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Perceived usefulness of design thinking activities for transforming research to impact

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ABSTRACT

Empirical studies that investigate the effect of design thinking within complex contexts involving multiple stakeholders are rare. The aim of this study is to contribute to the literature on design thinking, by investigating the perceived usefulness of including design thinking activities into a complex research project for food safety. A survey was distributed to all participants in SafeConsume, a Horizon 2020 research project, to measure perceived usefulness of design thinking activities such as collaborative workshops, visualization tools and empathic observation studies. Bivariate correlations and one-way ANOVAs were conducted in JMP Pro 14. The results indicate that design thinking activities may be useful also for large food safety projects. Multidisciplinary collaborative workshops can generate optimism and a sense of belonging among the participants, visualization tools can contribute to simplify complex information, and empathic observation studies makes it easier to think user centric. This study is one of few that quantitatively investigate the perceived usefulness of implementing design thinking into a multidisciplinary research project, and the findings contribute to a better understanding of the perceived effects of implementing design thinking into a large complex food safety research projects.

1. Introduction

Design thinking is gaining momentum within business. Evolving out of engineering and focusing on how designers approach development in their every-day activities, it has become a buzzword among business consultancies (Olsen, 2015). Recently, design thinking has also caught the interest of researchers. Attempts are made to synthesise our knowledge about design thinking (see reviews of design thinking in D'Ippolito, 2014; Luchs & Swan, 2011; and Micheli, Wilner, Bhatti, Mura, & Beverland, 2019), and to investigate the effect of design thinking activities (see Leenders, Engelen, & Kratzer, 2007; Seidel & Fixson, 2013; Roper, Micheli, Love, & Vahter, 2016). Although, design thinking is claimed to be a successful approach for product development and innovation, we still have a way to go before we understand the impact of applying design thinking. One of the things we do not know is when design thinking is a good approach to apply and when it is not. While studies have been conducted on applying design thinking in a university context (Seidel & Fixson, 2013), for development of educational programs (Scheer, Noweski, & Meinel, 2012; von Thienen, Royalty, & Meinel, 2017) and in technical product and service development (Patricio, Gustafsson, & Fisk, 2018; Roper et al., 2016), little is known of the effect of including design thinking into research projects. One of the few papers investigating this is Gonera and Pabst (2019), who found that design thinking is an effective approach to transform scientific findings into innovations and foster collaboration across disciplines and between industry and academia.

As in many other areas, design thinking is gradually making its way into the food value chain. While design thinking for food innovation (Olsen, 2015) and design thinking for food well-being (Veflen & Ueland, 2021) have been conceptually discussed and argued to be a good thing for food innovation in the literature, we still do not know enough about the effectiveness of applying design thinking. Design thinking is an approach consisting of some core characteristics that can be fulfilled with a range of different activities. That all the different design thinking activities always will have a positive effect is unlikely. Studies that investigate the effect of different design thinking activities under specific situations are therefor needed. In this study we will investigate the effect of some specific design thinking characteristics and activities for transforming food safety research into impact.

Most existing studies focus on design thinking in a corporate (single organisation) or educational context (Carlgren, Elmquist, & Rauth, 2016; 2014). The use of design thinking in science projects is not widely

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established. Large research and innovation collaborations, such as EU Horizon 2020 projects, must deliver on social, environmental and economic impact through innovation, collaboration, and solving wicked problems (European Commission, 2018; Mazzucato, 2018). This requires both good project management skills but also a methodology to facilitate knowledge transfer and collaboration between disciplines and stakeholders. A stream of literature exists that describes the role of orchestrators supporting the translation between disciplines but also between research and industry (Norman, 2010). In his opinion paper, Norman (2010) calls for the introduction of a discipline that bridges the research-practice gap "We need translational developers who can act as the intermediary, translating research findings into the language of practical development and business while also translating the needs of business into issues that researchers can address". Inspired by Norman, Wrigley (2016) coined the term of design innovation catalyst in her empirical case study of seven action researchers in industry innovation projects. The design innovation catalyst is a person or a team that facilitates innovation by introducing design thinking principles to a project or an organisation. The necessary capabilities and skills required for this includes design knowledge and skills, business knowledge and an understanding of the consumer/user, as well as research knowledge and skills. While the studies mentioned above refer to a corporate context, Gonera and Pabst (2019) investigated the catalyst role in several research projects within academia. In their multiple case study, they identified challenges and benefits of using design thinking in large research projects. They found for example that it is difficult to introduce an iterative and qualitative way of working to trained scientists. The different communication styles of researchers and designers and existing hierarchies and power structures in large research projects acted also as barriers to implementing design thinking. The benefits of applying a design thinking approach in a large research project lie according to Gonera and Pabst (2019) in an increased flexibility of the research process, increased user focus and better collaboration. The only study, to our knowledge, that has looked at design thinking specifically in the context of food safety is Tsekleves et al. (2019), who found that the focus on obtaining ethnographic and user-centric data was helpful in developing solutions for behavioural change necessary to reduce antimicrobial resistance in Ghanaian homes. While this study focuses on the discovery phase of design thinking and highlights the importance of user-centricity, the notion of using design thinking as a collaboration and co-creation tool is absent.

Studies that investigate the effect of design thinking within complex contexts involving multiple stakeholders, such as large research projects are missing. The aim of this study is to contribute to the literature on design thinking, by investigating the perceived usefulness of including design thinking characteristics into a large transdisciplinary research project for food safety. We want to empirically investigate and discuss how design thinking activities, such as collaborative workshops, different visualization techniques and empathic observation studies, are perceived by research participants to relate to known design thinking outcomes, such as psychological empowerment, ideation, knowledge transfer and insights.

2. Literature review

2.1. Design thinking activities

Over time, an agreement on the operationalisation of design thinking has evolved. Despite differences in wording, the content of the different design thinking stages seems to be approximately the same across scientific articles. Design thinking is described as an iterative, experimental, non-linear approach to development, emphasising the importance of human-centricity, visualization, and collaboration by combining what is technologically feasible, with what is desirable and economically viable (Brown, 2008; Brown & Katz, 2011; Liedtka, 2014; Micheli et al., 2019; Roper et al., 2016; Seidel & Fixson, 2013). The most influential applied models of design thinking, like the D-school model at Hasso Plattner Institute of Design at Stanford University, highlight the importance of being empathic with the users, defining the problem clearly up-front, ideating in multidisciplinary groups for solutions, and prototyping for visualization and continued testing (Micheli et al., 2019). What first and foremost distinguishes design thinking from other innovation processes is the strong emphasis on ethnographic methods, such as observation, in-depth interviews, customer journey maps and diaries, in-depth problem learning, the use of simple prototypes to communicate ideas, and frequent experimentation and testing to fail faster (Beckman & Barry, 2007; Brown, 2008). Abductive reasoning (a logic that promotes workable solutions), a gestalt view focusing on a holistic understanding of the problem, and reflections around the path taken from the project to the market are other characteristics of design thinking (Micheli et al., 2019).

In this paper, we focus on three core design thinking characteristics: 1. Collaboration, 2. Visualization and, 3. Empathy, which are operationalized as specific design thinking activities: collaborative workshops, three specific visualization techniques and empathic observation studies.

