schlesinger, 2008; Maurer, 2009; Turell & Earle, 2018). For example, William excelled at making people understand why change is needed, by highlighting the individual benefits for each stakeholder. Based on cultural awareness and their emotional sensitivity, the diplomat can understand different systems of beliefs and can specifically address the meaning seeking needs and motivations of employees (Fisher, 2011; Van der Walt et al., 2006). This becomes crucial to manage second level resistance (I don’t like it) which often stems from fear (Maurer, 2009). By developing trusted relationships with colleagues, the diplomat provides a “safe house” to address fears and concerns within the team (Baer, 2012; Rezvani et al., 2016). Thereby, the diplomat can create a shared understanding and a positive perception of change by supporting the team members emotionally (ibid.; Vakola et al., 2004). For example, frequent touchpoints with their teams helped the Diplomatic Rebels to understand their colleagues’ standpoint and address potential feelings of mistrust or fear towards the change project. The strong sensibility towards colleagues, demonstrated in the concept of “writing love letters” and “making other people shine”, is found as a unique competence of the Diplomatic Rebels. Their empathy, care and sincere interest to understand other people, helps them in being exceptionally successful leaders in situations of change (ibid.).

It can be argued that the rebel/Design Thinker, is surely also able to build empathy with others (Holloway, 2009). Sato (2009) even claims that Design Thinkers must not only empathize with the customers’ practical needs, but also with their emotions and social and cultural environment. The difference between our point and Design Thinking literature is, that Design Thinking focuses on the meaning seeking needs of users and customers, but it neglects the focus on internal stakeholder management. Intrapreneurs need to be agreeable and empathic with their colleagues to help them cope with their inner resistance to change. This diplomatic management aspect represents an essential contribution to Design Thinking, required to successfully manage design and innovation in organizations.

Lastly, it can be discussed whether too close emotional bonds can lead to underperformance and inertia as team members fear to express criticism (Boschma, 2005; Turell & Earle, 2018). This dilemma is often termed as over-embeddedness; It can lead to a lack of diverse perspectives, impeding the innovation performance (Lowik et al., 2012; Andersen, 2013). Accordingly, strong buy-in ties should be seen with caution. For example, it could be questioned whether innovation is always required, after all. In the observed cases, the Diplomatic Rebels were merely concerned with effectively building trust to bring colleagues on board, whereas voices about concerns might have been unheard. I.e., in Greg’s case, many employees expressed that digital gaming would betray Spiel’s tradition in physical toy bricks. Whereas the interviewees didn’t deviate from their initial path, innovation managers should see resistance as valuable feedback to continually reflect if the project is going in the right direction (Ford & Ford, 2009; Turell & Earle, 2018). Here, Design Thinking puts importance on reflective reframing and ambiguity tolerance (Holloway, 2009; Dunne & Martin, 2006), two elements found as shortfalls in the Diplomatic Rebels cases. More specifically, we argue that Lincoln might have been able to succeed with his project, if he had acknowledged the perspectives of his new superior and integrated those into his project approach. The supervisor had strategic insights from a top management perspective that probably implied valuable reasons for not accepting the project.
Strategic thinking

The strategic and rational side to the diplomat is especially needed when it comes to convincing supervisors and overcoming their resistance - a second aspect disregarded in Design Thinking. Supervisor support is vital for successful innovation implementation as the project is not further scalable without the buy-in from higher management (Černe et al., 2016; Škerlavaj et al., 2014). Being a conscientious decision-maker who acts in line with the commercial goals and values of the organization, the diplomat can negotiate legitimacy for a project towards C-level management and supervisors (Turell & Earle, 2018). Whereas the rebel/Design Thinker focuses mainly on desirability and makes decisions based on external user insights and creative intuition (Hassi & Laakso, 2011), the diplomat can demonstrate the business viability of a project towards top management (Van der Walt et al., 2006; Turell & Earle, 2018). Especially William excelled at gaining his supervisors’ backing through his tailor-made strategic approach and by presenting sales numbers according to whom he would talk to on C-level. To add the strategic business perspective to Design Thinking is a second contribution of our paper.

The question could be raised whether the diplomat manipulates colleagues through customized rhetoric (Von der Walt et al., 2006; London, 2002). We, however, argue that the diplomat merely communicates the rebel’s inner, true motivation and passion in a way that others can resonate with. Whereas the rebel likes to shine on stage alone, the diplomat would “tell the story in a way that makes everybody believe in it and makes everybody understand that they can be part of it.” (Greg, Interview).

Concluding on how the Diplomatic Rebels manage the innovation process, the rebel is predominant for the idea generation phase to overcome organizational barriers and to push innovation forward. To implement an innovation project successfully, one needs to manage resistance and bring stakeholders onboard – a core competence, where the diplomat comes into play.

c. Interrelation between Diplomat and Rebel

With the Diplomatic Rebel, we introduce a new holistic concept, bridging the gap between Design Thinking (the rebel) and management literature (the strategic and agreeable diplomat). Questioning why those streams haven’t been combined before and whether conflicts might arise, we discuss if and how the two modes can be combined in one concept (one person). Here it is important that we take the intrapreneur as a starting point of our study, instead of innovation teams with different competences distributed across people (Design Thinkers and managers). Thus, we don’t question if different people could take on the different roles, we rather ask: Could one person occupy both?

Looking at literature that discusses Design Thinking and management jointly, we find ambidexterity literature as a first attempt to combine the two fields. Ambidexterity constitutes the dual roles in terms of exploration and exploitation (Paliokaite & Pacesa, 2015; Rosing et al., 2011). Here, exploration would represent the rebel, as it is defined as challenging existing systems and discovering new concepts. Exploitation would reflect the strategic diplomat as it is expressed in resource-sustaining and analytical approaches (Paliokaite & Pačesa, 2015). While authors in ambidexterity literature do not reach a consensus whether exploration and exploitation can be combined in one person or should be split between different roles in a team, we argue that the two modes can be unified – namely, in the unique concept of the Diplomatic Rebel. The empirical data shows that the interviewees do not experience an inner bias to reconcile the rebel and diplomat in one person. All interviewees agreed that the two modes complement rather than conflict each other. “I think in that sense they’re not separated. Because that would make it a bit…. […] schizophrenic. […] In that sense one just enforces the other. I think it’s a perfectly balanced mix” (Greg, Interview). In line with Bodwell and Chermack (2010), Rosing et al. (2011) and Keller and Weibler (2014), we claim that the two roles can co-exist and merely come into play for different tasks and situations. The Diplomatic Rebels mentioned it was
intuitive to them due to their high level of empathy, in which situations to push for innovation and challenge status quo, and when it’s crucial to speak to people and to involve them for implementation. Thereby, the Diplomatic Rebels make the innovation process complete, as they reconcile the two main activities: idea generation (creativity) and implementation (innovation) (Amabile, 1988; Baer, 2012; Rosing, et al., 2011).

