

Is There a Proper Way to Teach Design Thinking? Empirical Evidence from Design Thinking in Education

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Abstract

Since about a decade ago, design thinking has become a prominent topic in the scientific and business world. In order to keep up with global competition, design thinking has proven to be a valuable concept for assisting companies to innovate their products, services and processes. Therefore, business schools worldwide have introduced design thinking courses with the aim of preparing the future workforce. Scholars debate about the appropriate approach to teach design, with this paper trying to identify how a design thinking course should be arranged to teach non-designers the processes, methods and mindset of design thinking. It deals with the question of which form of knowledge conversion is more effective for bringing non-design students closer to the design thinking mindset. To answer this, it reviews current studies on design thinking in education. In particular, the research refers to Simon's and Schön's concepts of science of design and reflection-in-action, along with Nonaka and Takeuchi's SECI model. The research involves an experiment with two similar one-week design thinking courses, each having different teaching approaches. The courses are then compared through analysis of reflection reports by students, semi-structured interviews with them and a survey. This research shows that applying design thinking knowledge to real-life projects should be a core element in design thinking curricula, as it plays a crucial role in successfully imparting design thinking. Further, co-teaching and co-learning modes, where designers and non-designers work together and socialization takes place, is more appropriate for imparting design thinking than instructional teaching and learning modes, where design thinking coaches instruct non-designers to internalize design thinking.

Keyword

Design Thinking, Teaching Modes, Reflection-in-Action, Science of Design, Socialization

Introduction

Since the mid-2000s, design studies have contributed more and more to management studies with businesses widely acknowledging the importance of design and designer's mindsets and thinking modes. Economic factors — instead of aesthetics— and user-centricity link design with management studies. Nowadays, leading design schools agree upon the necessity of including art, science and technology in theory and practice. They integrate knowing, acting and being in their design curricula, a link that has been taken up by design thinking schools, such as the d-schools at Stanford University, U.S., Potsdam University, Germany, the Rotman School of Management in Toronto, Canada, the Pop-Up Campus in Risør, Norway or at Jacobs University's D-Forge in Bremen, Germany. However, design thinking curricula and syllabi vary in their focus on design process, methods and mindset. Furthermore, they vary in their orientation towards technology, design, business and science, whether in theory and practice, as well as their experiential and interdisciplinary learning approaches and embeddedness in social and business communities.

After a decade of design thinking courses and programs, it is now time to review the experiences gained in design thinking education. The present paper will answer the question how a course should be designed to teach design thinking to non-design students in a sustainable way, including the design thinking mindset, processes and methods.

We will first present historical strands in theory towards design thinking education. Second, we conducted an experiment by setting up two design thinking courses, where one course followed a socialization teaching approach and the other course followed an internalization teaching approach. We explain and highlight their similarities and differences. The learning outcomes of the different ways of teaching design thinking will be reviewed by contrasting in-depth students' reflections with teaching modes on undergraduate and graduate levels at the Risør Pop-Up Campus and at the D-Forge at Jacobs University from 2018 and 2019.

The insights might be used to enhance future teaching of interdisciplinary courses in the intersection of design, entrepreneurship and technology. These findings will provide interesting insights for teachers and will contribute to the design of future design thinking syllabi and courses.

A Review of Design Studies, Design Thinking and their Teaching Modes

1. *Design Studies and Design Thinking*

Since the 1920s, when Gropius revolutionized the educational model for design (Kimbell, 2009) and the Bauhaus Design School slogan read Art and Technology: A New Unity (Findeli, 2001: p. 6), design education has been built on an archetypal threefold structure of a single curriculum, composed of art, sciences and technology. This structure has seen some changes over the years, being transformed into a polarity of practice and theory with the Bauhaus in Dessau (1930s), the New Bauhaus in Chicago (1940s) and the Hochschule for Gestaltung in Ulm (1950s), all of them considering design as applied — human and social— sciences (Findeli, 2001: p. 7).

During the late 1960s, Simon started a debate about design practices. According to his approach of science of design, design could be learned, as it comprises analytic, partly-formalized-partly-empirical, teachable doctrines about design process (Simon, 1969). It applies methods from empirical sciences, mathematics and logic (Meadows et al., 1972). Schön (1983) criticized this technical perspective of design, urging design studies to adopt the approach of reflection-in-action, in which a master shows and explains what a student needs to do and the student tests these new understandings by translating them into performance (Schön, 1984). This underlines that becoming a professional involves not only what we know and can do, but also who we are — becoming—. It involves the integration of knowing, acting and being in the form of professional ways that unfold over time (Dall'Alba, 2009: p. 34).

