Towards an Understanding of the Role of Visualisation and Experimentation in Design Thinking Processes with Novice Designers

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Abstract. Design thinking (DT) used by established design teams has been a topic for research since the 1960s. However, the use of design thinking in organizational settings carried out in novice design teams, that is, users with no experience of design and design methods can still be regarded as a newcomer in research. There is a strong discourse in the field of DT acknowledging the benefits of visualization and experimentation to facilitate and enhance the design process. However, research shows that there is a lack of understanding of the role visualization and experimentation plays in specific phases of design thinking. This work-in-progress paper investigates how a design thinking process can provide a novice design team with resources to release the team's problem-solving capacity based on the participants' practical experiences and needs. The study is based on a co-creation methodology including a DT process divided into four phases. Methods used were focus groups with a novice design team including five participants from three different companies within the field of welfare technology. In addition, participant observations were used to capture the participants' interactions within the different design phases. Expected outcomes will incorporate identified good practices and design guidelines. The study will contribute to unfolding knowledge about how participants from local practices can ensure effective collaboration to cope with emerging dilemmas.

Keywords: Design Thinking Processes · Novice Design Teams · Companies · Innovation Hub · Problem Framing · Visualization · Experimentation · Focus Group · Participant Observation

1 Introduction

Design thinking used by established design teams constitutes an area that has been a topic for research since the 1960s [1, 2]. However, the use of design thinking in organizational settings carried out in novice design teams, that is, users with no experience of design and design methods can still be regarded as a newcomer in research [3–7]. Design thinking

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(DT) is a complex concept with a range of different definitions. Stanford d-school defines DT as "a methodology for creative problem solving" [8]. In his book, Brown [4:4], applies a more nuanced definition to the concept when stating that "Design thinking relies on our ability to be intuitive, to recognize patterns, to construct ideas that have emotional meaning as well as functionality, to express ourselves". While agreeing with both of these definitions, the present study argues for a more distinct approach to the concept of design thinking. This is in line with a qualitative study carried out by Carlgren, Rauth and Elmquist [9] who argued that although several often process-oriented studies of DT exist, they are limited in taking account of what happens in practice. Based on an interview study carried out in six large organizations, their findings identify five different themes to frame a design thinking approach, namely: user focus, problem framing, visualization, experimentation, and diversity. Each theme is associated with principles, practices, and techniques, which together form a framework acknowledging DT both as an idea and as the enactment of the idea. In such DT framings, Stier and Smith [10] argue for the inclusion of co-creation referring to collaboration between different actors (e.g. from academy, industry, and societal partners) who together address existing challenges [11]. Similarly, Puerari [12] refers to such collaborations as multi-actor learning environments, where new methods and practices can be tested within real-world contexts.

According to Brown and Wyatt [13], the fundamentals of DT processes are inspiration, ideation and implementation. The authors describe these in the following way, "inspiration as the problem or opportunity that motivates the search for solutions; ideation as the process of generating, developing, and testing ideas; and implementation as the path that leads from the project stage into people's lives" [13:33]. Although DT is growing in importance when it comes to managing innovation and creativity, the concept as such seems to be ambiguous and thus unclear in its practical performance [cf. 14]. This is particularly so in regard to novice design teams' exposure to DT, where the research is limited [15]. A study carried out by Efeoğlu and Møller [7] investigated how DT can be redesigned to accommodate the involvement of novices and non-designers with elaborated applicability of DT methods. Their findings from a real-life case study involving novices and non-designer as well as a survey involving a large sample of DT experts in software enterprises demonstrate that DT with regard to no-ndesigners can be simplified and redesigned for efficiency and effectiveness.

There is a strong discourse in the field of DT acknowledging the benefits of visualization and experimentation to facilitate and enhance the design process [16, 17]. However, while the use of visualization and experimentation methods in design thinking are frequently applied, there is a lack of understanding of the role visualization and experimentation plays in specific phases of design thinking [18]. In this regard, problem framing is considered as key to both visualization and experimentation situations. Framing the problem is about expanding and challenging as well as reformulating the problem rather than simply focusing on solving it [9].