2.2. Design thinking outcome

Most of the articles about design thinking are viewpoint articles that focus on conceptualising what design thinking is. A few systematic reviews (D'Ippolito, 2014; Luchs & Swan, 2011; Micheli et al., 2019) exist within the business and innovation literature, and recently researchers have started to empirically investigate the effect of implementing design thinking for innovation (Gerken, Falk, & de Paula, 2022; Leenders et al., 2007; Meinel et al. 2020; Nagaraj, Berente, Lyytinen, & Gaskin, 2020; Nakata & Hwang, 2020; Robbins & Fu, 2022; Roper et al., 2016; Roth, Rau and Meyer, 2020; Seidel & Fixson, 2013). The findings indicate that design thinking practices have a positive effect on product innovativeness and market success. Nakata and Hwang (2020) found that six interrelated design thinking mindsets and actions strengthen new product and service performance. A human centred, abductive learning and learning by failing mindset significantly improves discovery, ideation and experimentation activities, which positively influence new product development (NPD) and service performance (Nakata & Hwang, 2020). The effect from design thinking activities on performance seems also to be mediated by psychological empowerment (Roth, Rau and Meyer, 2020). Design thinking activities, such as user centeredness, problem framing, prototyping and iteration influence the participant's psychological empowerment, which again influences the innovation outcome. In a review of the last 20 years of design thinking research for innovation, De Paula, Cormican, and Dobrigkeit (2021), conclude that design thinking activities lead to psychological empowerment, reduce cognitive biases, improve user research, increase cross functional collaboration and provide structure to capture communication knowledge. Design thinking activities have also been found to outcompete quality function deployment (QFD) in terms of feasibility, relevance and specificity of concepts developed (Nagaraj et al., 2020).

Articles discussing the pros and cons of design thinking, as well as the enablers and barriers for implementing design thinking into established firms, have also been published (Carlgren et al., 2016; Wrigley, Nusem, & Straker, 2020, pp. 1–19). By linking design thinking to cognitive bias reduction, Liedtka (2014, 2018) tries to explain why design thinking has a positive effect on innovation outcomes. She argues, among other things, that the empathy phase of design thinking reduces projection and egocentricity bias. By immersing decision-makers into the experience of others, they are, according to her, less likely to use themselves as the primary source of information. She also proposes prototype testing to reduce the planning fallacy, since teaching decision-makers better testing abilities will reduce their over-optimism and thus result in more realistic planning. The more sceptical voices claim that design thinking is fundamentally conservative and preserves the status quo (Iskander,

2018). That some researchers now question what they call "the uncritical adoption" of design thinking indicates the need for empirical investigations of when design thinking is a valuable approach to apply.

In a systematic review of the design thinking literature, Micheli et al. (2019) presents eleven key attributes of design thinking, with creativity and innovation and user involvement being the two most frequently mentioned attributes. In this paper we focus on four core design thinking outcomes: 1. Psychological empowerment (the optimism and creative confidence that design thinking can lead to), 2. Ideation (inspiration for new ideas provided by design thinking), 3. Knowledge transfer (transfer of knowledge both within the project and towards actors outside), and 4. Insights (increased understanding and user involvement).

3. Conceptual framework

Collaboration, visualization and empathy are three fundamental aspects of design thinking that are argued in the literature to influence the psychological empowerment of the participants (De Paula et al., 2021; Roth, Rau and Meyer, 2020), to stimulate knowledge transfer, ideation and insights generation (e.g. Micheli et al., 2019). In Fig. 1, we present a conceptual framework proposing that different design thinking activities in a research project will influence the outcome and thereby the perceived usefulness of including design thinking activities into a research project.

3.1. Collaboration

Collaboration is one of the core elements of design thinking. Most papers describing design thinking talk about the importance of cross-functional, multidisciplinary teams (e.g. Brown, 2008; Liedtka, 2014, 2018; Micheli et al., 2019; Olsen, 2015; Seidel & Fixson, 2013). Product development teams need to consist of people with different experiences and varied expertise to be able to solve complex problems. A common challenge in product development and innovation is that people from different departments have different perspectives and different ideas, and a tendency to seek confirmations for their own view (Liedtka, 2014, 2018). To overcome this endowment effect, people with different ideas and perspective need to work together, not against each other. There is a need for reflection, debate and integrative thinking for a common understanding of the problem to evolve. A problem needs to be viewed from different angles for new ideas and novel solutions to be developed (Brown, 2008; Seidel & Fixson, 2013).

One of the success criteria for development teams are the willingness to share information, skills and resources (Fuller-Love & Thomas, 2004). An atmosphere with positive energy, involvement and trust has been found to improve information sharing and learning (Gordon & MacCann, 2000), and to lead not only to better understanding and problem solving, but also increased optimism and confidence among the participants (Veflen, Scholderer, & Elvekrok, 2019; Olsen, Elvekrok, & Nilsen, 2012). Creative confidence is one of the core pillars of design thinking (Kelly, 2015), and good designers seem to cultivate an attitude towards wise project management (Sutton & Hargadon, 1996).

A research project is not only supposed to deliver new knowledge, but also to create innovative solutions to a social problem, in this case to reduce food-born illnesses. In this respect, research projects has some similarities with industry-driven development processes. Both industry-driven development projects and European commission funded research and innovation projects, such as Horizon 2020 and Horizon Europe projects, are expected to deliver innovations and technical solutions to societal problems. It is not enough to deliver peer-review scientific publications. Accordingly, we propose that participating in multidisciplinary collaborative workshops, which have been found useful for innovation in industry projects, also will be perceived useful for complex research and innovation projects.

3.2. Visualization

The ability to visualize information, and to make abstract thinking into something concrete, is another core element of design thinking. Influenced by design practices, mental ideas and fleeting thoughts are made into something physical (Micheli et al., 2019). Models, sketches, prototypes or even role plays are expressive ways of making internal thoughts externalised and ideas easier accessible for other people (Kelly & Litterman, 2001; Olsen, 2015).

One of the core problems for innovation and development teams is, according to Liedtka (2014), to make sense of an overwhelming amount of information. Often the team lacks a shared understanding of both the problem and the ideas presented as solutions. Since, what people say is not always what people hear, it is not enough that ideas are discussed. In design thinking processes, visualizations are applied to help communicate ideas and to make it easier to imagine the experience of others. Prototypes and sketches are made to move the project forward and to

