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Design-driven innovation in design practice

The case of designing a ship-bridge vision

Abstract

The aim of this paper is to investigate Verganti's framework for design-driven innovation (DDI) in the context of design practice and to discuss, elaborate and deepen the understanding of DDI, especially on aspects related to design. To meet this aim, an in-depth longitudinal case study of a DDI project for developing a radical new vision for an offshore ship bridge concept is performed. DDI is generally recognised as an in-depth research process, but we also approach it as a highly creative, generative process of design in which design artefacts serve as knowledge production and exploration. Therefore, Verganti's divide between research and creativity and his critique of user centredness are challenged. The paper adds complementary understandings to Verganti's framework, particularly regarding the role of design, and the Generative Design-Driven Innovation framework is developed.

***Keywords*:** Design-driven innovation, maritime industry, offshore ship bridge, generative design-driven research framework.

Introduction

Innovation is currently regarded as important for companies and nations as a means to remain competitive. Within innovation, designers' competency and reasoning have increasingly gained the attention of business managers and management scholars, like in the notion of "design thinking" as advocated by Tim Brown (2008, 2009) and Roger Martin (2009, 2011). In recent years, several national and international working committees, e.g. in Denmark (Danish Enterprise & Construction Authority, 2011) and Ireland (Lawlor, O'Donoghue, Wafer, & Commins, 2015), and by the European Commission (European Commission, 2013; European Design Innovation Initiative, 2012), have also highlighted design as a competitive advantage. In addition to design thinking (Rowe, 1987), new terms, such as *Design-Inspired Innovation* and *Design-Driven Innovation* (DDI) have emerged. In the book *Design-Inspired Innovation* (Utterback et al., 2006), several researchers show how design is considered an impetus for innovative capability.

Although DDI is in frequent use, the term is not necessarily easy to define. The fundamental idea, however, seems to be a focus on how design can be the catalyst for new ideas that may be taken into the more traditional innovation processes (Acklin, 2010). Others have argued that DDI is a special mind-set in which designers can play an important role, which also needs to be understood at a managerial level (e.g. Verganti, 2009). Verganti is regarded as one of the most prominent current DDI researchers, and his work (2003, 2006, 2008, 2011a, 2011b) is widely acknowledged in the research community, especially among management scholars. His book *Design-Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean* (2009), in which the DDI framework is proposed, is one of the most cited within this research field.

Verganti's (2009) DDI framework justifies its importance by offering a business and managerial-oriented innovation agenda. It seems, however, more negligent regarding the role of design, as also stated by Eggink and Van Rompay (2015). There is, of course, research that has purported to elaborate on DDI, e.g. Rylander (2010), who unpacked DDI as an aesthetic experience, or Rampino (2011), who presented an innovation pyramid in the field of product design in which the DDI process is analysed in types of results. Furthermore, de Goey, Hilletofth, and Eriksson (2017) have taken design-driven innovation to other contexts, e.g. business-to-business, and Jahnke and Johansson-Sköldberg (2014) have studied companies that successfully integrated design into their operations. Nevertheless, most of this research seems to either accept Verganti's framework without further critique or debate or to just criticise it without further elaboration or reasoning (Eggink & Van Rompay, 2015; Rasmussen, Mortensen, & Jensen, 2012).

There seems to be a need for more practice-based studies that connect Verganti's (2009) theoretical DDI framework (Figure 1) with design practice. The aim of this paper is, therefore, to investigate and explore Verganti's DDI framework in the context of design practice and to discuss, elaborate and deepen the understanding of design-driven innovation, especially regarding aspects related to design, and within a new context. To meet this aim, an in-depth longitudinal case study of a design-driven innovation project within the Norwegian maritime industry was conducted. More precisely, the case developed a concept for a radical new vision for an offshore ship bridge. The project was performed by the Ulstein Power & Control company and the Oslo School of Architecture and Design and was funded by the former Norwegian Design Council (now DOGA) and the Research Council of Norway.

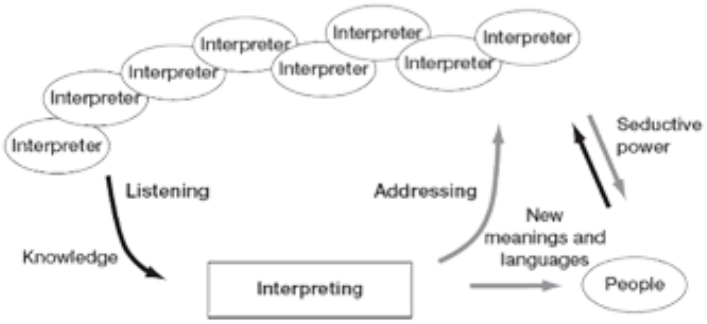

Figure 1: Verganti's process of design-driven innovation. Source: Verganti (2009, p. 134).

The concept of DDI is used extensively in the research communities of management and design, and this paper aims to contribute to both these streams of literature. This study is an attempt to bridge some of the isolated silos that often exist within research.