Specifically, in case of design, many problems could not be solved in the usual way managers do. It is not always possible to analyze them and solve them by applying a predefined range of options (Rittel, 1972). Managers face such problems considering the increasing internationalization and digitalization. These so-called wicked problems are ill-formulated, where the information is confusing, where there are many stakeholders, including decision makers with conflicting values and where the ramifications in the whole system are thoroughly confusing (Buchanan, 1992: p. 15). Designers do not try to solve these wicked problems. Instead, they redefine them and find an opportunity to improve the current state and innovate it by questioning the underlying assumptions of the current situation (Boland & Collopy, 2004). This thinking mode, defined as designerly thinking, demonstrates how designers deal with wicked problems and maneuver through the problem-solving process, which includes not only art but also a social process that involves thinking and working across different perspectives (Adams et al., 2011: p. 588) and the combination of theory and practice (Mosely et al., 2018).

In contrast to designerly thinking, design thinking refers to the application of design methods and tools in a business or social context. Beltagui (2018) and Elsbach and Stigliani (2018) described design thinking as thinking like a designer instead of being a designer in order to deal with complex problems. Design thinking can help non-designers, e.g. managers, to solve complex problems and innovate products, services or strategies by using design methods and tools (Bucolo & Matthews, 2010). The design attitude helps managers see each problem as an opportunity to improve the current situation, by questioning the underlying assumptions instead of solely solving specified problems by means of known analytical decision tools (Boland & Collopy, 2004). Further, design thinking is an interdisciplinary, systematic, user-oriented and innovative approach to problem-solving (Elsbach & Stigliani, 2018; Badke-Schaub et al., 2010). Various large-scale enterprises, such as Proctor & Gamble, KLM, SAP, Deutsche Telekom and Daimler have included design thinking in their processes for innovation development.

Brenner, Uebernickel and Abrell (2016) described three core elements of design thinking, namely design thinking process, methods and mindset. Although the sequence of different phases of design thinking process can vary, all known design thinking approaches follow a similar structure and logic, being interactive, agile, iterative and user-centered. Furthermore, all approaches make use of inductive, abductive and deductive thinking modes (Carlgren et al., 2014; Dunne & Martin, 2006). Further, design thinking approaches usually work implicitly with the design-driven Double-Diamond-Model, which reflects the sequence of divergent and convergent thinking over the design thinking process, as shown in Figure 1 (Kim & Ryu, 2014).

