INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
6 & 7 SEPTEMBER 2018, DYSON SCHOOL OF DESIGN ENGINEERING, IMPERIAL COLLEGE, LONDON, UNITED KINGDOM

DT: WHAT DESIGNERS CAN LEARN FROM THE NON-DESIGNERS WHO TEACH IT

Farzaneh EFTEKHARI and Carolina GILL
North Carolina State University

ABSTRACT
By analyzing the content of Design Thinking (DT) courses and conducting in-depth interviews with DT instructors, this study explored tools and methods used in 16 design, non-design and interdisciplinary DT courses in 10 universities in United States. The goal was to discover strategies and tools from non-design educators that could be useful to design instructors. Based on the secondary research, the non-design instructors used DT tools for divergent strategies and integrated the business tools in DT process to facilitate the convergence strategies in DT courses.
Six in-depth interviews with DT instructors revealed a surprising cultural shift in non-design instructors' perception for the role and value of design knowledge. The level of appreciation for designer's mentorship and initiation of transdisciplinary collaboration among instructors was unexpected. Additionally, project-based learning was identified as a critical conduit of DT and transdisciplinary collaboration. The formulation of design challenges is a complex process that requires consideration of scope, complexity, roles, etc. DT facilitates true collaboration when the scope of the project is not too narrow that it predetermines the roles of the teams.
The growing appreciation and awareness for DT opens opportunities for designers as mentors outside the disciplines of design in universities and in the professional practice context. Case study was identified as one of the most critical components in DT courses regardless of the discipline. When the challenges are given by clients in a real-life non-product-focused context, the opportunities for collaboration among students increase as the siloed opinions diminish in the face of practical concurrence of disciplines.

Keywords: DT, cross disciplinary education, DT in non-design disciplines

1 INTRODUCTION

Many disciplines in higher education are increasingly adopting DT. DT is defined as the intersection of the design, business and engineering disciplines [2]. In the discipline-based environment of academia, adoption of DT by faculty of non-design disciplines such as business and engineering involves risks of repurposing knowledge from another discipline. DT introduces a different pedagogy that moves students beyond the acquisition of pure knowledge toward application of knowledge. DT introduces a holistic approach that encourages students to think across boundaries, thereby enabling real and fundamental innovations [14].
Although the integration of DT has introduced exciting potential for non-design academic programmes, studies have criticized the growth of DT in non-design and STEM disciplines as these DT practices are distanced from their origins, housed in non-design programmes, and mostly taught by non-design faculty [11]. However, after more than a decade of DT practice in academia, relatively little has been written about how DT has been adapted, and perhaps transformed to meet the specific needs of the various non-design disciplines. Could these adaptations be beneficial for designers as well?
Non-design instructors have been successful in highlighting the value of DT in their disciplines, and in integrating it into their curricula. The objective of this study was not to describe DT, but rather to identify for designers and design educators the opportunities that arise from the adaptations of the DT approach in non-design disciplines. The methodology of this study included semi-structured interviews, designed to encourage open discussion and gather unanticipated findings. This study investigated the benefits of DT knowledge transfer across different disciplines.

2 METHODS

To study the DT status in the practical setting across disciplines in academia, this study first reviewed either syllabi or on-line course descriptions of 16 courses in 11 universities in the United States (Table 1). In the Google search engine, we searched for three key words: DT, course and the name of different academic institutions in the United States. The 6 out of 11 academic institutes were selected randomly from the list of top twenty universities in the United States. Because of the limited information in course syllabi, qualitative in-depth interviews were conducted with design, business and engineering faculty. The other 5 out of 11 academic institutes were added based on the interviewee's universities. In this study a total of 16 courses were reviewed that either included DT in the course title or as a topic session in the syllabi.