Design and innovation

Designers' creative way of thinking has gained great attention within innovation in the last decades, especially among managers and management scholars (Kimbell, 2011). In the popular managerial version of design thinking, the underpinning idea is that the way professional designers approach problems through empathy, integrative thinking, optimism, experimentalism and collaboration can be of great value to company innovation or to societal changes (Brown, 2008; Kelley, 2004). Rowe (1987) provides one of the earliest discussions of the concept of design thinking, and Rittel (1987) described the reasoning of design as far more disorderly than, for example, design engineering (Dynn, Agogino, Eris, Frey, & Leifer, 2006). The critical look at the design thinking discourse by Johansson-Skoldberg, Woodilla, and

Cetinkaya (2013) suggests that the notion of design thinking has been divided into a managerial version within business, as mentioned above, and a designerly version in the realm of design research (Buchanan, 1992; Cross, 2006, 2011; Krippendorff, 2006; Lawson, 2006).
In innovation processes, the creative element is regarded as central (Salter & Alexy, 2014), but what constitutes the concept *creativity* is not necessarily clear. It is in widespread everyday use and can be described as the ability to produce work that is both novel (original, unexpected) and appropriate (i.e. useful) (Sternberg & Lubart, 1999). There is currently no single theory that is agreed upon to describe creativity (Kozbelt, Beghetto, & Runco, 2010), but most creativity researchers and psychologists seem to believe that innate creative talent is overrated and that creativity is largely a result of hard work – meaning no magic and no secret (Sawyer, 2006). When it comes to the act of creation, the creative process has been studied by psychologists for decades. Today, psychologists widely hold that creativity tends to occur in four (or more) recognisable phases or stages, described as *preparation*, *incubation*, *illumination*, and *verification* (evaluation and elaboration) (Kneller, 1965; Sawyer, 2006). Although this model may appear almost linear, most researchers consider this process as rather cyclical (Sawyer, 2006). Sawyer (2011) has developed an integrated framework that captures a review of eight key stages of various creative process models.

Edeholt (2007) argued that designers can be valuable to innovation because their approach to ambiguous or wicked problems is to come up with solutions that can be explored, tested and critiqued. The designers' strengths are their reasoning, methods and tools especially developed for the purpose of exploring several and diverse sets of alternative solutions. These design methods and tools, including rapid prototyping, CAD-based simulation, high-fidelity renderings and real-time graphics, make it possible to quickly and cheaply generate a wide array of ideas for further selection (Kristiansen & Nordby, 2013). In addition, designers listen and search for interesting, relevant and inspiring facts and thoughts in their investigations. In this way, the subjective designer becomes a filter in his or her investigation through preferences, values, beliefs and desires (Hekkert & Dijk, 2011).

Buchanan (1992) argued that there is possibly no single definition that adequately covers *design*, and nor is it our purpose to enter this discussion here. One definition describes design as *"*the ability to imagine that-which-does-not-yet-exist, to make it appear in concrete form as a new, purposeful addition to the world" (Nelson & Stolterman, 2012, p. 12). In this understanding, design can, of course, be something performed by people other than designers. But designers trained in industrial design, for example, perform a craftsmanship learned in the tradition of handmade practice in their design work, and the outcome of this craftsmanship is often manifested in sketches and prototypes (Edeholt, 2007). Designers are also, like artists, expected to bring in issues and concerns to the process other than mere problem solving (Lawson, 2006). In the search for what to create, practicing designers frame and reframe, build, test and refine artefacts for exploration (Dorst, 2011; Ulrich, 2011) – a design process often referred to as conceptual design (Kristiansen, 2014; Nordby, 2010).

Design-driven innovation (DDI)

An extensive literature review showed how design-driven innovation and product meaning have entered the discussion based on Verganti's (2003) introduction of DDI as a managerial strategy for radical innovation (De Goey, Hilletofth, & Eriksson, 2016). Verganti (2003) is a management scholar who, by extensive studies of design-intensive Italian manufacturing companies, discovered that radical innovations often entail an innovation process that focusses on how to come up with a new interpretation of a product's meaning. Verganti denoted such innovation processes as DDI, which was launched as complementary to other innovation theories, not as a replacement *tout-court*. DDI sees design as a contribution to innovation through creating meaning, such as other drivers like technology or market (Verganti &

Dell'Era, 2014). The user-centred perspective, as found in design thinking, is criticised as not fully capturing the rich contribution of design to innovation (Jahnke & Johansson-Sköldberg, 2014) because people are not searching only for new solutions to existing problems (Öberg & Verganti, 2014). According to Norman and Verganti (2014), user-centred design (UCD) or human-centred design (HCD) methods are weak regarding radical innovation.

Verganti (2009) argued that design-intensive companies enjoy competitive success because they have the ability to envision a radical innovation in a product's meaning, e.g. the Nintendo Wii, a game console with motion-sensitive controllers that allows people to play games by moving their bodies. Nintendo did not invent the motion-sensitive controllers, but they envisioned how they could use this technology to transform game consoles from an immersion in a virtual world approachable only by experts into an active workout for everyone. No one asked for this new meaning, but everyone loved it once they saw it. Verganti (2009) also argued that this shows a mind-set in which the product developers and design managers shifted their focus from the users; they stepped back and searched for a radical new visionary interpretation, a new *why*. He further argued that radical innovation means proposing a new understanding into the users' world instead of asking them what they need. The public does not ask for anything; rather, the visionary companies are the ones *offering* them something, making new *proposals* (Verganti, 2009).

Furthermore, Verganti (2009) criticised design thinking and claimed that managers embracing design thinking are too focused on a codified, step-by-step manual that can lead to quick radical ideas for new products for commercialisation. Moreover, in order to produce radical new innovations, a company's top managers need to become immersed in what he termed the *design discourse*, an exclusive design circle of radical researchers and key interpreters that are explicitly and implicitly engaged in a continuous dialogue in which they exchange insights, interpretations and proposals in the form of artwork, studies, speeches, prototypes and products (Verganti, 2009).