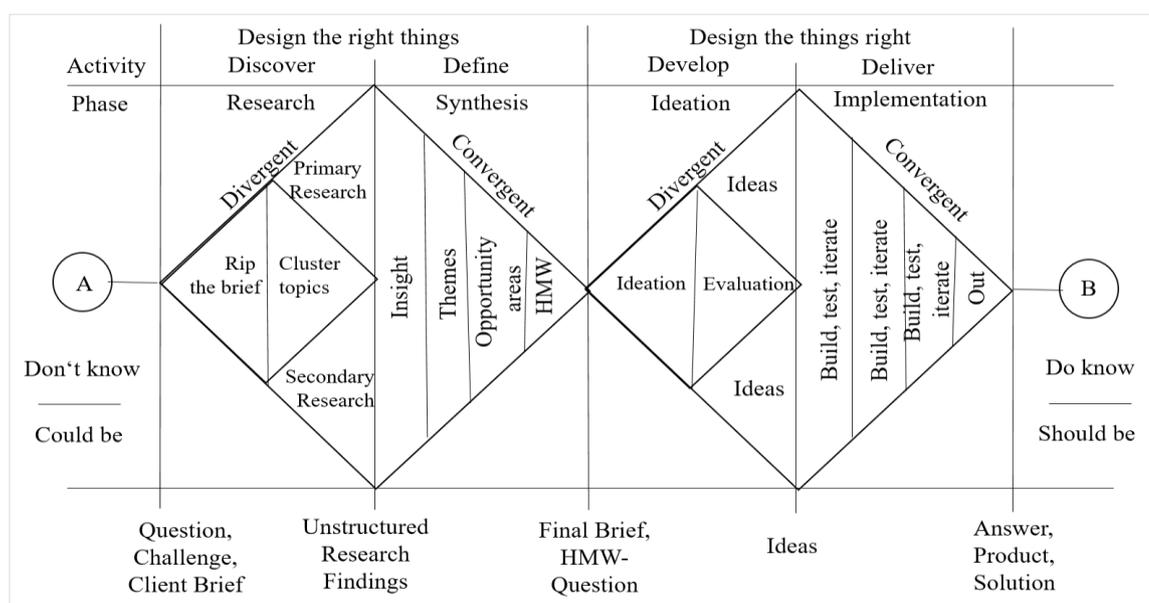


Figure 1: The Double-Diamond-Model (Source: Nessler, 2016)

Design thinking methods have their origin in various scientific disciplines and serve as parts of the design process. Finally, design thinking mindset represents the frame of design thinking process and is defined by open-mindedness, willingness to collaborate across disciplines, user-centeredness, being experiential and experimental, as well as inductive, deductive and abductive reasoning, among others (Redlich & Lattemann, 2019).

2. Current Researches about Design Thinking in Education

Martin said in an interview that *today's business people do not need to understand designers better; they need to become designers* (Dunne & Martin, 2006: p. 513). Hence, it is vital to prepare current students for solving wicked problems through application of design thinking in today's business world. The first design thinking courses in higher education started around 2005. Since then, many business schools around the world have introduced courses and programs with a focus on design, innovation and creativity (Heiman & Burnett, 2010; Melles et al., 2012). Many courses joint programs of design and business studies. The leading universities with design thinking programs are, for instance, the Rotman School of Management in Toronto and the d-school at Stanford University (Gloppen, 2009).

Many scholars see the necessity of not only an improved current education system but a paradigm shift in education (Norman, 2001). Teachers should become facilitators, the curriculum content should be closer to real-life, and visualization should be used to help understand and explain problems and solutions, with students expected to learn and decide more autonomously (Norman, 2001). This is particularly true when teaching creativity is concerned, rendering collaborative learning and learning-by-doing core elements of teaching creativity (Eagen et al., 2010; Rauth et al., 2010). Scheer, Noweski and Meinel state that design thinking education [...] *needs a transition from transferring knowledge to developing individual potentials with the help of constructivist learning* (Scheer et al., 2012: p.8). Additionally, business should be taught in form of projects, where students have to solve wicked problems together in a team, using abductive reasoning (Dunne & Martin, 2006).

Dall'Alba (2009) believed that becoming a professional in design was not confined to knowing about design thinking or acting out the gained knowledge. It was about truly being a professional (Adams et al., 2011; Dall'Alba, 2009). He developed a three-staged model, comprised of:

1. *Knowing*
2. *Doing*
3. *Being*

Before becoming a design thinker, the process and methods of design thinking — explicit knowledge— should be understood — knowing— and experienced — doing—. According to the SECI Model from the study by Nonaka and Takeushi (1995), this explicit knowledge can be acquired by the learners through a combination of different knowledge sources, e.g. via documents, lectures, seminars or databases. This is in line with the common instructional teaching modes at universities as well as the concept of *science of design* (Simon, 1969). However, it is also essential for design thinkers to embody what they are doing by adopting a design thinking mindset. Since the design thinking mindset is difficult to formalize, it is tacit knowledge, which can be acquired through learning-by-doing or shared experience, such as spending time together or living in the same environment. This is also supported by the SECI model, which says that tacit knowledge can be transferred by socialization or converted from explicit knowledge through internalization, a process that happens through learning-by-doing, experimentation or trial and error. Socialization occurs either through face-to-face sharing of knowledge or experiences (Nonaka & Takeushi, 1995). It typically takes place in a traditional apprenticeship, where apprentices learn the tacit knowledge needed in their craft through hands-on experience, rather than written manuals or textbooks. This is in line with the concept of reflection-in-action (Schön, 1984) that can be defined as a form of learning-by-doing. From Schön's perspective, professionals gain their knowledge by practicing and sharing and from experiencing challenging situations (Figure 2).