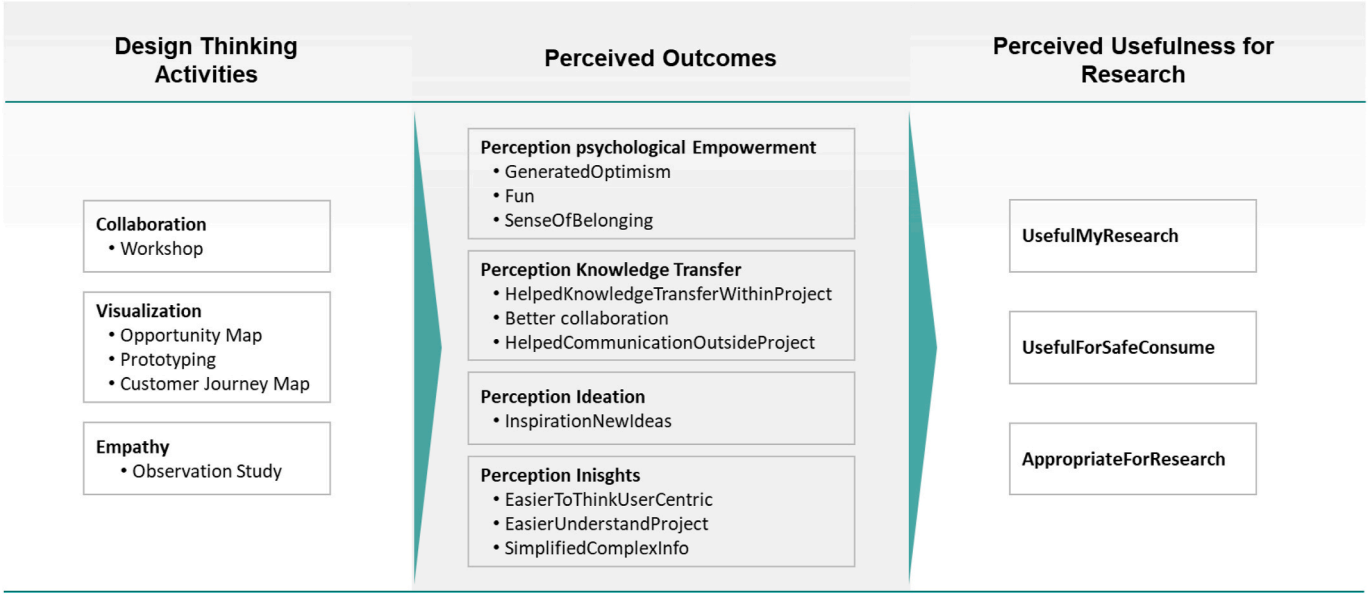

Fig. 1. Conceptual framework of the study.

stimulate the imagination of others (Brown, 2008) and act as boundary objects in innovation processes (Rhinow, Koeppen, & Meinel, 2012) Visualizations are not so much about validation of ideas as they are tools for stimulating thinking around ideas (Hargadon & Sutton, 1997).

It can be challenging to create a common understanding and a smooth information flow in a multidisciplinary research project, consisting of researchers from different fields, market actors from consumer and health industries, authorities and NGOs. Accordingly, we propose that visualizations can be useful for large research projects.

3.3. Empathy

User-centeredness is a fundamental feature of design thinking (Brown, 2008; Liedtka, 2014; Micheli et al., 2019). We need to understand the users, their life experiences and their latent needs, to be able to develop good solutions for users. To be empathic, to try to see what life is like from the users' perspective, to immerse into their situation, leads to a deeper insight than what a survey can offer. By watching, listening and collecting stories while users interact with what is to be improved, unexpected insights and inspiration for new ideas can be captured (Olsen, 2015).

Product development teams can sometimes be trapped in their own expertise and experience (Liedtka, 2018). To use yourself as a model for others, often labelled the ego-centrism bias, or to perceive today's situation to be the situation of tomorrow (the projection bias) may hinder successful product development. Participative ethnographic observation studies, where team members are immersed into the experiences of the users to gather deep insights into the preferences, behaviours and emotional state of someone else, helps against these self-centred problems (Liedtka, 2014) and enables better solutions to existing problems.

In a research project consisting of a team of experts, often with a very deep and specialised knowledge, sometimes with little interaction with the end users, observation studies can be an eye-opener to new insight and understanding. This new insight and understanding can lead to new ideas for both research and innovation and help transfer knowledge within the project.

4. Methodology

4.1. Case description

SafeConsume (http://safeconsume.eu/) is a large Horizon 2020 project with 32 partner organisations from 14 countries and approx. 100 individual project members from various disciplines working in nine different work packages. SafeConsume consists of ten partners from natural sciences, nine from social sciences and humanities, four food/health/education authorities, three trade associations, three SMEs and three market leaders for consumer goods.

The project started in May 2017 and continues until autumn 2022. The overall project objective is to "reduce health burden from foodborne illnesses: changing consumers' behaviour to reduce exposure to hazards and decrease risk through effective and convenient tools and products, communication strategies, education and an inclusive food safety policy". Recent analyses from World Health Organization (2015) estimate that bacteria, parasites, toxins and allergens in food account for about 23 million cases of illness and 5000 deaths in Europe every year. SafeConsume targets the top five foodborne hazards in Europe, accounting for about 70% of the health burden related to food borne illness. SafeConsume aims to support human health through reducing foodborne illness by increasing consumers' confidence and competence in responsible and safe food handling and consumption.

SafeConsume is based on the assumption that consumer behaviour is both a core problem and the solution to mitigating risk from foodborne illnesses. In addition to create new knowledge and publish scientific papers, the research project aims to develop *tools, products and technologies* that stimulate safe food handling practices, *communication strategies* for uptake of risk mitigating tools and food safety information, and *education programs* and *policy models* to increase skills and knowledge about safe food handling.

Since the complexity of SafeConsume is high, a specific work package was assigned the responsibility to aid the process of translating scientific findings into opportunities for change. This team applies a design thinking-based approach to facilitate ideation and collaboration across disciplines. Example activities of design thinking in SafeConsume are ethnographic observation studies, multidisciplinary workshops for facilitating knowledge sharing, and visualization tools, such as user journey maps, opportunity maps and prototypes, for dissemination of ideas.

The timeline and detailed design thinking related activities in the SafeConsume project are illustrated in Fig. 2, the activities were iterative, and the objectives and content followed a typical design thinking approach of "discover – define – develop – deliver".

The *user journey* as illustrated in Fig. 3 was developed and designed by a multidisciplinary team early in the project. The user journey map incorporates knowledge on microbiological hazards and consumer behaviour into an easy to understand visualization of where consumers can be exposed to risk. It shows all critical handling stages that a consumer may be involved in from planning a shopping trip, to storing, cooking, eating and disposing food and was used to guide the research and innovation work in the project.

Working with *prototypes* in SafeConsume included drawings of ideas by all project members in different interactive workshops to communicate one's idea to the rest of the project (see Fig. 4). For three consecutive years, social scientists, microbiologists and designers provided the SafeConsume case and research insights to design students from The Oslo School of Architecture and Design. The student's work resulted in over 150 ideas and drawings and 63 physical prototypes of interventions that could lead to safer food behaviour. One of the project partners, a design company developed 23 visual concepts and high-resolution drawings representing the prioritised innovation ideas in SafeConsume. The prototypes were used as inspiration for the innovation process and further insight generation on consumer's food safety behaviour. Low-definition prototypes were tested with individual consumers and fully functional prototypes were tested by the participating companies internally and in their respective markets.