While ambidexterity focuses on exploration and exploitation capabilities, we call for a new holistic theory. Our concept of Diplomatic Rebels enhances ambidexterity literature in two realms. Firstly, we advance the combination of exploration (rebel) and exploitation (strategic diplomat) by the emotional intelligent diplomat (agreeable diplomat), which as explained is crucial for successful implementation and to bring people onboard. This unfolds a unique concept which has not been explored in literature before. Secondly, this study enhances the academic conversation by proving, through empirical findings, that in practice the combination of the rebel and the diplomat in one role is possible. As this dual concept is unique, rare to find and difficult to imitate (Paliokaite & Pacesa, 2015), we argue that it is admirable for organizations - that aim to innovate⁷⁰ - to recruit staff with the mindsets and skills of a Diplomatic Rebel.

7 Conclusion
This study examines the innovation process in large organizations - from idea generation to implementation - by studying Diplomatic Rebels. The rebel’s mindset and skills are thereby analysed through Design Thinking literature. Confirming Design Thinking’s purpose in the management field, the rebel proves crucial to overcome innovation barriers and bring an increased level of innovativeness to the business world. However, by challenging the status quo and introducing change, the rebel naturally stirs resistance within the organization – an aspect not regarded in Design Thinking so far. Here the paper adds to Design Thinking by bringing the diplomat – discussed through management literature – into play as a crucial factor turning creativity (idea generation) into innovation (implementation). With the combination of strategic and agreeable mindsets and skills, the diplomat can mitigate resistance and bring employees from different levels on board. If neglected, the innovation implementation is prone to fail.

Concluding, this paper adds novelty to the Design Thinking field on an empirical and theoretical level. Firstly, we contribute to the academic conversation with empirical evidence through a practice-based deep dive into a case study. In doing so, we enhance the mindsets and skills of a rebel (Design Thinker) with agreeableness and strategic thinking of a diplomat. Secondly, building on our findings, we contribute on a theoretical level. Design Thinking literature was brought to the management field because it introduced a new way of thinking and developing solutions, namely abductive reasoning. However, when looking at corporate innovation, the design way of working does not regard organizational settings and the implications to manage teams and resistance. Here we advance the field by bringing management literature to Design Thinking, adding with innovation managers’ agreeableness and a high level of emotional intelligence and cultural awareness. Uniting the two realms, the Diplomatic Rebel proves a powerful concept to advance literature with a new holistic approach that bridges Design Thinking and management theory. With more companies aiming to innovate, the Diplomatic Rebel can provide a competitive advantage and can serve as an attractive profile to recruit.

⁷⁰ Annotation: We focus on companies aiming to drive organizational innovation. Thus, for other company setups, it might be desirable to look at the rebel or diplomat alone.
8 Limitations & future research

Building on our main contribution, we see that ambidexterity literature takes a first step at integrating exploration and exploitation. However, the emotional element is missing. With our study, we contribute a novel, holistic concept. As we take an initial practice-based view, we call for future research and theory to go more in depth.

Our study focuses on a one-sided view through the eyes of the Diplomatic Rebels, merely based on interviews. For future research, a more in-depth analysis could follow including more cases as well as ethnographic observations on how change is executed from the organization’s view. We see that there are other factors that influence the success of change managers, beyond the personal level. It would be interesting to investigate Diplomatic Rebels in relation to already established theories on success factors, for example at the job level, team level, organizational level (Černe et al., 2016). Further, we acknowledge that our small sample size could influence the results. Here we see value in conducting further experimental studies with a control group.

Lastly, we distinguish between mindsets and skills, which was mainly influenced by literature (Hassi & Laakso, 2011), but we do not draw further consequences from this distinction. Theory defines the mindset as being genetically determined (Judge, 1999a) and skills being a developable trait (Vakola, 2004). The interviewees suggest that the rebel is more intuitive and therefore more difficult to learn whereas the diplomat could be developed more easily. So, could the rebel be defined as a mindset and the diplomat a skill? Researching how far the diplomat and the rebel can be learnt from an empirical and theoretical standpoint will yield further insights into how organizations can increase their innovativeness by recruiting and training intrapreneurs with the characteristics of a rebel and diplomat. To reconcile and enhance the two competence streams of employees, emotional intelligence trainings could be a starting point to understand differing mental and emotional conditions and the ability to turn them into constructive directions (Rezvani et al., 2016).

All in all, we call for an integrative theory-building that extends Design Thinking with management literature and merges all sides of the mindsets, skills and tools of the Diplomatic Rebel –thereby advancing academia for Design Thinking and innovation in an organizational context.

References


There no such thing as ‘strategic design’: Studying the dynamics of reframing and strategic transformation in the public sector

Kees Dorst and Rodger Watson
University of Technology Sydney, kees.dorst@uts.edu.au, rodger.watson@uts.edu.au

Abstract. This paper seeks to explore the way design practices, (and theories, and methods) lead to strategic innovation - on an organisational, as well as a sector-level. We begin this paper begins by stepping away from the assumption that ‘strategic design’ leads to strategic innovation. Let’s start by saying ‘There is no such thing as strategic design’ and take a fresh look at the ways in which design and strategy interact, to understand them deeply. For this exploration, we will focus on two professional case studies from the public sector. We will explore how design projects and practices have influenced (or failed to influence) the strategies of the major stakeholder organizations involved. We will then use a change theory perspective to critically reflect on what design can do, and where design practices fall short and need to be augmented by practices from other fields.

Keywords: Framing, Social Design, Strategic Design, Strategic Innovation

1 Introduction
To a degree, what designers can achieve is (pre)determined by the starting point of the design project: the ambition that is laid down in the brief, and the perceived freedom in the problem space (as well as in the solution space). Therefore, the quality of the design briefing (‘the question’) and its scope heavily influence the nature and quality of ‘the answers’ that design can bring – as a consequence, design practitioners have naturally sought to influence the formulation of these briefs. To achieve the up-front influence they covet, designers have attempted to get involved in the strategic decision processes in which design briefs are spawned in various ways (Paton & Dorst, 2011). In a way, the co-evolution of the problem space and the solution space is not just a natural part of design practice, it is also something that designers covet, and in practice often need to fight for (Dorst & Cross, 2001). It is hardly surprising that design practitioners, researchers and educationalists are now actively engaged in more broadly and systematically extending the reach and influence of design in this direction – towards strategy. Through these developments, Strategic Design is on the verge of becoming a design discipline in its own right. For instance, there are now Master of Strategic Design curriculums, where the elements of design practices and strategy development are brought together. Graduates from these degree programs find their way on the job market, in a wide variety of roles, and are often valued as bridge-builders in the space between design and the organizational context. Yet we hold that this notion of strategic design requires cautious consideration and critical reflection. After all, in moving into the strategic space, design is entering a context for which its practices weren’t originally conceived. In traditional design practice, the formulation of strategy and the resulting organizational transformation processes were always squarely placed with the client, rather than the designer.