Verganti's (2009) DDI process is rooted in three actions: *listening to*, *interpreting* and *addressing* the design discourse, which he further described as:

- *Listening to the design discourse:* This action entails accessing knowledge about possible meanings and languages of new products. It implies understanding where this knowledge is and how to internalize it. And it requires continuously identifying and attracting key interpreters in the design discourse.
- *Interpreting:* This action entails generating your own vision and proposal for a radical new meaning and language. It implies integrating and recombining knowledge gleaned from the design discourse, as well producing novel interpretations. It requires that you conduct internal research and experiments.
- *Addressing the design discourse:* This action entails diffusing your own vision to interpreters. You may benefit from their seductive power and thus eventually influence how people give meaning to things. It implies defining the most appropriate means through which interpreters can discuss and internalize new proposal. (Verganti, 2009; p. 133)

To Verganti (2009), the radical researchers and key interpreters in the design circle are not necessarily designers. DDI is not designer-driven innovation. Hiring a bunch of designers does not guarantee anything, but:

> …designers are an essential voice in the design discourse and may be among the primary contributors to an innovation project. However, they are never the sole interpreters.
>
> (Verganti, 2009; p. 139)

Verganti (2009) described DDI as a research process in which knowledge and interpretations are fed into the creation of a new vision and proposal. Such processes are exploratory, aiming at creating an entire breakthrough product family or new business, and occur before product development, as known in traditional industrial design. This is illustrated in Figure 2. Design-driven research processes consist of a deep investigation, like technological research, that "escapes attempts to imprison innovation in simple, sequential ten-step rules" (Verganti, 2009, p. 172). Moreover, Verganti (2009) asserted that radical innovations are not the sudden result of a spark of creativity but, rather, the result of years of research.

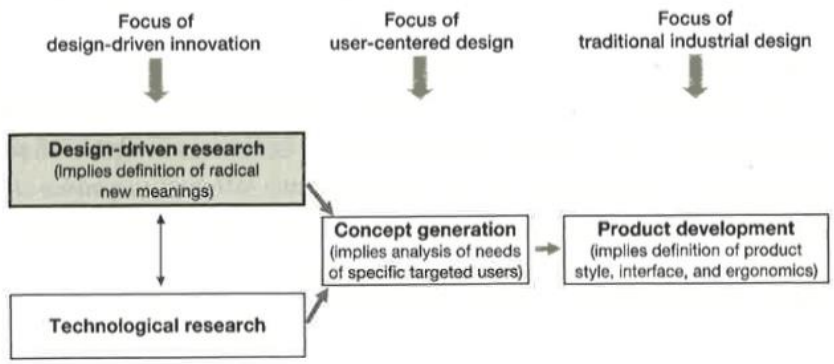

Figure 2: The process of design-driven innovation as research and its position relative to other phases of innovation. Source: Verganti (2009, p. 173)

In the current study Verganti's DDI framework is chosen as the foundation for comparison because of many similarities and touching points with the case project.

Method

The empirical data used here stems from an extensive, longitudinal, in-depth single case study of one DDI research project that developed a concept for a radical new vision for an offshore ship bridge. In order to start with an open mind and an anthropological approach, no assumptions or hypotheses were made before entering the project (Bryman, 2008). In this respect, the research design remained flexible, which means that the details of the procedures were not fixed in advance and that the research focus was liable to change during the project's evolvement (Robson, 2002). An emphasis was, however, placed on the discovery of knowledge rather than on verification. As a research mode, this can be seen as a methodological approach that is based on grounded theory (Glaser & Strauss, 1967); however, where grounded theory prescribes rigor, this project has, in line with Denzin and Lincoln (2011), been more open regarding its use of methods, theories and perspectives.

The primary data were collected through a combination of ethnography or participative observation (Bryman, 2008) and qualitative interviews (Kvale, 1996). The first author endeavoured to immerse himself in the social settings of the project team and spent about 720 hours in the design research lab. As an electrical engineer and Human-Computer Interaction (HCI) specialist with knowledge and skills from the maritime industry, he was accepted as an integrated participant. He contributed with field work on offshore vessels and participated in the ad-hoc design discussions, although he did not perform any active design work. This insider's perspective contributed the research-by-design approach to the project (Sevaldson, 2008). The rationale behind this research perspective was to be as close to the actors as possible, instead of just being an outside observer. The observations were recorded in 382 fieldnotes, blogposts and reflection notes. A total of 186 interviews were performed, including 154 open, unstructured interviews and 32 semi-structured, in-depth interviews with interview guides.

Finally, 56 video recordings and about 1,500 images were captured, functioning mostly as visual memory aids for further reference when needed. Most of the data collection was performed between 2011 and 2013, although four interviews were conducted later to clarify interpretations.

The active participation and direct access and immersion with the project's DDI team provided a deep insight and understanding of what constitutes the complex and fuzzy nature of a practice-led, design-driven research process. Due to the close researcher involvement, the interaction with the team's participants became natural, and the mundane design activities and ad-hoc conversations became accessible in a natural way.

Throughout the entire research period, the collected data went through a continuous spiral of analysis. The data management and reading, interpreting, classifying, describing, visualising and representing meanings were carried out through organising the material, reflecting on it, writing notes and blogposts searchable for later connections, making comparisons to relevant theory, making categories and relating this to the actual contexts (Creswell, 2007). The research process also became an ongoing activity of matching between the theoretical and the empirical world and between the analytical framework and the case (Dubois & Gadde, 2002). Through this activity and analysis, interesting touch points with Verganti's (2009) framework emerged and became one way of discovering new insight regarding the case as a DDI project.