This work-in-progress paper aims to contribute to the body of research on design thinking by forming a knowledge foundation on how problem-framing, visualization and experimentation can be used across the different phases in a design thinking process with novice designers to enable co-creative interactions. The study is based on a project targeting development of a digital platform connecting companies' and other stakeholders'

promotion and uptake of product ideas within the public health area. The need for such a platform was initiated by a science innovation cluster for welfare technology (SICWT) in northern Denmark. The mission of the cluster is to through user-centered approaches connect partners, drive innovation, and create networks between companies, research institutions, and organizations within the field of innovation and welfare technology. The study included five participants from three healthcare-oriented companies and from the science cluster. They were all involved in a design thinking process towards developing a digital platform to connect stakeholders and promote innovation within this area. In this paper, we focus only on the development of a web-based interface (roadmap) for a digital platform that systematically can assist its users to register a product idea within the welfare technology sector and be connected to other stakeholders that have an interest in developing a similar kind of health promoting idea. The central research question is:

- How can a design thinking process including problem framing, visualization and experimentation elements provide a novice design team with resources to release problem-solving capacity based on their practical needs?

The continuation of the paper includes an overview of related work on visualization and experimentation in design thinking processes. Next, we shortly introduce a theoretical framework based on design thinking followed by the methods applied in the research. We finally end the paper with a short note on expected outcomes of the study. The data generated from the study is in process of being analyzed and therefore not included in this work-in-progress paper.

2 Related Work

This section presents an overview of research carried out in the field of design thinking with a particular focus on the effects of visualization- and experimentation elements in collaborative design thinking processes.

Design thinking (DT) is characterized as a human-centered approach to problem solving [15, 19, 20]. According to Brown [3, 4], organizations and companies can profit from being inspired by how established design teams think and work. Using such a human-centered approach can be beneficial in processes related to innovation, developing strategies for growth, developing strategies for better user satisfaction, product development etc. [3, 4, 19]. In relation to DT, co-creation is considered as a tool to push innovation and enhance democratic legitimacy [21]. In this regard, participants from local practices are crucial to ensure productive collaboration, overcome hindrances as well as to cope with emerging dilemmas [10, 21]. However, there is limited knowledge about how this can be done in practice.

Innovation through collaboration in DT is a central topic questioning how actors from different disciplines can respond to cross-disciplinary challenges as well as stakeholder complexities. In this regard, Björklund et al. [11] state that innovation hubs can represent an effective resource for developing new methods, techniques, and perspectives that can foster cross-institutional change. The authors further stress that a way to increase collaborative effectiveness across different stakeholder disciplines is to encourage creative

and novel approaches, such in DT, where innovation can be achieved through experimentation. In general, research [cf. 12] advocates a strong need for collaboration across stakeholder disciplines emphasized by the actors' openness to combine different types of knowledge to better handle complex issues and exploring opportunities. However, there is a clear need for someone to be in charge and frame the direction for the work to at all accomplish innovative experimentations and solutions [11].

A strong claim is made underlining the importance and advantages of visualization as a support in a design thinking process [22, 23]. Anderson and Lilly [24:2], describe visualization as "a process of mentally constructing, shaping and understanding information and the ability to externally communicate it." [see also 22, 23]. In DT processes aspects such as communicating ideas and working towards consensus, or a common understanding of a problem are important parts of the visualization activity [16]. Other advantages are possibilities of organizing information in various ways, i.e., to beside text, include sketches, mock-ups, models, diagrams, knowledge maps which enable richer presentations and representations of information [8, 16, 25]. The visualization element also functions as a resource to facilitate collaborative work and co-creation of knowledge [26, 27]. In his study, Van der Lugt [28] illustrates how collaborative sketching supports team members in thinking processes and in storage of information as the sketching activity functions as a visible memory. However, the visualization element in DT differs throughout the design process [29] depending on whether visualization is used to support generation of ideas or decision-making [30]. Similarly, research [16] shows that the use of different visual formats leads to different design processes and design outcomes.