Type of Knowledge	Explicit Knowledge	Tacit Knowledge
Learning Process		
Elements of Design Thinking	Process, Methods (Brenner et al., 2016)	Mindset (Brenner et al., 2016)
Theoretical Foundation	Science of Design (Simon, 1969)	Reflection-in-Action (Schön, 1984)

Figure 2: The passage from knowing and doing towards being, through internalization and socialization

Based on the discussions above along with our framework, depicted in Figure 1, we put forward the following proposition;

- Proposition 1:* Teaching design thinking effectively requires a socialization approach, where non-designers learn from designers in a team, thus moving from the *doing* to the *being* stage.

However, in a scenario where the teaching team does not take part in the practical group work, which is the common instructional teaching modes at universities, a well-structured internalization process can also direct learners beyond the doing stage to think like designers. Since reflection-in-action is a form of learning and internalization happens through learning-by-doing experimentation, i.e., trial and error, the following proposition is also put forward:
- Proposition 2:* Teaching design thinking effectively can be conveyed through internalization, where non-designers learn from design thinking instructors without taking part in group work, to move from the *doing* to the *being* stages.

Empirical Research

The foundations of learning (Nonaka & Takeushi, 1995), the insights from design education (Schön, 1984; Simon, 1969) as well as different learning stages in design (Dall’Alba, 2009), combined with elements of design thinking, shape the very foundation of our experiment on how to teach design thinking effectively. The present research aims at testing whether internalization of design thinking knowledge — transferring explicit knowledge to implicit knowledge— is effective in design thinking education or if socialization — transferring implicit knowledge— is needed to educate design thinking, in particular the design thinking mindset.

Our experiment requires the development of artifacts based on the above-mentioned findings (Hevner et al., 2004). These are two specifically-designed, one-week courses on design thinking with a similar setting but different elements. One course was implemented as a dedicated design thinking course for non-design students at Jacobs University Bremen, Germany. The other involved a course for non-design students and design students on *innovation through design and entrepreneurship* in Risør, conducted by the University of Agder (UiA) as well as Oslo School of Architecture and Design (AHO), Norway. At Jacobs University, the course followed a combined mode of design science ideas (Simon, 1969) and reflection-in-action (Schön, 1984).

The facilitators of the course — professor and teaching assistants, being experts in design thinking— explained the course design tools and methods to the students each day, with the latter — the students— applying their newly-gained knowledge on real-life design challenges. Instructors coached students during their project work; though, they played no role as team/project members.

At the Pop-Up Campus in Risør, the course followed the idea of reflection-in-action (Schön, 1984), wherein design students acted as facilitators for business and engineering students to learn design methods and the design process. The engineering and business students acted as facilitators for the design students to learn about entrepreneurship. The professors, also acted as group coaches, helping the groups in difficult situations of their real-life projects. On a basic level, the coaches provided instructions on design thinking methods, process and mindset.

Table 1. Experimental setting, similarities and differences in the course settings

	RISØR Pop-Up Campus UiA & AHO	D-Forge Jacobs University Bremen
<i>No. of Students</i>	34	29
<i>Students' major</i>	15 design, 18 business, 1 engineer	10 business, 10 engineering, 2 economics, 4 computer sciences, 2 social sciences, 1 psychology
<i>Level</i>	Graduate	Undergraduate/Graduate
<i>Internationality</i>	Design and engineering Students: 100% domestic (Norwegian), Business Students: 50% domestic, 50% international	20% domestic (German), 80% international
<i>Schedule</i>	8 hours to open end per day 5.5 days 1 week	7 hours per day 5 days 1 week
<i>Preparation</i>	2.5 ECTS course on innovation for business and engineering students, no specific design thinking training	N/A
<i>Practical/ Experience Part</i>	<ul style="list-style-type: none"> ▪ 5 projects with challenges from local companies ▪ Companies introduced design challenges and assessed the projects' process 	<ul style="list-style-type: none"> ▪ 4 projects with challenges from local companies ▪ Companies introduced design challenges and assessed the projects' process
<i>Theoretical Part</i>	<ul style="list-style-type: none"> ▪ Two-hour introduction to design and design thinking ▪ Co-learning elements (students taught students) ▪ Reading list 	<ul style="list-style-type: none"> ▪ Two-hour theoretical introduction to design thinking ▪ Six 15-min. theoretical introduction to each design thinking phase ▪ Reading list
<i>Coaching/ Training Concept</i>	<ul style="list-style-type: none"> ▪ Reflection-in action ▪ Design students as facilitators for non-design students ▪ 3 permanently available instructors as coaches and facilitator (1 design thinking, 1 design, and 1 entrepreneurship professors) 	<ul style="list-style-type: none"> ▪ Science of design and reflection-in-action ▪ 1 instructor as coach (design thinking professor) ▪ Teaching assistants (educated in design thinking) as facilitator (one TA for two groups)
<i>Living and Working</i>	Students worked and lived together off campus in the rural city of Risør for 5 ½ days	Students lived on campus and worked together in the D-Forge