For the purpose of comparison in an inductive analysis (Miles, Huberman, & Saldaña, 2014), the DDI framework (Verganti, 2009) was summarised into four main categories: Mind-set, Design Discourse, Design-Driven Capabilities and Role of Executives. Design Discourse was further divided into three sub-categories: Listening, Interpreting and Addressing. The degree to which the case project had touch points with these DDI categories is presented in **Error! Reference source not found.**. The terms used represent a coarse synthesis of an extended DDI framework and naturally compress Verganti's thorough and diverse research into overly simplistic categories. Table 1 is a condensed version of the analysis and is proposed as one way to organise and understand the DDI framework related to the case under study.

As a qualitative case, statistical generalisations were not accessible. However, case studies may definitely contribute to analytical generalisations and thereby influence theory (Dubois & Gadde, 2002; Eisenhardt, 1989; Yin, 1984). Moreover, in-depth single cases provide opportunities to explore and richly describe the existence of a phenomenon (Siggelkow, 2007).

The Case

The case is the Ulstein Bridge Concept (UBC) project. The point of departure for this project comprised the practitioners and researchers at the Oslo School of Architecture and Design (AHO) searching for a closer collaboration with the Norwegian maritime industry. The maritime industry was chosen because it constitutes an important field of national industrial development and is traditionally known to be dominated by the disciplines of engineering. The collaborating company, Ulstein Power & Control (UPC), belongs to the family-owned Ulstein Group ASA. Ulstein Group ASA is a group of maritime companies specialising in ship design and maritime solutions, shipbuilding, power and control, as well as shipping (ulstein.com). The UBC project started as a Design-Driven Innovation Program and was carried out from March to December 2010. This programme was intended as a means to stimulate the use of design in the early phase of innovation. The project was later developed further into an innovation project funded by the Research Council of Norway with a total research period of three and half years.

The core project team consisted of nine people doing their research and practical design work in the dedicated UBC design research lab on the premises of AHO, which is illustrated in Figure 3 and 5. Six team members were designers, one was a software engineer and two were design researchers. The researchers and designers came from the fields of interaction, industrial,

sound and graphic design, as well as from human factors and engineering. In addition to the core team, domain users, employees and managers of Ulstein promoted the work internally and externally and participated with their insights and expertise whenever needed.

The fundamental approach to fostering innovation in the UBC project was based on design practice as an instrument of investigation and creation and on the belief that an early strategic focus on design would stimulate new ideas and proposals for a new design vision that could be taken further into traditional R&D and – ultimately – into commercialisation.

The project's scope was to create a new design vision for a possible near-future offshore ship bridge described at a conceptual level (Salter & Alexy, 2014). The developed vision turned out to be quite radical, hence attracting a great deal of attention in the global maritime community. The conceptual outputs resulted in several design ideas. Some of these where later taken further for commercialisation, while several others were registered as patents. Other significant results were a national innovation prize and several published research papers. Further descriptions of the project are available in a video published at https://vimeo.com/72330811 and at the Oslo School of Architecture and Design website (http://designresearch.no/projects/ulstein-bridge-concept/about).

Figure 3: From the UBC design lab. Source: UBC.

Findings and discussion

The findings identified an in-depth research process in which several approaches were used and facilitated by the project's design team. Such approaches included user and industry expert interviews and collaborative workshops that included users as well as sales, marketing business, engineering and management at the Ulstein Group. Additional approaches included researching documentation of today's solutions, rules and regulations and investigating technology and interaction solutions from other domains, etc. This work was combined with an extensive amount of observation hours in the field (Lurås & Nordby, 2014; Nordby, Komandur, Lange, & Kittilsen, 2011) in order to fully understand the nature of this particular domain, which is infrequently accessible to the designers (Hutchins, 1995). Figure 4 shows a screenshot of a video recording on an anchor handling vessel in operation.

When doing such fieldwork, the researchers and designers were inspired by techniques and tools from the domain of ethnography, i.e. immersing themselves into the social settings of

the users, observing their behaviour and listening to and engaging in conversations with the mariners (Kristiansen, 2014). The fieldwork also included taking a huge number of photos and video recordings to document the various bridge operations.

This in-depth investigation process also included a rich set of activities and social inter-relations that were played out in the dedicated project space, the UBC design research lab. In the UBC lab, an iterative process of generative creation of design artefacts served as a manifestation of design ideas, providing further knowledge and insight into the specific domain of offshore ship operations. *Generative* should here be understood as being capable of producing or creating something. Through the creative process by which artefacts were created, the designers gained further insight that served their search for the new vision. Dorst (2011) referred to such processes as a complex abductive reasoning where there is no clear "what" to create and, at the same time, no chosen "working principle". Therefore, in the search for a new vision that could lead to a possible innovation, what to create and how it should work needed to be established in parallel. Therefore, the design-driven research work of UBC was recognised as both thorough investigation and generative design work.

Figure 4. Field study on an offshore vessel in operation. Source: UBC.

In the case project, the creative and generative design-driven research work was manifested in sketches and design artefacts, such as mock-ups and rapid prototyping made in the workshops of AHO, high-fidelity renderings, CAD-based simulations and real-time graphics. The importance of sketching is described, for example, by Buxton (2007), while the nature of prototyping is discussed in Lim, Stolterman, and Tenenberg (2008). As an example, one of the designers on the design team thoroughly investigated the concept of sitting, both in general and specifically regarding the special user-related situation at the offshore bridge, where the mariners might spend an entire shift of six hours supervising a demanding anchor handling operation, as exemplified in Figure 4. The purpose for this investigation was to propose new ways for the mariners to combine standing and sitting during such tedious, although safety-critical work.