Another central theme in DT is the role of experimentation. Aspects relevant for experimentation work in design processes are iteration, trial-and-error, and prototyping [31]. Research has revealed that iterative processes is one of the key activities when it comes to innovation and decision-making [31, 32]. In their study, Rekonen and Hassi [6] investigated impediments for experimentation in novice design teams. The study pointed out that the participants in the novice design teams were resistant to work iteratively when involved in experimentation activities [6]. Furthermore, the novice design teams found it difficult to reframe the initial problem in cases where the first experiment did not support the idea being tested which led to stagnation and difficulties in moving forward in the design process [6]. This, according to the authors, is an aspect that distinguishes people in novice design teams from experienced designers where the latter find iterative processes as a natural part of approaching design problems. This is aligned with outcomes from a study by Efeoğlu and Møller [7], who also found that time constraint in DT processes with DT novices is a risk for the participants' engagement to decrease but on the other hand also constituting an opportunity to develop effective results under time pressure. Expressed differently, time shortage "can lead to a sharper focus on the design challenge, faster consensus-building and reflexive design acting based on the synthesis of insights." Björklund et al. [11] emphasize that experimentations in cross-disciplinary collaboration can foster flexibility and support and build communities to ensure design-driven experimentation. Beltagui, Bell and Candi [17] argue for the value of prototyping and iteration as tools for generating ideas, testing, and improving ideas, etc. What approach and what tools used in the experimentation process varies depending

on which stage of the innovation process the design teams are in, but it also depends on the background and preferences of the individual designers in the teams. This chapter on related work will in the next step be further developed.

3 Theoretical Framework

Design thinking is acknowledged as a driver of creative and innovative processes [33, 34]. It does not have a clear definition and has been addressed in several different and nuanced ways, for example, as a methodology [35, 36], a culture, and a user-centered philosophy [37]. A general way to understand design thinking is to relate it to the ways designers think and as such it is mostly applied in the field of design research [38] and design education [39, 40]. Von Thienen et al. [41] state that a general agreement of design thinking is that it seems to be a successful practice in sparking innovation processes, but that a deeper understanding of this is hard to explain. Several studies have attempted to uncover principles, potentials, and challenges of design thinking-based innovation approaches [39–41]. In this regard, Leifer and Meinel [42:2], state that "cumulative work of a global design thinking research community /…/ have started to understand the underlying principles".

In this study, the users were involved in iterative and co-creative design processes, where the focus has been on problem-framing, visualization, and experimentation by means of prototyping [cf. 43]. Sanders and Stappers [43] define co-creation as 'any act of collective creativity' and state that when co-creation is applied early in a design process, it has a positive influence on the design development. This in combination with involving the users as experts in a partnership, where the design process is carried out in an iterative manner provides conditions for the designer and other stakeholders to jointly develop an understanding of the different needs related to the design under development. This, in turn, will create a collaborative understanding of the problem- and design space [44]. In this regard, Stickdorn et al. [45] suggest prototyping as a way to materialize outcomes from such creative processes. In this paper, the prototyping is in low- as well as hi-fi formats and focuses on visualization and experimentation to understand how this influence and frame a co-creative design process.

Within the field of DT, a range of expressions for participants have been developed to help them imagine possible futures as well as exploring situations in them. One such expression is prototypes through which participants can express and experience ideas about situations that may become more apparent compared to abstract considerations alone [9]. According to Sanders and Stappers [9], creating a prototype and testing it, and improving it iteratively is most appropriate when a team has little experience with the situation at hand. The creation and testing of prototypes is useful to break down boundaries between design and implementation [21]. Hence, prototypes can function in activities investigating design possibilities, for example to inspire DT, to explore ideas, and to evaluate and enhance understanding. In the context of the present study, prototyping activities can be seen as a collaborative process through which the participants developed mutual learning [46]. Through visualization and experimentation through prototypes, the participants thus iteratively refined the prototypical design and step by step generated desirable results assessed against a predefined goal [47]. In this

way, the present study involved prototyping activities for the participants to share an understanding of the design ideas.