The design thinking course at Jacobs University took place in January 2019, with 35 hours spread over five days. The course took place in a co-working space, especially designed for design thinking trainings. 29 students from Jacobs University — with an international background— lived on campus, and came from different undergraduate and graduate backgrounds, including business, engineering, biochemistry, psychology, history and computer science. The design thinking course from the UiA and AHO took place in November 2018 in the small city and summer resort of Risør, located between Kristiansand — home to UiA— and Oslo — home to AHO—. 19 engineering and business students from UiA and 15 design students — product, service and interaction design— from AHO worked together. Students lived together in apartments and worked in a co-working space in the center of Risør. The set-up of the two courses were very similar. Both courses aimed at training design in a business context — design thinking— and letting students apply their newly gained knowledge to real-life projects.

Students with different academic backgrounds worked together in mixed groups of five or six on design thinking challenges, provided by local — Bremen— and regional — southern Norwegian— companies. Right from the beginning of the course, students got to know representatives from the companies and had the chance to visit the companies' offices on the second day of their courses. Over the week, the students followed the design thinking process and applied design methods. At the end of the courses, they presented their solutions and prototypes to the companies and following the end of the courses, they had to write designer's diaries.

In the Jacobs University course, the intended learning outcomes primarily involved design thinking. Students had to learn, understand and transfer the concept and elements — process and methods— of design thinking by working through the design thinking cycle. The course focused on design thinking mindset, such as concepts of user-centricity, empathy and testing in a new working culture. At the end of the course, the students should have been able to transfer the knowledge about design thinking in different situations.

In the Risør Pop-Up campus course, the intended learning outcomes focused primarily on design, design thinking and entrepreneurship. Students had to demonstrate their knowledge about the relation between design and entrepreneurship and were expected to assess the field of design management and how it relates to practical design cases. Furthermore, students had to develop business models for new ventures.

Data

Students from both Jacobs University and Risør Pop-Up Campus wrote reflection reports about one month after the courses, where they explained the projects they had worked on during the week, the methods they had used, and the outcome they had received. Additionally, students of UiA wrote a feedback report about their Risør Pop-Up Campus experiences. These anonymous feedbacks included their opinions about the course, the challenges they had faced, and the positive and negative aspects of the workshop.

Nine UiA students and 11 AHO students took part in a survey on the learning outcomes, conducted about one month after the Risør Pop-Up Campus course. All of them had to rate their experiences on a Five-Point Likert-Scale (Creswell, 2012). In addition, 10 Jacobs University students — two engineering, one psychology and seven business students— were interviewed on their course experience about one month after the course. The semi-structured interviews took about 30 minutes each and were finally anonymized, coded and transcribed. What is more, in order to evaluate the course outcomes, we referred to the information from the mandatory course evaluations.

Results

1. Feedback from Jacobs University Students

In general, all interviewees enjoyed the design thinking course. More specifically, out of the total 10 interviewed students, eight participants appreciated the practical experience. *I definitely prefer more practical experiences. So that it is not only about the practical experience within the project, but also the process of learning the techniques. It was good that from the very beginning, when we were introduced to a new technique, we could put ourselves into an [...] interactive environment to learn the tools. So that everyone could benefit from it and could get a deeper insight into the tool, rather than just read from the slides on what it is about. And then probably, people can better apply the tools to specific situations to solve the problems* (Student J(acobs)6). This quote well demonstrates that reflection-in-action helps students fully understand the design thinking methods by applying them in a real-life context, and making their own experiences with those working methods.

Although the balance between theory and practice was all right for the majority of the participants, five students mentioned that they would like to have more theory, but not necessarily in the form of a lecture. Additionally, 6 interviewees said that a booklet or handouts with more explained methods and tools would be useful to deepen their knowledge, look something up in unclear situations, or review concepts after the

course in case someone is interested in it. Moreover, one person suggested including technologies into the course, in order to support the prototyping process and integrate tech-savvy students into the course for creation of a co-learning atmosphere.