An *opportunity map*, which is a visual representation of innovation opportunity areas, was developed based in an iterative approach involving all project members. Qualitative and quantitative consumer risk assessment by microbiologists, social scientists and data scientists across ten countries were discussed and synthesised in several cross-functional workshops. 21 risk areas were prioritised, and the opportunity map addresses each of these risks by formulating a "How might we?-question", e.g. "How might we avoid that consumers store eggs at too high temperature?". The opportunity map is a prioritisation, communication and visualization tool meant to stimulate ideation and focus innovation efforts.

Multidisciplinary collaborative design thinking workshops were also conducted within SafeConsume and can be exemplified by the opportunity map workshop that was held during the project's general assembly meeting in 2019 (see Fig. 5). The 60 participants were divided into nine multidisciplinary teams where each team selected three opportunities from the opportunity map. The groups brainstormed ideas and solutions and then clustered these for selecting three ideas to be developed in more detail and present to the rest of the project. The creative process was facilitated by a specific work package, who provided templates and instructions. The activity is illustrated in Fig. 6.

A human-centred *ethnographic* design thinking approach was also applied in SafeConsume. Led by social scientists, a multidisciplinary research team studied barriers to safe food handling of consumers in everyday domestic settings. Project members from different disciplines and work packages visited 75 households and observed consumers in five European countries. They observed critical consumer handling

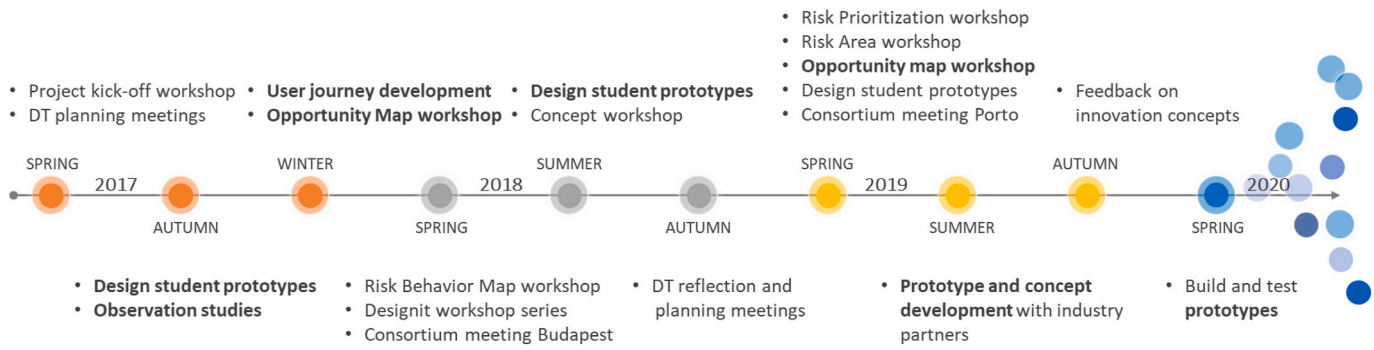

Fig. 2. Timeline of project activities (relevant activities for this study in bold).

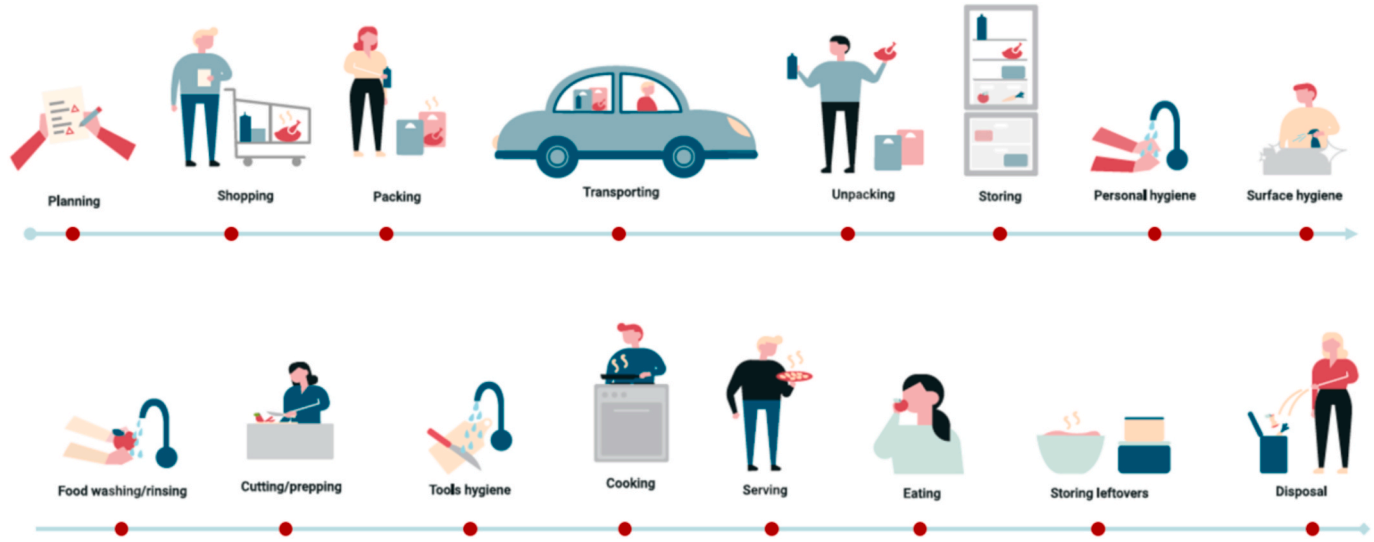

Fig. 3. The SafeConsume user journey map highlighting critical consumer handling points.

practices and identified barriers for behavioural change both in the store and at home and took microbiological samples for laboratory analysis. All insights were shared by video footage, pictures, reports and presentations. It is worthwhile noting that ethnographic approaches are not a common research methodology practiced by microbiologists. Social scientist on the other hand rarely collect lab samples for quantitative analyses.

4.2. Survey design, participants, and measurements

The aim of this study was to investigate how useful participants of SafeConsume perceived design thinking activities such as collaborative workshops, visualizations, and ethnographic observation studies to be for the research project. To be able to investigate this, a survey was developed using the EyeQuestion® software and deployed to 104 SafeConsume project members via email to the projects mailing list. We received complete surveys from $N=37$. It is worthwhile noting that large EU projects like SafeConsume span over various disciplines and geographies and are very dynamic in terms of project members' participation in the various activities and work streams. The research project runs for five years, and not all members are active during the whole duration of the project.

While there have been many collaborative workshops in the project, we specifically refer to the last collaborative workshop in the survey (as this is the workshop participants are most likely to remember). 60 project members participated in the project meeting in spring 2019 where the opportunity map workshop was held.

Of the 37 participants that completed the whole survey, 54% were from natural sciences, 30% from social sciences, and 16% from design and arts. 73% were from academia, 19% from industry, and 8% from NGO or government. The mean age was 39 years and time in current position was 9 years (both calculated by using category midpoints). Participants from all work packages took part in the survey (varying from 27% to 3% for the different work packages).

The perceived outcome of the workshop, the visualization tools (opportunity map, user journey, and prototypes), the observation studies, and the overall usefulness of design thinking were measured with the statements mentioned in Table 1. All statements were measured on a five-point scale from totally disagree (1) to totally agree (5). After answering the question about perceived usefulness of implementing design thinking into SafeConsume, the respondents were presented with different images of activities happening during the project and asked to think back to the activities that were presented in a randomized order (As an example "Please, think about the workshop in Porto and indicate how you perceived it"). After the reminder of the activities, the process outcome questions (see Table 1) were presented in randomized order.