In this paper we will look at this developing field of practice (perhaps a bit early to call it a ‘discipline’ in its own right), to see what the fit is between design practices as they are now, and the demands of a strategy development process. To take a fresh look, we begin from the starting point that ‘There is no such thing as strategic design’. So, what actually happens in the area between design and strategic development when design influences strategy? What are the bridges that need to be built,
across which gaps, and what are the tensions that need to overcome? To what extent are design-based practices up to this challenge?

To start this exploration, we need a working definition. Nowadays there are many ways in which the words Strategic and Design are combined within practice and academia, reflecting the many ways in which the relationship between design and strategy plays out and can be shaped. This brings to mind the way Frayling articulated the various possible relationships between research and design: ‘FOR’, ‘THROUGH’, etc. (Frayling, 1993). All these adjectives can similarly be used in this context, but these very different relationships tend to all be clustered under the umbrella notion of ‘strategic design’. This rich diversity of (potential) relationships unfortunately also means that what KIND of strategic design is considered in a specific paper or piece of literature isn’t clear – and then the discussion becomes nebulous. So, let’s just define it here, locally as it were, and stick with this definition for the purpose of clarity in this paper –realising that what can be learned by sticking to this narrow focus probably can also be generalised to the broader field. In this case, strategic design is considered to be the influencing/shaping of organizational strategies through design projects, approaches and practices.

So, the central question for our exploration is: What are the qualities that design can bring to the influencing/shaping of organisational strategies? This general question can be approached from several perspectives, here we have chosen to focus on design (1) as a practice, and (2) as an approach.

We will be building on the academic discussion and literature concerning both of these.

**Design as a practice** –in the discussion around design as a practice in relation to strategy development, we can see two general positions, for the sake of brevity here represented by eminent design scholars, Verganti and Kimbell.

(1) Verganti in his work on Design Driven Innovation demonstrates with case studies how design practices – with their human centered nature – can be very valuable contributors to strategic change. And indeed, Human Centered Design (HCD) is increasingly taken up in the private and public sectors (McGann et al., 2018). In the public sector, this take-up is sometimes embodied in the establishment of Design Labs or teams that adopt a project approach with HCD as the underpinning practice (van der Bijl – Brouwer, 2016). Some of these Labs will be given a further label, either around the topic that they are to deal with (crime, policy, social, user experience, etc.) or will be defined by the expected output (digital, procurement, product, service, etc.). However, as Verganti states, the very human centeredness of these labs might lead to over-emphasis on finding better outcomes within the existing problem frame - achieving incremental, rather than strategic innovation (Norman & Verganti, 2013).

(2) Kimbell has been observing pioneering social design practitioners. In a particular study on social design and its effectiveness on impacting inequality, Julier and Kimbell (2019) point to the sense of agency that is present within the emerging profession of social design, but on the other hand they also find that social design has limited ability to impact strategically. Importantly, Julier and Kimbell point out that social design is an emerging profession, and point to a number of areas for development as a practice: (1) development of a manifesto, (2) shifting the power dynamic between designer and ‘client’, and (3) developing methods that transcend the tactical, moving the practice into the strategic space.

These two positions help understand where strengths and weaknesses of design practices in the strategic space might lie – where Verganti focuses on what design can do, and Kimbell seeks to outline the practices that need to be added into the design mix to achieve outcomes on a strategic level.
**Design as an approach** – again, we will use the work of two eminent design scholars to set the scene for discussions, in this case Buchanan and Liedtka:

(1) In a recent further extension of his Four Orders of Design concept, Buchanan (2019), shares a personal and expressive exploration of his approach of design as dialectic. In his model, Design exists across four orders: Signs, Things, Actions, Thoughts (ibid). Buchanan draws on well established ‘strategic designers’ to explore their approaches and practice of facilitation. Each of the facilitators and their firms have been engaged by their clients to play a role within the development of strategy. When describing their practice, Buchanan proposes that they mediate/facilitate a dialectic that leads to the discovery of a ‘middle ground’. This to Buchanan is the uncovering of an underlying shared value, that has not explicitly been aired before, and the job of the facilitator is to bring the participants to a discovery of this shared value.

(2) In exploring the Design Thinking approach in organizations, Liedtka (2018) puts forward a number of key characteristics that make Design Thinking work. In this study, Liedtka is looking at the adoption of Design Thinking as a way of working within existing company structures. To Liedtka the key elements of why Design Thinking is successful are that it is useful in; (1) creating immersion in the context at hand, (2) instilling a flow from research to implementation, (3) building in buy-in with team members and stakeholders through them having a hand in the creation and development of solutions, and (4) bringing a playfulness that facilitates emergence through prototyping. Liedtka points to a raft of case studies all embodying Design Thinking across the private and public sectors. There is quite a sharp contrast between these two positions on the approach that design could and should bring to the shaping of strategy: design as a way to shape a (critical) dialectic process versus design as a way to bring people along on a journey, in a sense moulding the problem situation and taking it away from the original discussion arena.

In this paper we aim to contribute to knowledge on design practice and design approach to shaping organisational strategy by focusing on two professional case studies from the public sector to explore how design projects and practices have influenced (and sometimes failed to influence) the strategies of some of the major stakeholder organisations involved. This requires a longitudinal research setup: while design interventions are often aimed at immediate success (‘a solution’), to answer the question whether a strategy is successful requires a much longer timespan (‘an unfolding’). The first, 10-year longitudinal case study of a bottom-up design approach will be used to create a model in which some of the steps and major relationships between design and strategic development are sketched out. We use a change theory perspective to reflect on both the case study and the model. This gives us a basis from which to critically consider what design can do, and where design practices may need to be augmented by practices from other fields to enhance their effectiveness in the strategic space (thus addressing the first discussion, on design practices). The second case study starts from a top-down need for strategic change and shows the potential role a design approach could have in achieving this (addressing mainly the second discussion, on design approach). These two practice-based case studies, and the model that springs from them, create new insights into the way design could be used to influence and shape strategic processes in organisations. Building on this analysis, we explore how design practices could be more effectively used in the strategic arena.