90% of the interviewees said that they gained new experience which was useful for their future way of problem-solving. This indicates that students were now more familiar with the design thinking process. 6 interviewed students mentioned that they learned how to think, the right direction towards adapting the design thinking mindset and becoming a professional. For example, one student mentioned: *I think the core is the divergent thinking [...] because we have always learned to think in a convergent way. So, I think it is really important to open up and collect as many ideas you possibly can, even though they don't necessarily make sense and cannot be implemented* (Student J1).

Additionally, the participants learned many new design thinking methods, such as empathy map, customer journey, persona and brainstorming techniques. The following quotation shows how the students experienced reflection-in-action, thus learning design thinking methods: *Because you can't really learn design thinking by reading, you learn it by doing, since you have to somehow [...] orient your brain to work in that way like thinking about the user orientation, creativity and innovation, all of which, I think, comes from doing and not just from reading* (Student J3). 90% of the interviewed students mentioned having understood the methods through learning-by-doing. Apart from learning-by-doing, the facilitators also helped the teams understand the different steps and tools. About two months after the course, 80% of the interviewees felt comfortable to apply their design thinking knowledge in the future for other projects and even in a job setting where the company is interested in using design thinking.

In general, the students expressed their improved creativity through the process and the methods they used. Moreover, they learned to deal with emotional ups and downs that can arise during a design thinking process. Additionally, one interviewee said that they improved their skills in interacting and understanding the people they were dealing with, i.e., both the team members and the customers. *The most valuable was to empathize with people who had problems, and then to figure out how to find solutions to it* (Student J7).

5 interviewees explained — though in different ways — that design thinking was a creative way of working and solving problems, where there was no right and wrong. It can help generate new, creative and innovative ideas that necessarily do not need to be logical in the first place. Furthermore, as one student said *it may not be the best solution, it may not be the perfect solution, but it is definitely the right direction into achieving the correct solution. [...] Even though there is no real correct solution in design thinking, which is the one that you feel most comfortable with and the one that suits you the best as the user* (Student J7).

50% of the interviewed Jacobs students answered that designers need to be open-minded and think out of the box. You need to *really open your mind towards different solutions and then narrow it back together in the end* (Student J1). There was one person who, when describing the meaning of design thinking, said: *Design thinking means, I guess what it says, [...] — thinking in the perspective of a designer* (Student J3). Three students defined design thinking as a user-oriented method, hence capturing another important element of the design thinking mindset. In addition to this, 90% of Jacobs students were describing the design thinking process and its methods by stating that the whole process is about learning-by-doing, which is supported by working in a creative environment. There was one interviewee who said: *I think we need to put [...] our mental design glasses on, and we need to rethink the way things have already been designed* (Student J7). 9 out of 10 students agreed on the fact that mixed and diverse teams, in terms of cultural and disciplinary background, had strong advantages for teamwork. These advantages are mainly the chance to learn something new, increase one's knowledge about other disciplines and share different opinions and insights on a topic, which is, in particular, useful in design thinking. For example, a student expressed: *for such a creative task it is important not to have students from one major, only. So, when it comes to product development or something, there is not only business there. There should be an engineer, at least* (Student J4).

These advantages show that one way to grasp tacit knowledge is co-learning, i.e., working together side-by-side to exchange ideas and opinions.

2. Feedback from UiA and AHO Students / Risør Pop-Up Campus

The feedback from the business and engineering students from Kristiansand was positive, with everyone enjoying the workshop. 60% of the students stated that they learned a lot from working in interdisciplinary teams, though it was not always easy. *As they say, the opposite pole attracts and plenty of knowledge can be learned from diversity* (Student R(isør)2). Moreover, by working alongside design students, they learned about the design process (e.g. double diamond model), got to know new methods (e.g. persona, customer journey) and had grasped the specific mindset, attached to design. In particular, 4 students were impressed by the ability of the designers to visualize complex aspects: *They are trained to visualize in every situation, if that is analyzing the problems or solutions. The work done by design students is very lively and it gives the feelings of indulgence when you vent out each idea in the big paper* (Student R2).