The theoretical framework is at the moment a work in progress and will be further developed in a next step. The theories on DT, co-creation and prototyping will be elaborated by, for example critically positioning the topics and, based on the soon to be finished data analysis, identify core and relevant analytical concepts.

4 Methodology

The study is based on a co-creation methodology [48] including a DT process divided into four phases (see Table 2). The co-creation procedure is an iterative and structured process, including different methods and techniques. One of them is prototyping, which is a valuable strategy to enable participants to visualize their thoughts, experiment with potential solutions, and suggest improvements to enhance a solution [48;49].

The iterative, cyclic, process, was a crucial ingredient in the present study and included features such as collaborative idea generation, reflection, and evaluation of ideas, and finally a refining process. These aspects were important to the participants' motivation and learning along with the iterative process [9]. The process was not linear but based on repetition, where each repetition (or iteration) was used as a starting point for the next one. The starting point was in other words a way to frame or reformulate the specific problem and thus constituted a direction for the iteration [11]. It was the project leader who had this kind of 'steering the boat' role, i.e., pointing towards a clear direction for the co-creation process.

4.1 Context of the Study

The framework of the project, which this work-in-progress paper is based on, was to investigate how open innovation can be promoted, nurtured, and facilitated by means of a digital platform. The need from the science innovation cluster for welfare technology (SICWT) was to move from a non-digital procedure of registering product ideas from companies or other stakeholders and facilitating connections between different stakeholders within the healthcare area, to a digital procedure through a platform designed to guide individual idea holders through the procedure of registering ideas and connecting with potential business collaborators. This study focuses on how such a digital registration roadmap can be designed to fit the digital platform by involving participants from the healthcare business sector and representatives from the SICWT in design thinking processes.

The participants in the study come from three different companies, which all are focused on innovation and have an interest in contributing to the development of a digital platform to support their innovative work. They were selected from the SICWT network of business collaboration partners and thus constituted a convenience sample available at the time the research should be carried out as well as willing to participate and contribute to the investigation [50]. We are aware that this kind of sampling lacks clear generalizability, a disadvantage which we tried to mitigate by involving the participants on a longer term through three iterations of DT processes over a time period of four

months. Another potential disadvantage of the participant selection is that they are part of the SICWT network and thus assumed to be a reasonably homogeneous group. Halkier [51] emphasizes that there may be a risk that the interactions will not be diverse enough with a homogeneous group, but that it may make it easier for the participants to relate to each other. Since this study targets insight into the design of a particular part of the platform (the registration roadmap) within a specific context, a homogeneous group representing a joint interest is thus considered as a strength. Table 1 presents an overview of the participants and companies involved in the study. Each one of the three companies was represented by one participant in each of the three design iterations. The companies, the SICWT cluster, as well as the participants are anonymised. The participants from the SICWT cluster vary, while the selected companies are consistent.

Table 1. Overview of the participants in the study.

Design iteration	Individual participants	Company
First iteration	Participant FE	Company 1
	Participant LN	Company 2
	Participant LB	Company 3
	Participant TC	SICWT
	Participant M	SICWT
Second iteration	Participant FE	Company 1
	Participant LN	Company 2
	Participant LB	Company 3
Third iteration	Participant FE	Company 1
	Participant LN	Company 2
	Participant LB	Company 3
	Participant BB	SICWT

4.2 Procedure

The participants were part of a design thinking (DT) process divided into four iterative phases: (1) Problem framing, (2) Ideation, (3) Prototyping, and (4) Testing the design [9, 33]. The focus of each phase is described in the below, Table 2. The study included five participants from three healthcare-oriented companies and from the science cluster. The design task included in the present paper was to develop a web-based interface (roadmap) for a digital platform that systematically can assist its users to register a product idea within the welfare technology sector and be connected to other stakeholders that have an interest in developing a similar kind of health promoting idea.