Another typical example is how the design team collaborated in the exploration of how different interaction designs could interact with physical devices made by low-cost technology

(e.g. Arduino), electric wiring and computer programming, as shown in Figure 5. In this way, the UBC design research lab made it possible to explore and refine ideas. As one of the designers put it, "You need to make new connections in your head…" and "use your experience and subjective skills to create new combinations of possible solutions" (Research blog, 29 October 2013).

The UBC design research lab also provided a valuable maritime context, both for the present and for the future, when the new design ideas were explored and placed into the operational maritime context. The lab became an arena where the built prototypes, represented in various forms and details, could be discussed and acted upon in conjunction and interrelation. The possibility of investigating ideas through design action inspired and influenced everyone in the project, and the lab became a realm where the relationships between design methods, tools and outcomes became alive. This continuous process of reflection in action (Schön, 1991) was shared among the design team through ad-hoc meetings and conversations about the mediating artefacts. Here, the design research environment was taken to its extreme as a generative exploration of the possible future (Binder et al., 2011). Through the generative work, far-reaching and robust design concepts that both embodied and pointed to a desired future bridge vision could be made, fit to challenge the existing paradigms in the maritime culture.

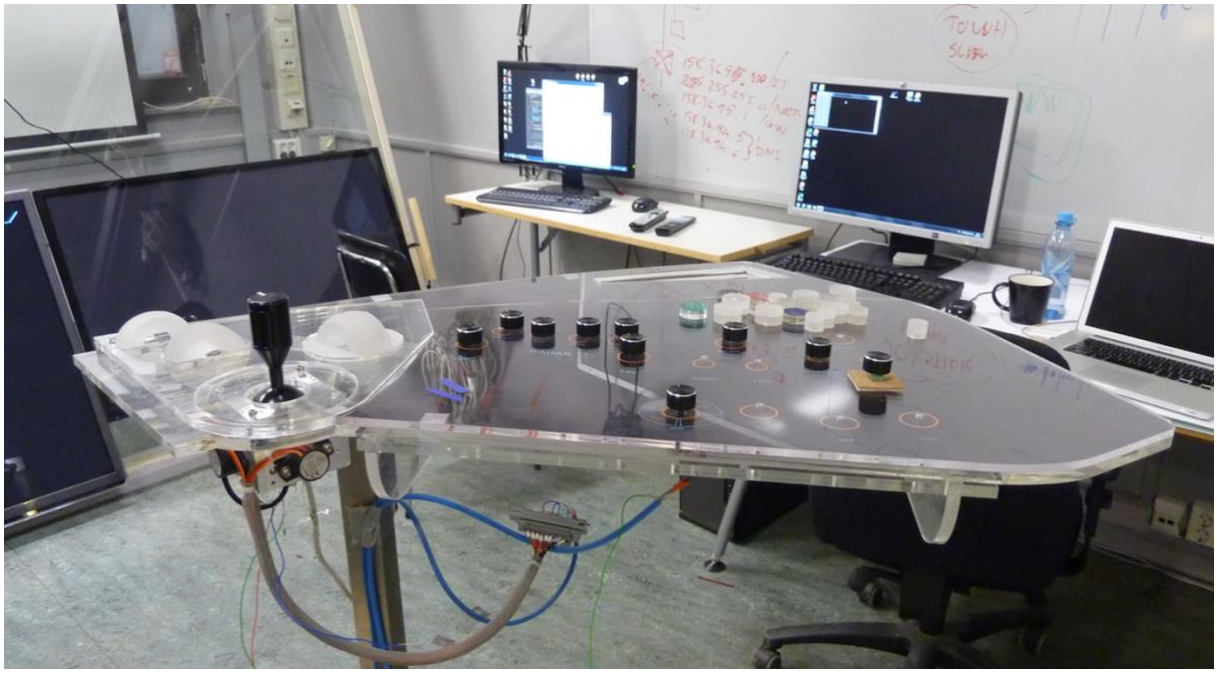

Figure 5. Prototyping in the UBC design research lab. Source: UBC.

In the reliance on design competence, the *subjective* designer was lifted up as a key component in the design-driven research work. As argued by the UBC design manager, "the designer uses himself as a filter, or prism, in his investigation" (Research interview, 26 April 2016). According to him, designers have a wish to build desirable experiences for people through technology and materials, and, in this, they are often known to immerse themselves into the users' cultural environment – in this case, the culture of professional mariners. But in order to deal with the huge numbers of facts and factors that are often involved in such research work, designers acknowledge the subjectivity in their design approach, where their personal values and experience influence everything they do through preferences, values, beliefs and desires.

Our informants saw this subjectivity as both an advantage and disadvantage but accepted it as crucial to the design process.

The designers' crafts of visualisation and prototyping were recognised as extremely powerful in the generative design-driven research work of the case. This was seen in the design mediation for internal collaboration within the UBC design team, in mediation between the design team and the Ulstein managers and with externals when selected results were diffused further to the maritime community. The video presented at the trade fare ONS in Stavanger 2012 is an example of this, and a screenshot of this video is shown in Figure 6. This video was the first public presentation of the project and attracted great attention in the maritime industry. Another example is the interactive demonstrator presented at Nor-Shipping in 2013, which is illustrated in Figure 7. One of the project managers of Ulstein expressed the power of visualisation and prototyping as follows: "You could have written page up and page down without ever expressing what they did through these illustrations, films and animations. It sounds simple, but it was quite ground-breaking in the way ideas were mediated" (Statement made in a video published by the Norwegian Design Council, 2013).