### 2 Case study 1: Kings Cross from reframing to transformation

Design predominantly takes place in projects, in which designers aim to create new solutions to a given problem (the design brief). But a new solution is not really the end-game: for a new solution to really stick, it needs to have influence beyond the confines of the design project (and its closest stakeholders): it needs to impact the practices in the organization, the strategy of the organization,
perhaps (in the case of a radical innovation) the processes and structures of an organization and radically new design solutions potentially influence the way of thinking in a whole sector (‘a paradigm shift’ (Khun, 1962)).

This brings up the question of agency, for *strategic design* to be truly ‘strategic’, it needs to move beyond the role in which ‘design’ is conventionally cast.

As a first investigation of the strengths and possible limitations of designerly ways of thinking for achieving this, we will introduce in a case study of a radical design project, and a critical longitudinal analysis on its influence and impact in the ten years since the original project. Ten years on, what has actually happened with the frames and design ideas of the initial project? Has this project led innovation on a strategic level, and perhaps to organisational transformation? What does this tell us about the link between design practices and strategy development and implementation?

### 2.1 Case Study 1 – as it happened

In 2009, the Designing Out Crime (DOC) research center was approached by the City of Sydney (a local council) to look into the problem of ‘alcohol related violence’ in Kings Cross, an entertainment district.

Australia had a significant crime hotspot. According to the statistics, Kings Cross was the epicenter of violence in Australia. The government responded with an ‘evidence-based approach’ leading to tighter regulations and restrictions on business. This approach was rational and built on the knowledge of Kings Cross as a hotbed of crime and corruption. In order to reduce crime, the government applied the evidence-based crime prevention approaches that fit their diagnosis. In practice this led to treating 10,000 young people every Friday and Saturday night *as if* they were criminals. Until the Designing Out Crime Research Centre reframed the issue around the underlying values of the 10,000 young people who were going to the location every Friday and Saturday night. *(for a much more detailed description of this project and its outcomes see (Dorst et al., 2016, pp: 14-19 and 48-51).*

**The good news: impact.** By its very nature, such a radical reframing (from ‘alcohol related violence’ to ‘a music festival’) cannot be implemented without having deep repercussions for the key organisations involved. Such a reframing implies a change agenda for the stakeholders that have earlier framed the issue, defined the problem, organized themselves around the response and thereby inadvertently kept it in place.

**Towards a new strategy.** A number of remarkable people within the City of Sydney local government quickly picked up on the possible role that they could play within the ‘Music Festival’ frame and recast their organization from being centered around the conventional local government roles (provision of infrastructure for public life, and rule enforcement) to become a ‘conductor’ of night life in the Kings Cross area. From this much more active, creative role they recalibrated their relations with a wide group of stakeholders that could be involved in shaping the future of the Kings Cross experience. And they even went much further: the Music Festival frame is a nice metaphor to think with, but it has obvious limitations: (1) many elements of the complex Kings Cross environment cannot be captured within this frame (e.g., the experience of local residents), (2) this frame only applies to Kings Cross (which is only a couple of streets), and merely to a couple of nights per week, mostly in the summer months. For the City of Sydney to become a true conductor of nightlife throughout its local government area, it would need frames or development agendas for all of its different neighbourhoods – some are local entertainment oriented, others more tourist focussed, and yet others are residential. These would need to be based on evidence as to the current state of the night life there, and of course involve the participation of citizen, local businesses and other societal stakeholders. The City of Sydney commissioned research into the night life (City of Sydney, 2011)
and consulted with residents and stakeholders about appropriate ambitions and frames for the various areas going forward. This resulted in a comprehensive Open Sydney strategy (City of Sydney, 2013) that captures the local ambitions and translates them in hundreds of action points for the short, medium and longer term. These action points in turn resulted in more projects being commissioned to explore possible futures in Kings Cross and other parts of the city.

**Towards a new organizational structure.** The original 2009 Kings Cross project was done in collaboration with the Safer Sydney unit of the City of Sydney as the commissioning party. In the years after the project, this unit spun out the ‘Night-time Economy team’ with a member of the DOC design team joining the leadership of the Night-time Economy team. This team takes a much broader and more comprehensive and inclusive view of the meaning, significance and the value of nightlife. The dollar value of the economic transactions of the city at night has also become part of the bottom line, in 2019 Sydney’s night-time economy is $27 billion per annum (Deloitte, 2019). The Night-time Economy team set about implementing many of the recommendations of the Kings Cross project. The Chill Out Zones from the ‘music festival’ frame became Take Kare Safe Spaces. The Kings Cross Guides became Precinct Ambassadors and then Take Kare Ambassadors integrated with the Take Kare Safe Spaces. Portable urinals were implemented (Moore, 2011) as well as portable dynamic signs and secure taxi ranks. The Take Kare Safe Spaces had an immediate impact, and in the first three years of operation provided direct support to more than 50,000 people. In some cases this support was lifesaving (Doran et. al. 2018).

**Towards sector-level change.** The Kings Cross case study story has travelled really well, in professional practice and in academia, as an early example of social design, and a successful case of design contributing to public sector innovation (Bason, 2010). It has had a widespread international influence. The project itself has had direct influence on the thinking about nightlife in cities like Vancouver, New York, London, Cardiff, Manchester, Edinburgh, Paris, Amsterdam, Berlin. Direct follow-ups for the Designing Out Crime team include invitations to projects in Amsterdam, Eindhoven, Seoul, Hong Kong, among other places. The founding director of the Night-time Economy team at the City of Sydney won a Churchill fellowship to study best practices around the world (Matthews, 2009). In parallel, the Night Mayors movement emerged to help cities think about the importance and potential of the nightlife in a city. In 2019, this movement had spread to 40 cities across the world (Seijas and Milan, 2019). This in turn has led to an international series of ‘Global Cities after Dark’ conferences, sharing practices and lessons on the creation of a thriving night-time economy from around the world (www.globalcitiesafterdark.com). Through the impact the movement is having and the discussions it is enabling, it is sharpening the emerging role of the Night Mayors.

**Part of this discussion is recognizing the various roles that they play (regulatory, advocacy, etc.) in curating the night-time as a space for ‘trust and identity building’ (ibid).** The Kings Cross project is one of the iconic examples that helped establish this new paradigm.