Table 1. Sample of the courses with design thinking in the title or reference topic

	Academic Institute	Title of the Course
1	Harvard Business School	DT and innovation
2	Harvard Business School	DT
3	Stanford Graduate School of Business	Designing Creative Organizations
4	Sloan Business School	Product Design and Development
5	McCormick School of Engineering	DT & Communication
6	Kellogg School of Management	New Venture Discovery
7	Haas Business School	Collaborative innovation
8	Haas Business School	Innovation & Entrepreneurship, from DT to Funding
9	Ohio State University, College of Engineering	Fundamentals of Product Design Engineering
10	Ritchie School of Engineering & Computer Science	Creativity & Entrepreneurship, Living &Learning Community
11	Ritchie School of Engineering & Computer Science	Product Development and Market Feasibility
12	Poole College of Management	Experience Innovation and Strategic Design
13	Poole College of Management	Product and Brand Management
14	Tepper School Of Business	Introduction to DT & Practice
15	Tepper School Of Business	MA Seminar I: DT
16	Kenan-Flagler Business School	Innovation & DT

The purpose of in-depth interviews was to understand if non-design instructors integrated any type of business and engineering tools into the DT process. The six interviews with DT instructors were the secondary data collection through purposeful and referral sampling strategy and they were conducted with two design, two business and two engineering instructors. Purposeful sampling is relevant because individuals are selected based on their experience of the central phenomenon (Creswell, John, 2013). Data from interviews was collected from a limited number of instructors and from four academic institutes in the United States and results were developed based on the most common perspectives, thoughts and suggestions by the instructors. This study is intended to continue collection of data from a larger cohort of instructors to validate our findings. The semi-structured in-depth interviews in this study design provided an opportunity to explore findings and insights beyond the proposed research question.

3 DESIGN THINKING AS A PLATFORM FOR KNOWLEDGE TRANSFER

Deduction, induction and abduction are the key factors of reasoning. The DT approach offers a great potential for abductive reasoning (Dorst, 2011) and approaching complex problems. Abductive reasoning should encompass creative steps of both inductive and deductive reasoning. However, the majority of methods and processes of design involve a style of thinking characterized by synthesis, inductive reasoning and divergent thinking (Norman, Klemmer, 2014). In analyzing the content of course syllabi, a common pattern was the integration of design thinking in some sessions of the existing business and engineering courses as a design tool to fill the gap and encourage divergent thinking, empathy and human-centred design. Prototyping also has been seen as a design tool for exploration and interaction. In addition to terms such as "creativity," "innovation," "prototyping," "human-centred design," and "problem solving," this study uncovered other important associated terms with design thinking in the 16 DT courses. Looking at Figure 1, terms such as "entrepreneurship," "new venture," and "business model" were repeated considerably. DT in business courses seems more relevant in the early stage of idea generation, new venture creation and in entrepreneurial approaches. It is important to note that DT was as a supplement with the existing business and engineering tools. However, business and engineering instructors attributed the most benefit from DT in the initial stages of product and service development, rather than a model for the whole product development process. Other models such as StageGate were mentioned by interviewees as complementary materials for teaching DT in business programmes. One of the business instructors mentioned, "The *StageGate process starts with discovery, brainstorming and it misses out the first stage [of DT] which is journey mapping. StageGate also does not include prototyping. That's why I use Darden's [Business School] DT model because it has stages that align with StageGate."*

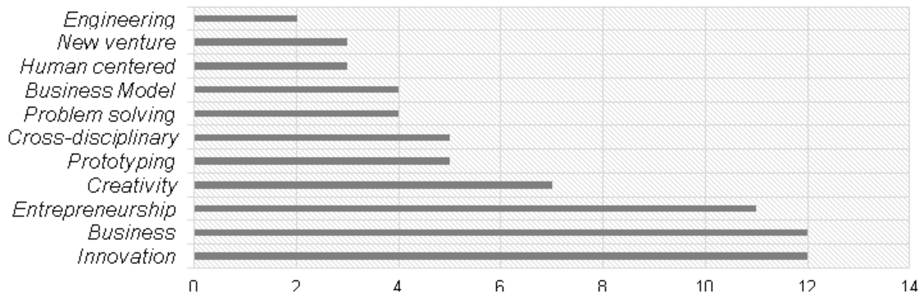

Figure 1. Important terms associated with DT in the sampled DT courses: content analysis and word counting

In addition to the StageGate model, other business tools and concepts were reported as especially relevant for teaching the DT process, including value proposition, lean start-up, business canvas, and cost analysis. These findings suggest that designers could learn and benefit from analyzing how engineering and business professionals have identified and creatively addressed the gaps in the DT process and educational materials.