9 out of 15 business students in the Risør course wrote in their reports about having problems with teamwork, especially in the beginning. The interaction with design students was not always straightforward, which was mainly due to the different working styles and communication issues. These conflicts also affected the working atmosphere negatively. One student stated: *To be honest, at times we had conflicting ideas and very cold days to speak with one another* (Student R2). One major challenge, described by business students, was that in contrast to them, the designers did not want to use their methods: *[...] it seemed to me that the design students had less interest in including us in their work or participating in the work that was not about design* (Student R7). Some groups went through a negative experience from task division, where business, engineering and design students worked parallel with their own methods, without any interaction and collaboration. This was perceived as additional and unproductive work.

Six of 10 business and engineering UiA students in our sample wrote that they were able to learn from the Pop-Up Campus experience, in particular in respect to teamwork and collaboration. For example, one student expressed: *We realized soon that we should be better listeners and learn equally much from each other's methods and analysis* (Student R3). Another was able to assume a new role; in which they were cautious about everyone's contribution to the teamwork. The following quotation summarizes most of the learning outcomes of UiA students: *I have learned a lot about cross disciplinary work and I am now more aware of how other people approach a challenge and use dissimilar processes and methods. Next time, I will work in a team like this, and I will be much more prepared on how to deal with the situation* (Student R9).

The Risør Pop-Up Campus students were asked if their understanding of the disciplines, represented by students from the other school, had increased or not. 90% of the UiA students indicated — on a 5-Point-Likert-scale — that they strongly/very strongly enriched their understanding of the subject of design. As an example, student R6 expressed: *Design thinking is simply the use of designer tool kit to find new ideas and to discover innovative ways of solving problems*. In contrast, only 45% of the AHO students indicated — on a 5-Point-Likert-scale — that they very strongly/strongly broadened their understanding of business and engineering.

Student R6 wrote: *Personally, I got a whole new experience on how challenges can be solved through the design thinking process and through methods that I was not familiar with in advance*. This quote indicates that the students learned to deal with problems differently and less traditionally than they used to. Around 90% of the UiA students, but only 50% of the AHO students, rated that they gained new experiences about problem solving and value creation, relevant for future employers and clients.

The Risør Pop-Up Campus teams experienced challenges with different ways of working and communication. Only about 55% of UiA students and 35% of AHO students rated — on a Five-Point-Likert-scale — the experience of collaboration and knowledge exchange between the participants in the group as positive/very positive.

About 73% of AHO students perceived the Risør Pop-Up campus experience as personally useful, with 90% of UiA students responding to the Risør Pop-Up campus experience in a similar matter, rating it — on a Five-Point-Likert-Scale— as personally useful/very useful. Student R3 mentioned in the report that they already made use of the gained knowledge in their work life: *I have learned to use all efficient and exceptional working methods from the design students and already used several of the tools in my work as a junior consultant and in other classes at the university.*

Discussion

The Jacobs University D-Forge approach of teaching the design thinking process, methods and mindset was mainly based on knowledge internalization through application of learning-by-doing and experimenting in real-life projects. There, the coaches focused on an instructional teaching approach by presenting and explaining the design thinking process and selected design thinking methods. They were not directly involved in groups and project work, but helped students in critical stages to maneuver through the design thinking process. This teaching mode partly followed Simon's approach of science of design (1969), which assumed that design could be learned, as it comprised explicit knowledge (Nonaka and Takeushi, 1995) such as analytic, partly-formalizable, partly-empirical and teachable doctrines about design process. However, the teaching at Jacobs University also followed Schön's approach of reflection-in-action by working on real-life design challenges and projects.

In the D-Forge course, all students successfully gathered knowledge about design thinking process and methods. Furthermore, Jacobs students were also able to apply design thinking process and methods in real-life cases, thus reaching the objectives of knowing about and applying design thinking — knowing-and-doing stage in Dall'Alba's Model—.

60% of Jacobs students wished to have more theory included in the course, indicating that the students were still thinking in their traditional *business* way, i.e., having everything organized and fully explained instead of experiencing it by themselves and learning it by doing. In line with this observation, only about 60% of the students grasped the design thinking mindset (i.e., reaching the being-stage in Dall'Alba's Model), through experiencing design thinking in real-life projects. This shows that learning through internalization (Nonaka & Takeushi, 1995), i.e., transferring operational knowledge to tacit knowledge, was only partially successful. Our research results indicated that non-design students stopped at the knowing and doing stage (Dall'Alba, 2009), only grasping what was about being and thinking like a designer. Hence, we can only partially confirm Proposition 2, which says *Teaching design thinking effectively can be conveyed through internalization where non-designers learn from design thinking instructors to move from the doing towards the being stage.*