**Towards new projects and an ongoing engagement in Kings Cross.** Some of the new Kings Cross projects that the Designing Out Crime research centre was involved in, in the ten years since, built on the original reframe (the ‘music festival’), others were much more detailed and specific. For instance, one project focused on the problem of violence: to a degree, the reason groups of young men get into fights is because they want to fight, as part of their specific group culture as they establish a hierarchy within and between groups. The reframing here was based on the realisation that the key theme behind this behaviour is competition, not violence per se. Creating other arenas for competition, like urban sports, helps them achieve these goals by less violent means. And as it turns out, given the opportunity these people are quite happy to compete in these less harmful ways.

**The bad news: tragedy strikes - a cause for reflection on the limits of design.** But then in 2012 and 2014, two young men were killed in separate unprovoked one-punch attacks in Kings Cross.
These very tragic deaths were of course front-page news, which put pressure on politicians to create new countermeasures to clamp down on the ‘alcohol related violence’ in Kings Cross. In response, the state of New South Wales introduced “Lockout Laws” (reducing trading hours, and basically preventing people from entering/re-entering a pub, café or restaurant after a certain time and limiting the service of alcohol). These laws served to make these areas very unattractive, and effectively killed the nightlife. Restaurants, cafes, nightclubs, pubs and shops left the area or went bankrupt. In total, 176 establishments closed as a result of the lock-out laws (Taylor, 2018).

The changes in Kings Cross meant that other, more suburban areas of the metropolitan area became busier, stretching the local infrastructure (the sad irony behind this state of affairs is that the Lockout Laws would not have prevented the two one-punch attacks, as those were both early in the evening and not the result of late-night drinking).

**Protest and discussion.** The introduction of the Lockout Laws led to ongoing protest from Sydneysiders, the community and business owners in the area. A political party was created to advocate for their repeal. This sparked an impassioned societal discussion on what being an ‘international city’ actually means, what the role is of night entertainment in the life of a city, and how we as a society support young people going through the confusing years then they are coming of age, etc. The City of Sydney actively facilitated these discussions through platforms like sydneyyoursay.com.au › openandcreative while advocating for ‘Sydney as a 24-hour city’, commissioning research on the state of the ‘night-time economy’ to benchmark with other major cities around the world.

The New South Wales Government also commissioned its own research into the matter. After a public inquiry that attracted more than 200 submissions (see for instance (City of Sydney, 2019)). In the end, the Lockout Laws were largely repealed in 2019. The New South Wales Government launched its 24-Hour Economy Strategy in 2020, and in March 2021 the inaugural 24-Hour Economy Commissioner took his post, with five strategic objectives (Treasury NSW, 2020):

1. Integrated planning and place-making
2. Diversification of nigh-time businesses
3. Cultural entrepreneurism
4. Public transport
5. Changing the narrative

2.2 Reflection on case study 1

There are a number of lessons that can be learned from this initial success and unfortunate course of events. In retrospect, there were some weaknesses in the original Kings Cross project: (1) The DOC centre designers had not realized that responsibility for the area was shared between several departments in the New South Wales Government. (2) Secondly, the DOC centre designers didn’t involve the media in the project, and hence didn’t influence the societal discussion on Kings Cross. When the two tragic deaths happened, that discussion naturally started where it left off - from the old frame of ‘alcohol related violence’. In the years since, the societal discussion has moved on, and the NSW Government has been reflecting on the appropriateness of the Lockout Laws as a response to the situation in Kings Cross. There now is a much more resilient and robust societal discussion and a better context to really change the situation in Kings Cross for good.

There are several sides to the Kings Cross project story: on the one hand, there is the emergence of a compelling frame and the design of boundary objects that capture people’s imagination and lead to success on project level – but on the other hand, we can see how difficult it can be to create real and lasting change. In retrospect, we can now see clearly that in the initial project, the designers may have
been too focused on the project level. Despite the positive developments in the aftermath of the project, including the Open Sydney strategy and the organizational shift to the Night-time Economy, the outcomes proved to be critically vulnerable because the societal discussion had not moved on. This means that if design interventions are to have lasting impact, they will need to strategically work across all these levels.

These are the lessons that can be drawn on a practical level. Yet there is a pattern here: numerous authors have presented design case studies that run into similar difficulties and commented on the difficulty of ‘applying’ design as an agent for strategic change in a public sector environment (Bason, 2018, Stacey & Griffin, 2012, Tromp & Hekkert, 2019, Willemsen & Watson, 2018). What deeper lessons can we draw from this? In the next section we will build a model to capture the relationship between design approaches and the way strategy gets formulated in the public domain. Then in section four we will see that the vulnerability of the design approach is quite fundamental: it is integral to the nature of design as an agent for change. Implicitly design steers us towards ‘learning’ as a change strategy, to the exclusion of other change strategies.

3 Discussion 1: the dynamics of reframing and strategic transformation

As said, what happened in the Kings Cross project seems to happen all the time: great design interventions that have the potential to lead to new practices (and to some extent, they do lead to new practices, at least among the people close to the project) and deserve a hearing on a strategic level don’t get to the full impact they should have. And chances are, the project outcomes then remain vulnerable within the context of the organization, because it hasn’t shifted to a new state in which the design solution is a better ‘fit’ (Hekkert & van Dijk, 2011). The problem could be that strategy is normally determined top-down (Bason, 2010): the sector or organization reacts to what is sees as its relevant context (the ‘Field’) and adapts its structures and strategies accordingly (see Figure 1).

![Figure 1](image.png)

**Figure 1.** The blockage that comes from the top-down approach to strategy formulation

This blockage in the innovation system can be bypassed by using the insights that come from the projects to directly influence the Field (thereby changing the perception that a sector or organisation has of its relevant environment). This creates a new dynamic, combining the two movements: as the insights that come from the projects are used to create a new Field, the sector adapts to this new Field by using its normal top-down adaptive processes, and meets the bottom-up movement halfway (see Figure 2).
As seen in the aftermath of the Kings Cross project, the societal discussion that was sparked by the Lockout Laws (in Figure 2: the shift in the ‘Field’, in this case the societal discussion) has finally created the context for the outcomes of the initial Kings Cross project - and its reframing of the Kings Cross situation as a ‘music festival’ - to be supported. For radical innovation to occur, ALL levels in the model need to shift into a new alignment. In the case of Kings Cross, this realignment has eventually occurred, but it has taken ten years, and two tragedies, and a government keen to kick-start the economy after a recession, to shift the old ways of thinking. From a design perspective, the Dynamics of Reframing and Strategic Transformation model seeks to create a context for the outcome of the design intervention to be taken on board, and in creating a context for the broader innovation process. In conventional (product) design practice this influence might develop over time in the designer-client relationship, where the influence that a designer might have on the ‘Field’ increases as a trusted client relationship grows over many projects.