5. Results

Univariate statistics, bivariate correlations and one-way analysis of variance (ANOVA) were conducted in JMP Pro 14.

The univariate statistics show high mean scores for all variables, especially for the usefulness for research variables (see Table 2). Investigating which design thinking activities that gain the highest mean scores on the perceived outcome variables resulted in some interesting observations. While participating in the workshop and making

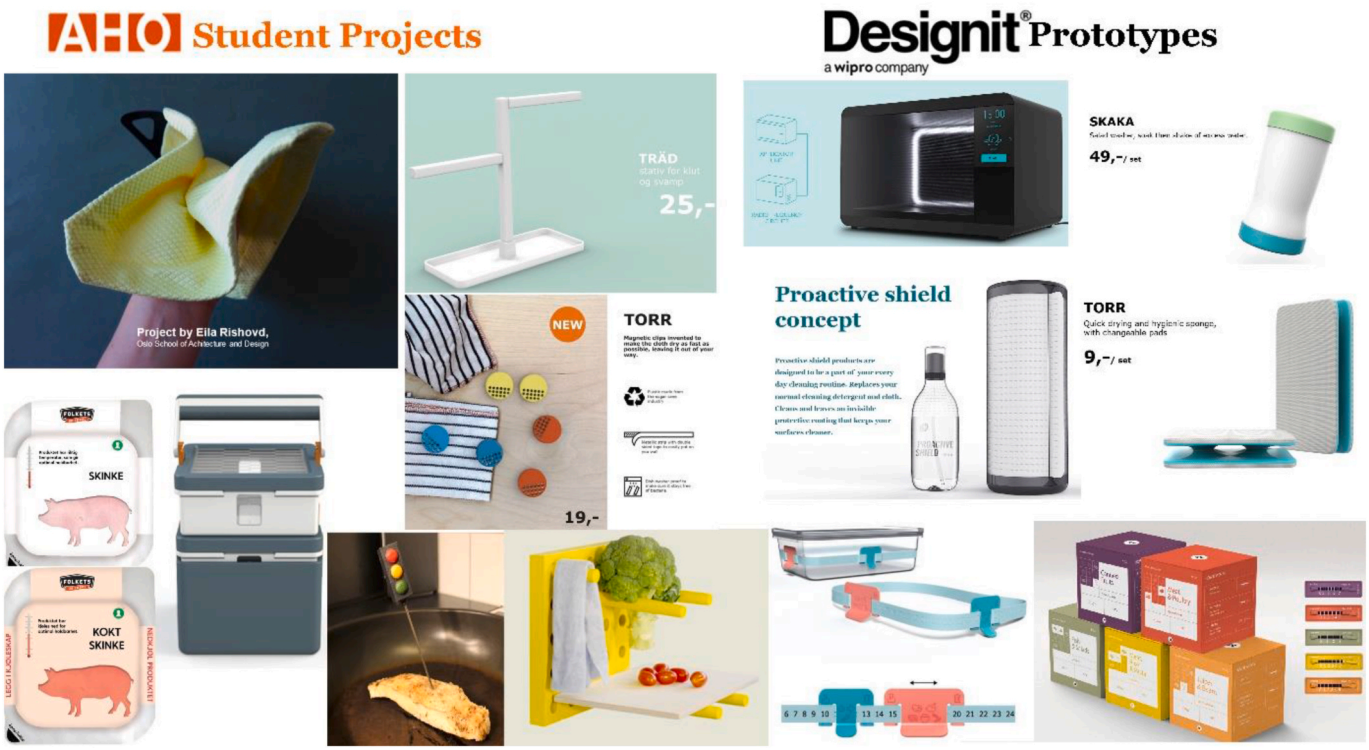

Fig. 4. Examples of the prototypes developed within SafeConsume by students from the Oslo School of Architecture and Design (AHO) and the design agency Designit

Fig. 5. One of the 21 examples in the opportunity map.

prototypes resulted in the highest mean scores on perceived psychological empowerment, the observation study had the highest mean score on ideation and usefulness for research. While two of the visualization techniques (the opportunity map and the customer journey map) got the highest mean score on knowledge transfer, the third visualization technique, the prototyping, scored highest on generating optimism. The opportunity map was also perceived on average as best in making it easier to understand the project and to simplify complex information,

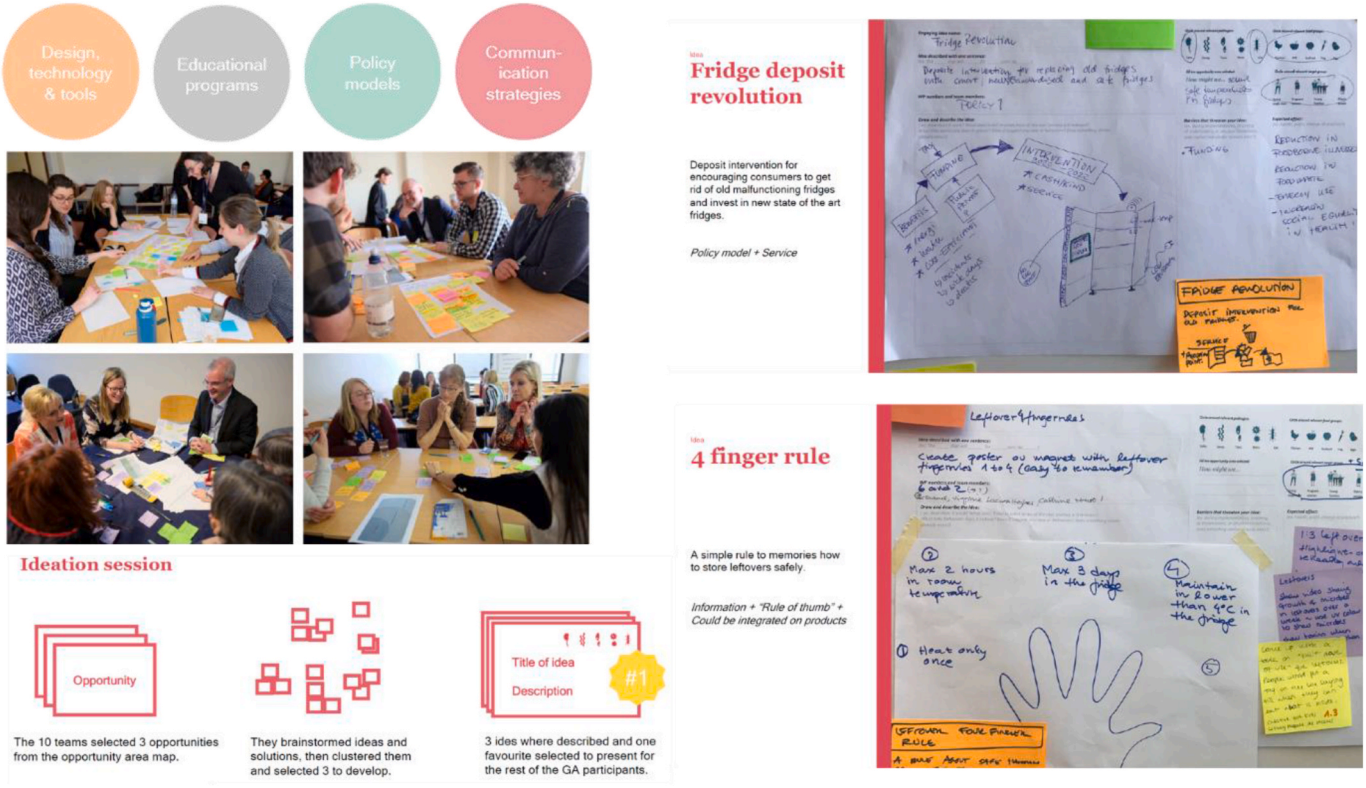

Fig. 6. Opportunity map workshop showing group work on developing solutions for prioritised opportunities.