Noble and Durmusoglu [9] compared the Lean Canvas model with the original and most popular business model canvas by Osterwalder and Pigneur [12]. They explained how Lean Canvas could embed the complexity and uncertainty of human behaviour in the canvas model, to offer a flexible method for the DT process. In lean start-up, research teams learn to develop minimum viable prototypes (MVP) and engage in agile development cycles and iterative process until a viable business strategy emerges and is converted into customer value [9]. This process encourages researchers to build customer empathy. This reiterative process of transformation and adaptation of the DT process to various courses in non-design disciplines adds utility to these materials in DT disciplines.

The non-design instructors in this study primarily used DT tools for teaching a limited number of sessions in product design/development courses, with business and engineering tools as key components in DT process. This finding suggests a distinction between the broad scope of DT theory and the limited design-oriented DT tools to respond to practical projects' demands. DT courses in business and engineering departments have benefited from the convergent application of design tools with engineering and business tools. For instance, Lean Canvas, value proposition, lean start-up, business canvas, StageGate model and cost analysis have been integrated into the DT process by business instructors. This study suggests that design disciplines could benefit immensely from further integration and exchange of DT materials with non-DT disciplines.

4 DESIGN THINKING AND NEW PERCEPTION TOWARDS DESIGN

4.1 Welcoming another discipline's priorities in the product design process

One of the important contributions of DT courses is creating a tolerance and mutual understanding of each disciplines' role in multi-dimensional and complex cases. One of the interviewees suggested that DT helps *"business and design to see eye-to-eye and to understand each other better. This is might be more of a cultural shift: How business values innovation and how design values businesses."* The new perception created a greater interest from design, business and engineering for initiating transdisciplinary education.

One of the instructors shared her interesting experience of teaching in an integrative product design course. She said, when she decided to teach the course offered simultaneously in the design, business and engineering programmes, "*The professors were totally on board. They believed that the course would be great for students.*" However, in reality they encountered a significant challenge and cultural shock in the cross-registered course. The instructor reflected, "*The people who hated the course were the students.* "There *was always this tension that [business students wanted to] write the business plan and quickly jump to the solution, … while designers wanted to do brainstorming. This [integration and collaboration between disciplines] was a lot more painful for students than for the professors."*

The tension was, in fact, between two systems of thinking: the divergent and convergent approach. The instructor continued, "*This does not mean that we don't need to teach a course like that. The whole benefit is to understand other people's priorities*." Students were not ready for the collaboration with students from other disciplines. Interestingly, this same instructor suggested that "*DT courses might help to reduce this culture shock a little bit.*"

One might question how this cultural shift in perception occurred? Based on literature, DT is a model of the constructivism paradigm [3], which emphasizes interdisciplinary collaboration that encourages students to explore problems in a real-world context [8]. DT can create a shared language for instructors and a mutual understanding of the broader product/service design process across disciplines. A business instructor who taught DT for around 10 years explained that, "*Now that we introduce [DT] prototyping [in business courses], we force [business] students to think more like a designer and more like an engineer.*" He continued, "*I never heard that they see themselves as better than engineers or designers, but definitely it creates empathy with the role of designers and engineers for business students.*" Our interviews and review of the literature suggested that the principle and bottom line of DT is that it encourages cross-disciplinary education. This collaboration encourages students to think about the priority and contribution of each other's discipline in the product/service design process.