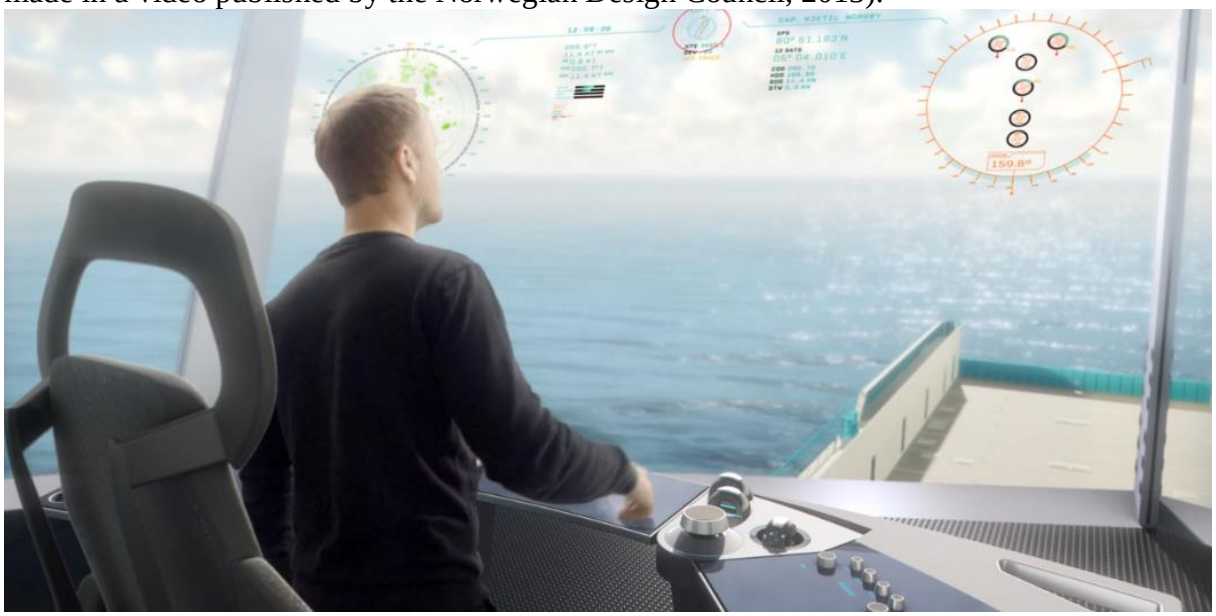

Figure 6: Screenshot from the animated video *Ulstein Bridge Vision*, presented at ONS in Stavanger, Norway. Source: UBC.

Figure 7: The Ulstein Bridge Vision interactive demonstrator presented at Nor-Shipping. Source: UBC

The mind set of design-driven innovation

A condensed version of the case analysis is presented in Table 1. The symbols "=" and "<" are used to indicate similarities or additions, respectively, to the understanding of DDI but should not be perceived as absolute. The analysis shows recognisable similarities to Verganti's (2009) DDI framework but also suggests additions and elaborations. His fundament, though, based on the definition of *design* as making sense (of things) is nothing new to design (Heskett, 2005; Krippendorff, 1989, 2006) and will not be discussed further here. In addition, the systemic approach needs more thorough attention and, therefore, remains outside the scope of this paper.

Table 1. A condensed presentation of the case analysis.

Design-driven innovation (DDI)			***UBC***
Mind-set	Design is making sense (of things)	=	Seemed as a natural approach to designers, almost mundane
	Innovation as an in-depth research process (not creative)	<	The project complied as an in-depth research process, but creativity seemed to be an important part of it. Research was both thorough investigation and generative design work
	Step back from users	<	Can be seen in the project. But the designers argued it was still human-centered
		<	A systemic design approach seemed to beneficial, viewing the offshore bridge as one integrated work area - holistic
Design discourse:			
- Listening	Attract key interpreters	<	In this project, the interpreters were the participant of the core UBC design team. The subjective designer was though recognised as important
	Do research outside own industry	=	Inspiration came from a multitude of sources, e.g. investigating the concept of sitting
	Be part of a design circle	=	The project engaged researchers, designers, students, artists, architects, engineers, users…
- Interpreting	Create new visions	<	In the project this was a natural process of design, and the designers used their methods, skills and techniques as in any other design activity. The main difference seemed to be the open and bold aim of the project, and how the UBC design research lab was used to investigate this vision thoroughly
	Go into deep investigation and exploration - experimenting	<	The design team performed a generative design-driven research process where built prototypes could be discussed and acted upon in conjunction and interrelation and build knowledge to strengthen the robustness of the design vision
	Design direction workshops	<	In this case, this was rather an on-going process of conceptual design collaboration
- Addressing	Leverage the seductive power of interpreters	<	Recognised as the designers' craft of visualisation
	Diffuse a new vision	<	Shown as holistic concepts in prototypes, demonstrators, an animated film, etc.
DD capabilities	Build relational assets	=	In this case, a research and design school
	Leverage internal assets	=	Ulstein has long traditions and a culture of innovation
	Integrate insights	<	Powerful when performed as design collaboration in a design lab
Role of executives	Ignite DDI	=	The UBC case initiated by design researchers, but gained strong support by the management of Ulstein
	Create relational assets	=	The UBC project located at the premises of an architect and design school
	Select solution (vision)	<	The power of visualisation and prototyping in the discussion
	Take pride	=	A strong support from the owners and CEO's of Ulstein was recognised
	Build culture	<	Seen as a special min-set of both managers and designers, closely related

= similarity of DDI < additions to the understanding of DDI

The analysis suggests an in-depth research process in which creativity seemed to be a natural and important part. This is in contrast to Verganti's statement that such processes are not creative in and of themselves but, rather, are more related to the process of engineering (Verganti, 2009; Verganti & Dell'Era, 2014).