Table 1
Perceived outcome measures of the design thinking actions.

Construct	Measurement: The workshop/opportunity map/ customer journey map/the protypes/the observation study
Psychological empowerment	
GeneratedOptimism	generated optimism about the outcome of the project
Fun	was fun
SenseOfBelonging	gave me a sense of belonging
Ideation	
InspirationNewIdeas	provided inspiration for new ideas in the project
Knowledge transfer	
HelpedKnowledgeTransferWithinProject	helped knowledge transfer within the project
BetterCollaboration	lead to better collaboration across disciplines
HelpedCommunicationOutsideProject	helped communication with actors outside of the project
Insights	
EasierToThinkUserCentric	made it easier for me to think user centric in my research
EasierUnderstandProject	made it easier to understand what this project is all about
SimplifiedComplexInfo	simplified complex information
Usefulness for research	
UsefulMyResearch	was useful for my SafeConsume research
UsefulForSafeConsume	was useful for SafeConsume as a whole
AppropriateForResearch	approach is appropriate to use in a research project

All questions were asked for a) the workshop, b) the opportunity map, c) the user journey map, d) the protypes, and e) the observation study and answered on a five-point scale: 1) Totally disagree, 2) Disagree, 3) neither, 4) Agree, 5) Totally agree.

while the observation study got the highest mean score on making it easier to think user centric.

The analysis of the bivariate correlations show significant correlations between many of the process outcome measures and the usefulness of the design thinking activities. We can also observe differences in what is perceived useful for own research, for SafeConsume and for research in general (see Tables 3–8).

The bivariate correlation in Table 3 shows that the participants perceived the collaborative workshop to be useful for their own research when it was perceived to simplify complex information, inspire to new ideas and help with knowledge transfer within the project. In addition to these outcomes, psychological empowerment and the ability to make it easier to understand the project correlated with the perceived usefulness of the workshop for SafeConsume. To include a workshop in the research project is perceived appropriate when it is perceived as contributing to psychological empowerment, ideation, knowledge transfer and insight. Sense of belonging had the highest correlation with the perceived usefulness of including a workshop into the research project with a correlation of 0,653.

Three tools for visualization were tested: the opportunity map, the user journey and prototypes (See Tables 4–6). Different effects were found for these activities. Both perceived usefulness of the opportunity map, the user journey map and the prototypes were significantly linked to the ability to simplify complex information. While the prototypes were perceived most useful for own research, the opportunity map and the customer journey map were perceived appropriate both for SafeConsume and for research project in general. While the opportunity map was perceived as contributing to psychological empowerment, ideation, knowledge transfer, and insights, with the highest correlation between simplifying complex information and usefulness for Safeconsume, the customer journey map was perceived as mostly simplifying complex information (highest correlation with usefulness for SafeConsume), make it easier to understand the project, and to make it easier to communicate with the outside world.

Table 2
Perceived outcomes of different design thinking activities, mean (St.d).

	Collaboration Workshop	Visualization Opportunity Map	Visualization User Journey Map	Visualization Prototypes	Empathy Observation Study
Psychological empowerment					
GeneratedOptimism	4.16 (0.92)	4.00 (0.97)	3.73 (0.99)	**4.24 (0.83)**	4.03 (0.80)
Fun	**4.41 (0.68)**	4.00 (1.03)	3.89 (0.99)	4.11 (1.02)	4.00 (0.82)
SenseOfBelonging	**4.08 (0.83)**	3.70 (1.10)	3.51 (0.99)	3.35 (1.09)	3.78 (1.08)
Ideation					
InspirationNewIdeas	4.38 (0.79)	4.24 (0.83)	3.76 (0.83)	4.24 (0.86)	**4.51 (0.65)**
Knowledge transfer					
HelpedKnowledgeTransferWithinProject	4.24 (0.68)	**4.49 (0.65)**	4.19 (0.66)	4.05 (0.94)	4.30 (0.88)
BetterCollaboration	4.14 (0.86)	4.11 (0.94)	3.89 (0.97)	3.73 (1.02)	**4.24 (0.83)**
HelpedCommunicationOutsideProject	3.60 (1.17)	3.81 (1.02)	**4.24 (0.86)**	3.92 (0.98)	4.08 (1.01)
Insights					
EasierToThinkUserCentric	3.46 (0.90)	3.78 (0.98)	3.82 (0.97)	3.62 (1.01)	**4.30 (0.70)**
EasierUnderstandProject	4.08 (0.95)	**4.35 (0.79)**	4.32 (0.71)	3.89 (0.99)	4.30 (0.85)
SimplifiedComplexInfo	4.03 (0.90)	**4.51 (0.69)**	4.32 (0.74)	3.59 (1.07)	3.38 (1.26)
Usefulness for research					
UsefulMyResearch	3.35 (0.92)	3.76 (1.04)	3.89 (0.88)	3.54 (1.24)	**4.57 (0.65)**
UsefulForSafeConsume	4.43 (0.72)	4.54 (0.73)	4.54 (0.60)	4.41 (0.80)	**4.73 (0.51)**
AppropriateForResearch	4.16 (0.90)	4.32 (0.82)	4.41 (0.64)	4.16 (0.87)	**4.57 (0.55)**

Highest mean score for each factor highlighted in bold.

Table 3
Bivariate correlations for the perceived outcomes of the workshop.

	AppropriateForResearch	UsefulMyResearch	UsefulForSafeConsume
Psychological empowerment			
GeneratedOptimism	**0.534*****	0.517**	**0.798*****
Fun	0.477**	0.120	**0.585*****
SenseOfBelonging	**0.653*****	0.399*	**0.723*****
Ideation			
InspirationNewIdeas	0.496**	**0.574*****	**0.670*****
Knowledge transfer			
HelpedKnowledgeTransferWithinProject	**0.477*****	**0.568*****	**0.620*****
BetterCollaboration	0.26	0.327*	0.350
HelpedCommunicationOutsideProject	0.17	0.292	0.409**
Insights			
EasierToThinkUserCentric	0.455**	0.471**	0.494**
EasierUnderstandProject	**0.536*****	0.252	**0.708*****
SimplifiedComplexInfo	0.305	**0.662*****	**0.577*****

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 4
Bivariate correlations for the perceived outcomes of the opportunity map.