Figures 1 and 2 introduce two new elements: (1) the notion of a ‘Field’ and (2) the arrow that bypasses the top-down/bottom-up blockage by connecting the insights that are sparked by Design projects directly to the Field. These two new elements are both strategic in nature: they are tools to create transformation in the organization, and as such they have to function relative to the current state of the organization and its current ways of dealing with novelty and innovation. This is beyond the domain of ‘normal’ professional design practice - although they both can be seen as designs that need to be made, and high-level design practitioners will undoubtedly do this as they engage with their clients on a strategic level (see Lawson & Dorst, 2013). To start detailing these new elements and their dynamics, we have to turn to theories of change.

4 Discussion 2: Design and strategic change

Looking at the field of design, there seems to be a naïve sense that if only the ideas and design concepts that result from a project are good enough, they will more or less inevitably lead to greater impact and more fundamental change within the client organization (this is certainly what the authors believed early on in their careers). The model in section 3 serves to contextualise that optimism a bit, showing that there is a structural problem associated with the fact that design starts from the lived
world, working bottom-up, while strategy is often determined top-down, and is bounded by the rationality that dominates the sector/field. And there is a second assumption behind this sense of optimism: that organisations will learn from the lessons of the design project, and change accordingly. In design, the implicit change strategy is through learning. Again, this simple statement can be unpacked to show that it contains a whole slew of assumptions about how organisations operate and change. To elucidate this, we can turn to the established academic discipline of change management. To capture the dynamics (or lack thereof) of organizational change, Vermaak and de Caluwe have created a meta-model of change paradigms that could be useful for moving forward. This ‘Colors of Change’ model sheds light on the challenges/forces at play when working with organizational structures and the various cultures around change that exist there. In the context of this paper, we cannot do justice to the extensive body of literature on this model (and the many case studies that elucidate its application). To just skim the surface here we will use some quotes from (Vermaak and de Caluwe, 2018) to explain what the Colors of Change stand for:

1. **Yellow-print change**
   ‘Yellow-print thinking assumes that something only changes when key players are backing it and that little will happen if key players oppose it. In this view, enabling change requires getting the powers that be behind it, whether their power is based on formal positions (e.g., board members) or informal influence (e.g., opinion leaders).’

2. **Blue-print change**
   ‘In blue-print thinking, rationality—not power—matters most. The assumption is that change happens only when you analyze first what problem is, suggest the best possible solution, and implement it according to plan. Change is thus deemed a linear endeavor: you think first before you act. The process is expert driven, the activities are executed by those who have the necessary know-how and experience.’

3. **Red-print change**
   ‘In red-print thinking the emphasis is not on power or rationality but on motivation. The key assumption is that change is not about policies and plans but about behavior, and that people change their behavior only when they are stimulated to do so. In its simplest form this comes down to barter, but it can also go beyond that by taking an interest in people’s wellbeing and creating an inspiring working environment.’

4. **Green-print change**
   ‘In green-print thinking everything is about learning. Changing and learning are deemed inextricably linked: they are thought to mean almost the same thing. The process is characterized by setting up learning situations, preferably collective ones as these allow people to give and receive feedback as well as to experiment with more effective ways of acting.’

5. **White-print change**
   ‘White-print thinking can be regarded as a reaction to the previous colors, in the sense that these still tend to view change as a planned affair. In contrast, white-print change agents view change as constant and taking place of its own accord. The key assumption is that people can make the most difference when they understand and catalyze a change that is about to happen. They see self-organizing and dialogical processes as an effective way to deal with that complexity and they take an active part in their emergence. The outcome is unpredictable.’

Vermaak and de Caluwe take pains to stress that all of these colors are equally valid and useful – one might posit that for an organization to be resilient, it probably would need elements of most or all of these. Each of these different Colors of Change comes with tools and strategies, and in later papers
Vermaak and de Caluwe place them within a general innovation framework that expresses their dynamic interrelationships over time. For the purposes of this paper, the attractiveness of this model lies in its comprehensiveness, and in the fact that it seamlessly works across different scales: all the way from macro (using these colors to characterize the dominant change strategy of an organization or unit) to micro (providing insight, tools and advice that can be used in design workshops and one-on-one conversations).

It should be clear that Design as a professional field is not neutral: the broader influence of design-based interventions is supposed to emerge from the fact that design is creating a new reality, that the organisation should then learn from. Design is also a great inspirator and motivator, the power of design to take people on a journey is key (Schaminee, 2019). This view of how design can exert a broader influence most closely aligns with the colors Green (learning), Red (motivational) and possibly White (motion). This is exactly why ‘Design Thinking’ and design-driven innovation are attractive to some people and organisations: they hold the promise of moving away from the often dominant Yellow (power) and Blue (planning and control) styles of thinking, and broaden out the repertoire. Yet we have seen that design’s concentration on learning comes with a lot of assumptions about the capability of the organization to support learning as a change strategy (Argyris, 2000; Senge, 2006). And this is where design becomes quite vulnerable: when we take all of these five change strategies to be omnipresent in most organizations, then the ones you do not involve tend to become blockers. We have seen this in the King Cross example: the intervention from the state government (‘yellow’) and the lockout laws (‘blue’) is what held back the progress in the area for many years. It was only when the societal discussion moved away from polarization to more of a learning dialogue that the results of the design intervention could become embedded in new ways of working, new strategies and a repositioning of the roles of the various layers of government. Only then could design start to exert a strategic influence.

5 Case study 2: Nitrogen pollution and strategic, sector-level change

In this case study, we will road-test these models by describing a design-driven innovation program that effectively started at the other end of the Dynamics of Reframing and Strategic Transformation model, top-down, and with the opposite change strategy: this program was very much a result of a power intervention that suddenly created a new Field, requiring change on a sector-level. Yet the major stakeholder realised that the Blue and Yellow change styles had been instrumental in creating the situation that needs to be resolved, and that they have effectively exhausted their possibilities. The situation is now in a state of crisis, rife with paradoxes that cannot be negotiated anymore without the introduction of other ways of thinking. Yet much to their credit the stakeholder showed a keen interest in what design can bring to this situation.

The Netherlands is a signatory to the Paris Climate Agreement, and the lawyers from the activist NGO Urgenda took the state to court over failing to protect designated nature reserves (designated as such under the EU Natura 2000 rules) from Nitrogen pollution. Nitrogen oxide emissions mostly come from transport, building works and agriculture (about 45%). The problem is that Nitrogen acts as a powerful fertiliser, dramatically altering the soil, and thereby influencing the flora and fauna in these nature reserves. In the end, the High Court, ruled in favour of the Urgenda objections, rendering the government in breach of the law. This ruling had huge repercussions, all through society: (1) to reduce the emissions from transport, the Dutch government reduced the maximum speed on (almost all) the highways from 130 to 100 km/h. (2) About 18,000 ongoing building works were ruled in breach of regulations (with earlier permissions being void) and had to be stopped, immediately. (3) The ruling impacted agriculture more than any other sector: many farms would now have to radically change their practices to cut their Nitrogen emissions. Farmers and building contractors were up in
arms and came to The Hague to protest in front of the Dutch parliament – and they came on their tractors and rather slow heavy building machines, effectively blocking traffic in the whole country for days.