It is, however, not the aim of this paper to boldly argue that Verganti has been proven wrong regarding creativity. Verganti probably used the term *research* in opposition to *creativity* to emphasise the thorough nature of the work that lies behind the creation of a complete new vision, something he emphasised as quite different from quick workshops or brainstorming, which he believes are dominant in, for example, design thinking (Verganti, 2009). Other studies, including contributions co-authored by Verganti, have also referred to creativity in DDI, e.g. Dell'Era, Buganza, Fecchio, and Verganti (2011). The current case analysis definitely supports Verganti's claim of design-driven research as thorough. A bold, open and loosely described design brief, as found in this project, demands a wide design approach and a considerable quantity of resources. However, this paper also suggests that there is probably no contradiction in describing such research work as creative and that design-driven research should not be seen as something opposite to creativity. This argument is also supported by Sawyer's (2011) framework, which presents a creative process as much more than mere brainstorming, prototyping and testing.

Verganti has also argued that it is important to step back from the users when the aim is radical innovation because users don't necessarily know what they want until they are presented with it (Verganti, 2009; Verganti & Dell'Era, 2014). Norman and Verganti (2014) took this even further and argued that user-centred design (UCD) or human-centred design (HCD) methods are weak regarding radical innovation. The need to step back from the users was clearly recognised in this case as well. Although a lot of user-related activities were carried out in the in-depth research process, most of the explorative work related to the development of the new vision was performed in the UBC lab by the design team, usually without any user involvement. Nevertheless, the designers in the project still seemed to be human centred. To them, the mariners using the offshore ship bridge as their professional work area was fundamental and at the centre of all their design considerations.

The rationales behind UCD or HCD are probably not equal in the various research domains. Sanders and Stappers (2008) proposed a model from design research in which UCD is seen as one mind-set amongst several in the larger landscape of HCD research. This comprehensive understanding of HCD is one probable explanation for why the designers in the UBC project made their assentation. Another can be found in Krippendorff's (2006) presentation of human-centred design. According to him, the underlying thread in professional designers' self-perceptions is a concern for what people do with artefacts and, due to this, they become advocates for users when they try to balance social, political, cultural and ecological considerations. Verganti used Krippendorff's (1989) definition of design, and his arguement that humans do not see and act on the physical qualities of things but on what they mean to them. Krippendorff (2006), however, declared his statement to be axiomatic to a *human-centred design discourse*. This might imply that Norman and Verganti's (2014) division between human-centred design and design as the change of meaning can be challenged. In the realm of design practice, human centeredness is not necessarily the same as just asking what the users want and then giving it to them.

Create new visions as a generative process of design

Verganti (2009) argued that interpretation is when knowledge is fed into a process that can create a new vision and proposal. He further described this as integrating and recombining knowledge into a deep investigation through exploration and experiments. One suggested

method is design direction workshops, which he described as processes of envisioning, sharing, connecting, selecting and embodying.
In this case study, this deep investigation through exploration and experiments was recognised as a natural process of design (Heskett, 2005) in which the designers used their design methods, skills and techniques as in any other design activities. The main differences seemed to be the open and bold aim of the project and how the UBC design research lab was used to thoroughly investigate this vision. The design team of the UBC project performed a generative, design-driven research process in which the knowledge investigated and the prototypes built could be discussed and acted upon in conjunction and interrelation with each other. This was further used to create novel knowledge in order to strengthen the robustness of the new design vision. Instead of design direction workshops, as proposed by Verganti, this was experienced as an on-going process of what can be seen as conceptual design collaboration.

There is, of course, a significant difference between the creation of a new meaning for consumer products, for example, and for a complex system of what constitutes a complete offshore ship bridge. The most radical, innovative idea that emerged through the generative design-driven research process in the case project was the changed interpretation of how the ship bridge could be understood. The result was that an offshore ship bridge could now be viewed as an integrated work area, and the aim of the bridge design would be to support advanced maritime operations. This understanding replaced the traditional view of engineering, in which advanced technological devices were just placed together wherever they could be fit in. Interpreting the ship bridge as an integrated work area represented a holistic and systemic approach with the consequence of the bridge needing to be designed as a whole. This new interpretation also led to the vision of a new ship bridge where technological equipment could be hidden and where the design focus became generating user experiences for the mariners. Furthermore, it led to the idea that material and technology should be viewed as design materials in themselves, as described by Nordby (2010).

The design discourse as a process of generative design-driven research work

Based on our findings, we have developed a new model, the generative design-driven innovation (GDDI) processes model. This GDDI model, which is presented in Figure 8, is proposed as complimentary to Verganti's DDI process. It is an attempt to describe an additional understanding of a generative design-driven research process and how the activities of listening, interpreting and addressing can be connected to the activities and skills of designing. The proposed GDDI model attempts to capture how the generative design-driven research process can be understood as a process of design in which the aforementioned design methods and tools are used in an effort to gain insight as well as to create and address a radically new design vision through the evolving conceptual design artefacts, as exemplified in the UBC project.