	AppropriateForResearch	UsefulMyResearch	UsefulForSafeConsume
Psychological empowerment			
GeneratedOptimism	**0.559*****	0.496**	**0.666*****
Fun	**0.529*****	0.391*	**0.741*****
SenseOfBelonging	**0.541*****	0.348*	**0.551*****
Ideation			
InspirationNewIdeas	**0.658*****	**0.522*****	**0.556*****
Knowledge transfer			
HelpedKnowledgeTransferWithinProject	0.269	0.427**	**0.717*****
BetterCollaboration	0.461**	0.399*	**0.725*****
HelpedCommunicationOutsideProject	**0.606*****	0.452**	**0.587*****
Insights			
EasierToThinkUserCentric	**0.647*****	**0.577*****	**0.520*****
EasierUnderstandProject	**0,679*****	0,378*	**0,625*****
SimplifiedComplexInfo	0,434**	0,256	**0,755*****

*p < 0.05, **p < 0.01, ***p < 0.001.

The perceived appropriateness of including observation studies in a research project was significantly linked to the perceived effect on ease of understanding the project. The perceived effect on ease of thinking user centric correlated also significantly with the perceived usefulness of the observation study for own research (see Table 7).

The ANOVA revealed no significant effect on perceived usefulness of implementing design thinking into the research project depending on which work package the participants came from, if they were from social sciences, natural sciences or design/arts, if they were from academia, industry or NGO/government, or if they differed in age or how long they had been in their current position. The only trend we could observe was that respondents from social sciences were more critical to design thinking activities than respondents from natural sciences or design/arts. These differences were not significant.

Table 5
Bivariate correlations for the perceived outcomes of the customer journey map.

	AppropriateForResearch	UsefulMyResearch	UsefulForSafeConsume
Psychological empowerment			
GeneratedOptimism	0.177	0.094	0.343*
Fun	0.331*	0.211	0.285
SenseOfBelonging	0.144	0.034	0.219
Ideation			
InspirationNewIdeas	0.19	0.116	0.158
Knowledge transfer			
HelpedKnowledgeTransferWithinProject	−0.02	0.193	0.019
BetterCollaboration	0.385*	0.216	0.435**
HelpedCommunicationOutsideProject	0.467**	0.367*	**0.645****
Insights			
EasierToThinkUserCentric	0.261	0.271	0.132
EasierUnderstandProject	0.495**	0.327*	**0.680****
SimplifiedComplexInfo	**0.585****	0.311	**0.831****

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 6
Bivariate correlation for outcome measures of a prototype.

	AppropriateForResearch	UsefulMyResearch	UsefulForSafeConsume
Psychological empowerment			
GeneratedOptimism	**0.677****	**0.544****	**0.728****
Fun	0.388*	**0.524****	**0.558****
SenseOfBelonging	0.351*	**0.557****	0.216
Ideation			
InspirationNewIdeas	0.392	**0.679****	**0.619****
Knowledge transfer			
HelpedKnowledgeTransferWithinProject	0.331*	**0.570****	0.451**
BetterCollaboration	0.335*	**0.670****	0.276
HelpedCommunicationOutsideProject	0.441*	**0.654****	0.397*
Insights			
EasierToThinkUserCentric	0.421*	**0.657****	0.334*
EasierUnderstandProject	0.408*	**0.703****	**0.547****
SimplifiedComplexInfo	0.284	**0.865****	0.362*

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 7
Bivariate correlations for the perceived outcomes of the observation study.

	AppropriateForResearch	UsefulMyResearch	UsefulForSafeConsume
Psychological empowerment			
GeneratedOptimism	0.278	0.077	0.155
Fun	0.123	0.263	0.201
SenseOfBelonging	0.302	0.298	0.093
Ideation			
InspirationNewIdeas	0.478**	0.081	0.431
Knowledge transfer			
HelpedKnowledgeTransferWithinProject	0.328*	0.233	0.497**
BetterCollaboration	0.416**	0.356*	0.489**
HelpedCommunicationOutsideProject	0.213	0.013	0.261
Insights			
EasierToThinkUserCentric	0.553***	**0.536****	0.232
EasierUnderstandProject	**0.578****	0.141	0.322*
SimplifiedComplexInfo	0.082	0.036	0.0777

*p < 0.05, **p < 0.01, ***p < 0.001.

6. Discussion

6.1. Theoretical contribution

In this study, we first investigated the perceived usefulness of implementing design thinking activities such as collaborative workshops, three different visualization techniques, and empathic observation studies into a research project. In Table 8, we present an overview of the results found.

As for the perceived usefulness of implementing collaborative workshops into a research project, our findings support previous papers describing the importance of creating a culture of collaboration for multidisciplinary groups to work well (Fuller-Love & Thomas, 2004; Gordon & MacCann, 2000). We find that a workshop that generates optimism for the whole project and gives a sense of belonging is perceived to be useful for the whole research project. This is in line with the findings from Veflen et al. (2019) and Olsen et al. (2012), who investigate product development in networks and found that good management and coordination of activities, team spirit, and willingness to share knowledge influence the success of a network. Our findings show that orchestrating multidisciplinary workshops also is important for complex research projects. Significant results for the link between the perception of a workshop's usefulness and its ability to create psychological empowerment, ideation, knowledge transfer within the

Table 8
Overview of design thinking activities perceived appropriate in research projects.

	Collaboration Workshop	VisualizationOpportunity Map	VisualizationCustomer Journey	VisualizationPrototypes	Empathy Observation Study
Psychological empowerment					
GeneratedOptimism	***	***		***	
Fun	**	***	*		
SenseOfBelonging	***	***			
Ideation					
InspirationNewIdeas	**	***			**
Knowledge transfer					
HelpedKnowledgeTransferWithinProject	***			*	
BetterCollaboration		**	*	*	
HelpedCommunicationOutsideProject		***	**	*	**
Insights					
EasierToThinkUserCentric	**	***		*	
EasierUnderstandProject	***	***		*	***
SimplifiedComplexInfo		**	***		

Pearsons correlations: *p < 0.05, **p < 0.01, ***p < 0.001, Cells highlighted in grey indicate the highest correlation of perceived outcome of activity and perceived level of appropriateness for research.

project and insights (made it easier to understand the project) indicates that collaborative workshops also are important for researchers' ability to broaden their perspective and to create a common understanding of the whole project. The argument among design thinking scholars, that product development teams need to consist of people with different experiences and expertise to be able to solve complex problems, and that these people need to learn to work together to succeed (Brown, 2008; Liedtka, 2014; Micheli et al. 2019), seems to hold also for research projects.

The aim of the different visualizations, the user journey map, the prototypes and the opportunity map, was to simplify complex information, and to make it easier for all the participants to understand the whole project. Our investigation of three different types of visualizations, show that visualization is not one thing. While the bivariate correlations show significant links between the usefulness of the opportunity map, the user journey map and the prototypes for simplifying complex information, the different visualization tools had also different effects. While the appropriateness of including an opportunity map in a research project was perceived to correlate with all the factors measured, the perceived effect on including prototypes correlated mostly with the usefulness for own research. Despite some different perceived outcomes of the visualization tools, the overall picture supports previous literature arguing that visualizations make internal thoughts externalised and thereby ideas easier accessible for other people (Gonera & Pabst, 2019; Kelly & Litterman, 2001; Olsen, 2015). That both the opportunity map and the prototypes provided inspiration for new ideas, support the argument from Hargadon and Sutton (1997) and Brown (2008) that visualizations stimulate the imagination of others.