The Department of Agriculture, Nature and Food Safety (LNV), enlisted André Schaminée and his team from the consultancy Twynstra Gudde to look into this matter. They used a Frame Creation approach (Dorst, 2015, Schaminée, 2019, Schaminee & Dorst, 2021) to address these matters, starting with 60 long conversations with various stakeholders in 3 localities. The paradoxes that surfaced were formidable indeed. Just to name a few:

- **It is a zero-sum game** The discussion is stuck in an either-or-pattern (either ‘nature’ or ‘agriculture’).
- **People complain about ‘going from crisis to crisis’**. Yet there is very little appetite to look forward, to the next problems that are going to come to the agricultural sector (drought, water management, salty groundwater, Nitrate pollution, etc).
- **Some parties have a vested interest in the problem** as long as the solutions lead to a steady increase in investment in the current state.
- **The value-models are not sufficient.** While the transition in agricultural practices is proposed as the only viable option, there is no clear path of action for the farmer – economically, this could only work if there is a structurally higher price level for their goods. And because there is no direct economic value to nature, the only thing that gets counted is ‘a loss of value to farming’.

These paradoxes on the relationship between Nature and Agriculture have been exacerbated by the lack of connection between the layers of the complex problem area: the policy layer, the layer of organizations (NGO’s, Companies), the lived world (private life, community, civil society) and the biosphere. These layers all have their own scale, dynamics, timelines, history and way of addressing the future. They all have their own vicious cycles and learning cycles. But currently they are mostly disconnected, as ‘worlds to themselves’. To link the learning cycles on the layers and create a common value discussion, the designers proposed to create frames that go across some or all of the levels. In the end, the central theme the participants arrived at is Vitality. The notion of Vitality is defined within all four layers of the problem area but does mean something subtly different in all of them – and these differences create the space for experimenting, learning, and the development of new mastery. In the end, this is not about initiating design projects as pilots or experiments to arrive at ‘a solution’ but creating designerly interventions to shape collaborative learning cycles across the whole system. This requires structural support, a common innovation infrastructure (innovation ecosystem). This innovation ecosystem itself is the key outcome of the whole program – and it can be harnessed to approach the current issue (Nitrogen) and future challenges.

The frames created in the second case study are learning frames rather than solution frames – the capacity of design to create learning is used as a means to open up a static situation. Design is used in a different way (i.e., this is not unlike Design for Debate, Dunne and Raby, 2013) to create a new Field, in which sits a strategy, in which then sit projects. Again, top-down and bottom-up have to work in concert to achieve real change. To support these processes, the designer and the commissioning party have to work together quite closely. This is exemplified in the ‘9 lessons for the public sector’ that were drawn from this project and published in a professional publication (Schaminée & Dorst, 2021):

1) **Start from Values and Principles** (i.e. framing)
2) **Don’t confuse the design approach with others like lean, agile or theory U** (they are not unrelated, but work out very differently)
3) **Give content and meaning to the roles in the collaboration** (not transactional, but shaped around a learning approach)
4) Make it “A UFO”: Attractive, Useful, Flexible, Open (communication is key, right from the start)
5) Connect bottom-up and top-down, (as in Figure 2),
6) Build competencies within the public sector organisation (do not underestimate the design expertise needed: just doing a ‘Design Thinking’ workshop is not enough).
7) Ask the expert: realise that this process requires a combination of design expertise, public service expertise and strategic expertise.
8) Create long lines of engagement, this is not a project but a learning program.
9) Realise that the design approach touches many in your organisation: decision makers, communication, etc. front line staff are especially important, as they can be bridge builders to the lived world of the stakeholders.

While the model in Figure 2 concentrates on connecting design’s Green style (Learning) with Blue (top-down planning), these 9 lessons are much more geared towards the Yellow (power) and the Red (human, capability building) to support people to build a broad innovation ecosystem within, around and/or across organisations. This is not just a question for a design department, or for an innovation unit: getting a new initiative up and running is a relay race, and its needs involvement from all critical functions across the organization (Bjorklund, 2020).

6 To conclude: from ‘strategic design’ to building innovation ecosystems

Where do these models and case studies lead us, in terms of the discussions we outlined at the beginning of this paper?
In terms of design practices; based on the first Kings Cross case study we can both support Verganti in confirming the importance of deep human-centeredness (on a values level) for driving innovation, and support Kimbell in realising that the design practices as we have learned them from the designing disciplines are not enough to achieve strategic innovation. The richness of the colours of change model points us towards a whole landscape of practices that could/should be added to the ones that design can bring.
In terms of the approaches; in the Nitrogen Crisis case study we’ve seen that to move beyond current stalemates, parties needed to be taken along on a common journey, very much supporting Liedtka’s insights on design as an approach that can help shape and mould problem situations. Perhaps because the conflict was so entrenched, there was no unsuspected middle ground to be uncovered between conflicting parties to help shape strategy. In this case, design was explicitly called for because the top-down dialectic approach (in terms of the Colours of Change: a mostly Yellow and Blue approach) had run its course and just led to a set of formidable paradoxes.
On reflection, we can say that Verganti and Buchanan have focused on ‘Design FOR Strategy’, identifying the valuable contribution that design practices can make to strategic thinking within an organisation. Both Kimbell and Liedtka have taken on the challenge of ‘Strategy THROUGH Design’. Following them we can clearly see that design’s contribution to strategy development is limited. In this sense, there is no such thing as strategic design.
At least, not yet. Looking at the dynamics of strategic transformation, we have seen that Design interventions, while they have the potential to spark strategic innovation, fall short in dealing with the organizational change issues involved. The Dynamics of Reframing and Strategic Transformation model is an attempt to start mapping this gap, and the Colors of Change model helps to position what design can bring, as well as what design would need to learn to achieve truly strategic design.

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In Memory of Professor Ömer Akin

Passed away March 13, 2020

Ömer Akin was a key player in the DTRS community. He organized DTRS3, convened in Istanbul in 1996, and had attended most DTRS symposia before and after that. Despite his illness, he wanted very much to participate in DTRS13 and sent a paper abstract towards that end. Sadly, he died some six weeks after sending the abstract, which can be found below.