Table 2. Overview of the design phases included in the study.

Design phases	Focus of the design phases
Problem framing	This phase focuses on clarifying the issues, where the empirical data generated from the contact with the participants is worked through to frame the design task. This is a key activity and is carried out before focusing on problem-solving
Ideation	The goal of this phase is to develop ideas targeting a number of solutions to the problem that has been framed in the previous phase
Prototyping	This phase focuses on creating a prototype, based on the outcomes from the previous ideation phase, i.e., to create a tangible design that can be analyzed by the participants
Testing the design	This phase has a focus on giving the participants the opportunity to reflect upon and give feedback to the prototype. This, in turn, opens for another empathizing process together with the participants to learn about their needs and wishes for the design

Each design phase was carried out in three iterations.

4.3 Methods

To answer the research question regarding the ways problem framing, visualization and experimentation elements were used in the DT process of the novice design team, we used focus groups and ethnographic participant observation as methods for the empirical generation of data. Focus groups can generate complex data at group level and were thus relevant to use in the present study as the DT processes included a variation of interpretations and understandings of the DT activities. Hence, the design team could challenge and complement each other's interpretations based on their contextual pre-understanding [51]. Halkier [51] identifies three models of focus groups: (1) a loose model, (2) a tight model, and (3) a funnel model. In this study, we applied a loose model to the focus groups, where only a few guiding questions were prepared in advance to leave space for the design team to take control of the direction of the discussion. We carried out six focus groups, two in each of the three design iterations. The purpose of the focus groups was to identify how the participants, considered as design novices, by means of prototyping, could frame, and reframe the problem at hand.

In addition to focus group interviews, we used the participant observation method [52]. The purpose of these observations was to observe the participants' interaction when framing the problem at hand, ideating, developing, and testing the prototypes.

This section on methods will be further developed in the next step, where for example the procedures of each of the methods will be further elaborated.

4.4 Ethics

The study followed the personal data acts in Denmark (502/2018) addressing handling, archiving and publication of data generated by research. This is in accordance with the General Data Protection Regulations (GDPR) [53] and ethical guidelines for good

research practice, including requirements for confidentiality, consent, information, and autonomy.

Before collecting data, we provided information about the study and the planned collaborative research, the responsibilities of the researchers concerning the data protection act, anonymization of data, storage of data and the participants' right to withdraw from the research at any time. In this paper, the data have thus been anonymized and stripped of any identifying details. Verbatim sequences quoting from interviews have been carefully edited to avoid identification.

4.5 Analytical Approach

The analysis of the gathered data is in the pipeline and thus not included in this work-in-progress paper. For the analysis, we will use a thematic approach adopting Braun and Clarke's analytical phases [54] (see Table 3).

Table 3. Overview of the analysis process [54].

Phase	Description of the analysis process
Getting to know the data	Watching and re-watching the video data and observer notes
Generating initial codes	Systematically coding interesting features of the data and gathering data relevant to each code
Searching for initial themes	Synthesizing codes into initial themes and gathering relevant data to each initial theme
Reviewing themes	Checking if the themes work in relation to the coded data and the whole data set, generating a thematic map of the analysis
Defining themes	Iteration of the analysis to refine the details of each theme in relation to the research question, generating definitions and names for each final theme

5 Expected Outcomes

The next step of thematic data analysis will extend the knowledge of novice design teams' capabilities to solve design problems by means of focused problem framing, visualization, and experimentation. Thus, the study will contribute to unfolding how participants from local practices can ensure effective collaboration to cope with emerging dilemmas. In addition, the study will contribute to specifying how a clear problem framing can provide direction for novice design teams to collaborate across stakeholder disciplines to handle complex issues. Also, the study will expose the kind of tools and approaches that productively can be used in problem framing, visualization, and experimentation processes where novice design teams are included.

The expected outcomes of this study will incorporate identified good practices and design guidelines. Thus, the study will contribute to seeking answer to how cross-disciplinary novice design teams by means of prototyping can release problem-solving capacity based on their practical experiences and needs.

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