Empathy and deep user insights are argued to be a fundamental feature of design thinking (Micheli et al. 2019; Liedtka, 2014, Brown, 2008 to mention a few). By understanding the users, their life experiences and latent needs, we will gather unexpected insights and inspiration for new ideas. Immersing ourselves into the life of the user, is argued to reduce the egocentrism and projection bias often observed within product development teams (Liedtka, 2014). Our findings partly support this. We find that the observation studies got the highest mean score on the easier to think user centric outcome. This ability correlated also significantly with the perceived usefulness for own research and the perceived appropriateness for research. These findings are in line with previous studies finding that user-centricity is an important outcome of observation studies. One explanation why we did not find the same significant correlation for observation studies in SafeConsume may be that not all of the participants in the project were involved in observing the users. Most of the participants only got the results from the observation studies presented, they did not immerse themselves into the lives of the users. Since only social scientists and microbiologists participated in the observation of users, the observation studies in SafeConsume have more character of a traditional process where results are conveyed to participants and not the typical design thinking study activity where participants are involved in observing users. However, the involved researchers orally confirmed, that the participation in ethnographic research approach and microbiology research respectively was valuable and extended their own horizon and point of view. Accordingly, we propose that the lack of correlation between perceived usefulness of the observation study and the ease to become user-centric in SafeConsume has to do with how the empathy phase was conducted in this project, and not that observation studies in general is uncorrelated with user-centricity in research projects. This also points to some limitations for using design thinking in large research projects – it would have been impossible for 100 people to visit consumers at home.

Secondly, we investigated how useful participants in a scientific research project perceived the implementation of design thinking activities into the research project. The overall usefulness of design thinking for SafeConsume was seen as high (Mean 4.35) with all individual activities and tools being perceived as useful for the project (see Table 2). Both the perceived usefulness of the workshop and the opportunity map significantly influence the perceived usefulness of design thinking in the entire project. This is in line with findings from Gonera and Pabst (2019) who identified a learning by doing approach and the establishment of tailored tools and formats such as, in our case, the workshops, the opportunity map, user journey and prototypes as important enablers for the usefulness of design thinking in research projects. The 17 voluntary qualitative statements from the survey participants on using design thinking in a research project had an overall positive notion. Themes being commented circled around simplification of complex information and user centricity.

> "[working with design thinking was] *helpful to simplify complex information.*";

> "*Design thinking is like an alternative way of approaching a problem that may be complex or that needs new input.*";

> "[It was] *useful in challenging some of my preconceptions about how consumers would use our products - always refreshing to get a completely different view and the process of explaining the thinking behind our product design and usage rationales context helps shake out some more ideas*."

Several project members commented on an overall positive and useful experience of the design thinking approach.

> "*It was a good experience and an important part of the project*";

"*Participating in* [design thinking activities] *was inspiring and fundamental for completing tasks in other areas that my partner-institution has been mainly involved*";

"*It is/was really good to get a more practical, hands-on approach introduced in a "traditional" microbiology research environment.*"

These comments support the usefulness of design thinking also in a research projects.

6.2. Managerial implications

From a research managers' point of view, our results are interesting. Our findings indicate that design thinking activities, as collaboration in multidisciplinary idea workshops, different visualization tools and empathic observation studies, might be relevant not only for corporate firms but also for large, complex research projects. We believe that design thinking has the potential to address the increased need for transdisciplinary collaboration and user centricity needed to achieve innovation outcomes of research projects, which are asked for by the EU commission (Mazzucato, 2018). Design thinking may help filling the gap between research and innovation practices. Well-orchestrated multidisciplinary workshops seem to be useful for creating a good atmosphere for information sharing, which is vital for developing a common understanding of the problem, for idea generation and for knowledge transfer. Good visualizations seem to stimulate people's imagination and generate new ideas within the project but also help communication of research results outside the project, which is important for achieving societal impact. To incorporate the mindset and toolset of design thinking seem to be something research management should consider during planning and execution of large research project. To plan in and establish a design innovation catalyst into the research project, seems to be useful for implementing design thinking.

6.3. Limitations and future research directions

As for all research, also this study has its limitations. First, we have a very limited sample. We have based our investigation on 37 respondents, all participating in the same research project. Although, it is positive that we manage to quantitatively, investigate how different design thinking activities relate to different perceived outcomes, future studies need to test our findings on larger samples, and on different types of research projects. The small sample size made it impossible to run advanced statistics. Our study is therefore based on bivariate correlations and one-way ANOVAs. The small sample size makes it harder to find significant results and might be perceived as a stronger test. However, the small sample size, also inflates the explained variance for the analysis. Larger sample size studies are therefore needed to verify our findings. Additional qualitative investigations of project members perceptions of usefulness can also help to provide deeper insights in the personal experience of using design thinking in complex research projects. Studying the entire design thinking process and individual activities and tools in an action research approach in future projects may lead to a new typology for using design thinking for food innovation.

The design thinking approach applied here is only one way of structuring a research and development processes. A comparative approach, where design thinking is compared to other development or project management approaches would therefore contribute with new knowledge to the field. We focused on three aspects of design thinking in this study: collaboration, visualization, and empathy. Future studies can investigate other aspects, such as the experimentation, the ideation, and the screening phase. More studies are also needed in relation to the empathy phase. We did not find a significant relation between perceived usefulness of the observation study and the ease of being user-centric. That is surprising. Accordingly, future studies need to further investigate the effect of observation studies for complex research projects.

7. Conclusion

Recently studies have quantitatively investigated the effect of implementing design thinking for innovation and found positive effects (Gerken et al., 2022; Nakata & Hwang, 2020; Meinel et al., 2020; Nagaraj et al., 2020; Roth, Rau and Meyer, 2020; Robbins & Fu, 2022). Few have, however, investigated the effect of implementing design thinking in a research project. By investigating the perceived usefulness of implementing design thinking activities into a large complex food safety research project, we contribute by testing the generalizability of design thinking for other contexts than product development and innovation. Although, our study has a small sample size and investigates only one research project (SafeConsume), we find many significant results of including design thinking activities into a food safety research project. Our study is one of the first to quantitatively investigate the usefulness of design thinking in a large complex research projects. There are still many unanswered questions and this study opens up an avenue of possibilities for new design thinking studies.

CRediT authorship contribution statement

Nina Veflen: Conceptualization, Conception and design of study, Data curation, Funding acquisition, Acquisition of data, Analysis and/or interpretation of data, Writing – original draft, Drafting the manuscript, Revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published. **Antje Gonera:** Conceptualization, Conception and design of study, Data curation, Funding acquisition, Acquisition of data, Analysis and/or interpretation of data, Writing – original draft, Drafting the manuscript, Revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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