Ömer was Professor Emeritus at Carnegie Mellon until his passing in 2020. Upon completing a graduate degree in architecture at Middle East Technical University in Ankara in 1970, he obtained a Fulbright Scholarship for graduate studies in the United States. Subsequently, he earned a Master of Architecture in Environmental Systems from Virginia Polytechnic Institute and State University in 1972, and a Ph.D. in Architecture from Carnegie Mellon in 1979 while working with renowned advisors and mentors such as Professors Herb Simon, William Chase, and Chuck Eastman.

Ömer remained at Carnegie Mellon for the rest of his career, where he focused his research in ethics, design cognition, computer aided design, and building commissioning. During his time with the School of Architecture, he taught design studios and graduate courses, advised graduate students, and lectured both nationally and internationally. He also developed the Architecture–Engineering–Construction Management Master’s and Ph.D. degree programs, Doctor of Professional Practice degree program, co-authored and taught the first professional Master of Architecture degree program at the school, and served as the director of graduate programs and as department head. Dr. Akin conducted extensive research in design cognition and is best known in this area for his books Psychology of Architectural Design, Representation and Architecture, Generative CAD Systems, A Cartesian Approach to Design Rationality, and the posthumously published new book, Design Added Value: How Design Increases Value for Architects and Engineers. He was a registered architect in the Commonwealth of Pennsylvania and the Republic of Turkey.

Dr. Akin was a 2010 recipient of the Jefferson Award, given to “community champions” in the U.S, for volunteering more than 3,000 hours of his time over ten years to the University of Pittsburgh’s Turkish Nationality Room—where he designed a culturally authentic room that is part of one of the
region’s most prestigious and visited landmarks—and for his work to promote academic diversity by bringing junior and senior architecture students from historically black colleges and universities to Carnegie Mellon through the Summer Internship for Diversity program. Those who knew Dr. Akin can attest to how inspiring it was to watch him pour his passion into teaching and research. The study of design, creativity, and the ethical considerations within it were always a central focus of his career. Professor Steve Lee, head of the Carnegie Mellon’s School of Architecture says that “through Ömer I learned the importance of teaching how we design, not just what we design.”

An endowed scholarship has been established at Carnegie Mellon in Ömer’s memory to promote diversity within the School of Architecture by providing support to students in need. To watch a memorial video about Ömer and learn more about how to support the scholarship, please visit [https://soa.cmu.edu/Ömer-akin-fund](https://soa.cmu.edu/%C4%B0mer-akin-fund).

Dr. Akin was extremely proud of being part of the Design Thinking Research Symposiaums over the years and often spoke of the insight he gained and the friends he made through the community. On behalf of his family, friends, and colleagues, we are so appreciative to have the opportunity to remember him today, and beyond. We know just how honored and grateful he would have been. We are reminded of one of Ömer’s favorite quotes: “When I let go of what I am, I become what I might be.” Thank you for allowing Ömer’s academic spirit and design research to become what is has over the years through such meaningful and thoughtful collaboration with the DTRS community. We know it will be such a great weekend, and Ömer’s family extends their greatest appreciation for allowing his spirit to be a part of it all.

![Memorial photos](https://soa.cmu.edu/Ömer-akin-fund)

*Most of the text and photos above were kindly provided by the Akin family at the request of DTRS13.*

### What is Design Research?

**Abstract submitted to DTRS13**

Ömer Akin  
Carnegie Mellon University

**Some questions:**

1. What roles do different participants in the design process have?
2. Can there be design without designers?
3. How do multi-disciplinary teams perform in design tasks compared to designers-only teams?
4. What are possible productive ways of involving non-designers in the design process?
5. Are there multiple definitions of ‘design’?
Some answers:
1. Designer as researcher;
2. Research as design;
3. Designer and researcher collaboration;
4. Researchers as designers;
5. Research and design;

The Cartesian Approach to Design Rationality describes the potential connection between design and scientific research, as well as applied research in engineering.

The sciences are engaged in their quest with a sense of ingenuity and courage, bordering on audacity. They assume that the truths underlying nature can be discovered. All of the difficulties [of this challenge] have not deterred scientists from pursuing this quest. If anything, both the energy and the results of scientific research have intensified. The one characteristic of this search, which remains unblemished by the intellectual skirmishes of the past, is the absolute rigor that must be applied to testing assumptions and hypotheses before they are admitted into the company of accepted theories.

In examining the field of architectural design and its practices, we find approaches which are both sympathetic and in opposition to this position. First of all, architecture is an interdisciplinary field of practice, which includes the results of many disciplines of the natural sciences. For instance, in determining the integrity of architectural structures, the law of gravitation and its effect on the equilibrium of building materials brings into consideration theorems from the area of building physics. In determining the thermal comfort of occupants in buildings, practices based on laws of thermodynamics are indispensable.

Furthermore, there are areas of application in architecture, particularly in decision-making during design, construction, and operation of buildings, which employ concepts and methods of the information sciences. This includes techniques of Operations Research from mathematics, computer graphics from the field of computer science, and systems analysis from the field of management sciences.

In pursuing these ends, the field of architecture displays some similarities to the natural sciences. First, the principal pursuit of architects is that of creating new designs. These designs, in addition to responding to the behaviors of physical contexts and occupants, also have to respond through stylistic expression to the psychological needs of both occupants and designers. These stylistic choices become fashionable for architects’ practice in cycles very much like the paradigm shifts that have been described by Kuhn (1970).

Second, architects are motivated to find tools that are as robust as those in the natural sciences for accurate explanation and prediction of behavior of buildings, whether these are manifested in occupants or natural materials and elements. Finally, architects are direct users of the sophisticated tools and technologies developed for the sciences in order to reach these ends. All of these factors indicate an ongoing if not a mutually beneficial relationship between architecture and natural sciences.

At the same time, there are forces that push the natural sciences and architecture apart. First, the fundamental posture of the architects, in practicing their ‘trade,’ is one of advocacy as opposed to the skepticism of the scientist. When the architect proposes a ‘correct’ solution to a given problem, at best she is looking for a good enough solution. Consequently, the motivation is to defend this position and persuade others to accept its merits. Before reaching this point of advocacy the architect of record has
to consider alternative solutions as well as weaknesses of these alternatives. But the fundamental posture still remains as one of advocating a solution.

The architectural designer is fundamentally skeptical of any solution until there is absolute assurance that all degrees of skepticism are completely eradicated. A similar distinction exists in the object of the architect’s search as opposed to that of the scientist. The scientist is ultimately interested in knowing what is, while the architect is interested in what ought to be.