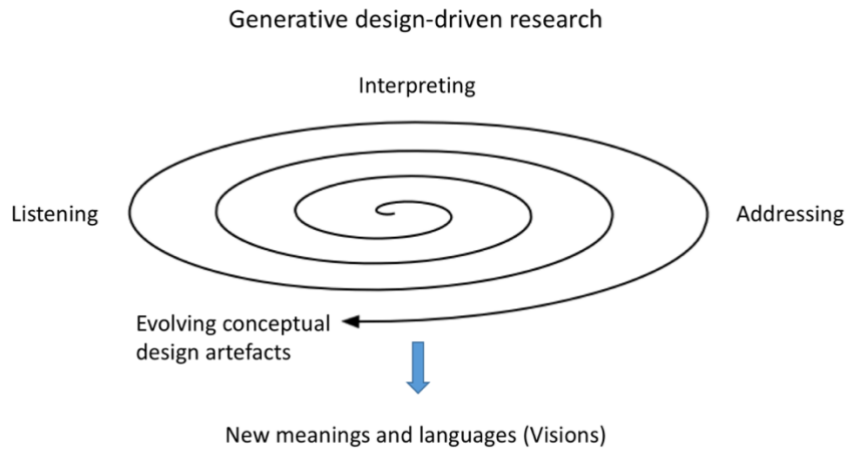

Figure 8. The Generative Design-Driven Innovation processes (GDDI) model. Source: the authors.

Sufficient management and resources are certainly needed in the DDI research processes, but in the realm of design, creativity also seems to be central. Creativity, however, needs to be understood as hard work through preparation, incubation, illumination, evaluation and implementation, not solely as a quick spark of inspiration. The generative activity that becomes manifest through evolving conceptual design artefacts then becomes crucial. When the design brief is rather loose, as is often the case when the goal is to reach a radical new interpretation, this generative design activity also provides the mediation of design knowledge and design direction among the project's participants and managers.

Verganti has highly emphasised the role of managers, and our findings confirm the importance of the top managers' commitment and support, both internally to the design team and externally when diffusing the company's vision – a vision that needs further research and development in order to be realised as a desirable, reliable and safe system. The role of management was not studied in this case study, but the analysis still suggests that the generated design artefacts seemed to have an essential role in the mediation of the new vision to the managers of Ulstein.

This paper does have some limitations. It could be argued that the comparison with Verganti's DDI framework is problematic because his empirical base is confined to consumer products rather than facing the immense task of redefining an entire complex holistic system, like the offshore ship bridge. The case process also went across boundaries where several sub-suppliers are usually involved. This conglomerate of businesses and technologies could have an impact on how Verganti's model was understood when used as an analytic reference for UBC as a complex industry project. However, several of Verganti's fundamental descriptions and reasonings remain familiar and recognisable within the case. Furthermore, the basic principle seems to remain the same, i.e. plunging into an in-depth investigation of the meaning of a new product. Therefore, we claim that the comparison is relevant.

It can also be argued that a single longitudinal, in-depth case study constitutes a weaker empirical base than Verganti's ten-year-long research on design-intensive Italian companies. Nevertheless, a single case provides the opportunity for unusual research access, as it allows exploration in a specific population (Yin, 1984). The aim of the paper is not to generalise but, rather, to show powerful examples from a practice based study, and the qualitative nature of this study serves to sustain a more convincing argument about causal forces than broad empirical research (Flyvbjerg, 1991; Siggelkow, 2007). Furthermore, the empirical data in the UBC case is rather vast and is presented by some thick descriptions (Geertz, 1973). In addition, some may question whether the insider perspective influenced the study's validity. Design-

driven research processes involve a large number of stakeholders, requirements, conditions and implications, all of which interact in complex and contradicting ways (Sevaldson, 2008). While understanding this complex process from the outside is almost impossible, the insider's role has provided this study with an extra dimension of in-depth insight as well as an unusual research approach aimed at understanding the DDI process. The insider perspective of one author is, therefore, regarded here as a valuable and unique resource. We argue that the validity, which is based on the argumentation and reasoning as suggested by Giere (1991), is acceptable. The open-minded approach was necessary at the outset to venture the suggestion that UBC be compared with Verganti's DDI framework. However, a more stringent research design may have provided other insights.

Conclusion

The aim of this paper was to explore, discuss, elaborate and deepen the understanding of Verganti's DDI framework, especially regarding design-related aspects. The case shows recognisable similarities to Verganti and examples that can enrich his framework, but it also proposes some additional aspects as complements. We argue that Verganti seems to have created an artificial divide between research and creativity when analysed from the realm of design practice. It also seems that Verganti's design-driven research process can be understood as a highly creative and generative process of design, a process that, in this case, we argue is user centred. Verganti mentioned professional designers as important interpreters, whereas this case implies that the subjective designer, and his or her activity and capability of designing, seemed rather crucial. This insight was used to create the generative design-driven innovation (GDDI) processes model, which can be considered a complement to Verganti's DDI process by describing an ongoing process of generative design-driven research through evolving conceptual artefacts. The artificial division between research and creativity further implies that the difference between incremental and radical innovation is not creativity in itself but whether the project's aim is visionary or not. This might suggest that Verganti's critique of design thinking and creative processes should instead emphasise that radical innovation needs sufficient resources for design research combined with bold and visionary leadership for the DDI process.

This paper has theoretical and practical implications. The main contributions to theory are the enrichment of and complement to Verganti's DDI framework, especially regarding aspects related to design. First, the study applied the framework to a holistic, complex project within an industry with limited design traditions. Second, the paper contributes to bridging the gap between theory and the practice of DDI with examples from a practical design-driven research process. Third, by launching the GDDI framework. The paper also contributes to practice by showing DDI and design practice in a new combination, which may be useful for managers as well as practicing designers and engineers.

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