In contrast to the D-Forge approach, the UiA/AHO Risør Pop-Up Campus teaching approach relied mainly on socialization (Nonaka & Takeushi, 1995). This approach was based on sharing knowledge among design and non-design students, as well as learning-by-doing and experimentation (Schön, 1984). By applying design processes and methods in real-life projects in collaboration with design students, non-design students had the change to ingrain the underlying design thinking mindset. Over the course, the coaches (i.e., professors of design, design thinking and entrepreneurship) focused on helping students in critical situations through giving suggestions in relation to the application of creativity techniques and design methods.

Similar to the D-Forge course, all Risør students learned the process and methods of design thinking. Furthermore, they were also able to apply the process and methods in real-life cases, with their majority, capable of applying their knowledge without the help of teaching staff. About 90% of the engineering and business students from UiA grasped the design thinking mindset and expressed their willingness to use it in their future projects. Hence, most of Risør students went through all learning stages, namely, *knowing, doing and being* (Dall'Alba, 2009). This indicates that sharing and experiencing the design mindset with designers in real-life projects led to deeper learning of the tacit mindset.

Therefore, we can conclude that imparting tacit knowledge from design students to business and engineering students by socialization (Nonaka & Takeuchi, 1995) and learning-by-doing (Schön, 1984) is more successful than trying to internalize operational knowledge to tacit knowledge. These results can validate Proposition 1, which states that learning design thinking effectively requires a socialization approach.

Even though 73% of AHO students believed that Risør Pop-Up campus was useful for them, students from UiA seemed to gain more knowledge in design, followed by business, entrepreneurship and engineering. At the same time, designers claimed that their understanding of business, entrepreneurship and engineering had increased only slightly. However, the design students indicated that they quite often took over a mentor role, since they took the time to explain to their peers how they worked along with the methods they used. As a result, they managed to gain leadership and didactic skills, thus improving their social skills, in general. Moreover, design students indicated that they learned some business concepts such as the business model canvas or SWOT Analysis. Something, learned by all participants of the course, was to better interact and collaborate in a team with people from various disciplines.

There were some limitations to this study, in which we analyzed in-depths reports and interviews from only 30 of the 63 participating students. Even though we relied on a convenience sample, the sampling might be biased. Furthermore, the lengths of the two compared courses was a week only. Future studies might compare one-week courses with semester-long courses with different teaching modes to reach a broader data basis. Finally, only if a socialization approach is possible in a time-fragmented setting, is such a broad research capable of answering the question.

Conclusion

The key findings from our research are the following: Firstly, an internalization learning approach is crucial for imparting design thinking. To learn and experience design thinking reflection-in-action and working on real-life cases is helpful, if not needed. Secondly, to think like designers and embrace design thinking mindset, it is beneficial to follow a socialization approach, where non-designers learn from designers through close collaboration.

Existing design thinking courses vary in their orientation towards technology, design, business and science, in theory and practice, their experiential and interdisciplinary learning approaches, and their embeddedness in the local social and business communities.

Our research showed that design thinking can be conveyed in various ways, whose main elements include design thinking process, methods and the mindset. Through a traditional ex-cathedra teaching approach, including theoretical foundations, it is probably possible to teach the basics of design thinking. However, as one student expressed in our research: *You can't really learn design thinking by reading; you learn it by doing*. Hence, design thinking knowledge must be applied. The best way to do so is in the context of real-world business problems or in — real— social challenges. But a design thinking course should go beyond *knowing* and *doing* design thinking. Students should rather understand and absorb how designers think, including their way of abduction - as a mode of reasoning – along with their understanding of problems as a challenge, not a restriction. The closest a non-designer can achieve here is to grasp and perhaps even adopt a design thinking mindset. An appropriate way to impart this kind of intangible knowledge is via a socialization approach where non-designers learn collaboratively from designers. In a university setting, this can be supported by building teams of designers and non-designer, where the latter can learn design(erly) thinking directly from the former, and the former can, in exchange, learn other skills from the latter, e.g. they can learn management of engineering skills from management or engineering students. It also seems to support the learning process if students also spend time together outside the regular classes and if they live in the same environment. Our findings show that more research is needed to deal with the way one can properly teach design thinking in different settings and with different aims.

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