4.2 Teaching DT and the Importance of the Mentors

A business instructor stated, *"My experience of teaching DT started with d-school's lectures or exercises" [d-school is a model of DT at Stanford].* At first, she showed d-school lectures in her courses. But the moment that she dedicated herself to teaching DT, she explained, *"I took online DT courses from Darden Business School in order to be able to teach it. I changed the exercises and cases that I use in the class. I like Darden's approach to DT because it has steps that are very easy to explain in the classroom*." It is interesting that some of the schools such as Darden Business School transformed, adapted and structured the DT concept into a classroom-friendly model for business instructors. This instructor further explained that "*The Darden model is more business-oriented than d-school.*" To teach DT in classroom, many of the business and engineering instructors in this study used a type of mentor.

Besides taking on-line courses, non-design instructors asked a design educator to play the role of mentor. Although the data of the current study was gathered from a limited number of instructors, the interest shown by non-design departments to initiate collaboration with design faculty in DT practices was considerable. For instance, based on the interviews, one industrial designer was recruited by an engineering department to direct an innovation space in cross disciplines. He reported that his friend, an industrial designer, also accepted a position at a business school as a design thinker. A third designer was contacted by a business department to provide advice or perhaps to develop a DT course for the business programme. A business instructor in one interview explained that she plans to initiate a joint course with design faculty in their institute. Also, as mentioned, an engineering instructor named a design educator as his mentor in his course. Future studies might explore if DT has the potential to create new job opportunities for industrial designers, and, whether design programmes should invest in training industrial designers for such positions?

The outcome of our interviews suggested a highly supportive environment for cross-disciplinary activities among DT instructors. In fact, the distance of design knowledge from its origin and the practice of DT in non-design courses seems not to "erode the quality of and appreciation for what trained designers do," [11] but rather to promote willingness for collaboration and the mutually-beneficial exchange of knowledge.

5 CASE BASED LEARNING AND TRANSDISCIPLINARY SKILLS

Traditionally, education has focused on the scientific perspective of breaking down complex real-life phenomena into little parts, isolating problems to be approached by a small set of disciplines [18]. This isolated scope of educational projects often lacks context and humanitarian information that would otherwise connect students to the real-life context [18]. Real world problems are complex, messy, and do not respect disciplinary boundaries [4]. Therefore, the biggest change in implementing a DT approach centred on the types of problem that educators encountered, which often seemed far afield from traditional problems in their disciplines [3].

The field of education appears to have welcomed integrative thinking to help educators to teach the team-oriented skills needed in the 21st century. Educators should plan to teach such skills to students and use new methods that facilitate integrative thinking and learning at the course level. Buchbinder and his colleague [4] reviewed many studies (e.g. [16], [17], [19]) and they summarized that "almost simultaneously with these calls for interdisciplinary collaboration, educators have expressed increased interest in the use of problem-based learning and, in particular, the case study method" [4] to enhance integrative thinking.

The instructors in our interviews introduced a similar strategy for teaching complex and multi-dimensional problems to students. In a more in-depth conversation, a design instructor explained that, "*The difference between design and DT has been the application of design methods to the problems that were not traditionally associated with design.*" For instance, he cited socio-culturally complex problems such as healthcare, environmental issues, and public policy. Students in DT courses are trying to address these complicated problems.

An engineering instructor said, "*The cases should be presented in different contexts, with different personas and broader stakeholders; or in summary, a complex problem that encourages students to think outside their own heads.*" An industrial design instructor described his experience in the cross-registered product design course in a mechanical engineering department: "*The cases are, importantly, in the real-life context.*" He continued, "*If a client from a real company presents a case for students, they become much interested and excited to collaborate in the team and solve the problem.*"

Our results confirmed that case study is the conduit that instructors used in their courses to create an environment of collaboration and transdisciplinary education. Traditionally, disciplines used cases but in closed-ended scenarios in which the instructor was an expert in the content [6]. In DT, however, the instructor is "an expert on the process and the scenario is used as conduit to discover how the 'process' can lead to innovation" [6].

The interviews suggested that students focused less on their disciplinary silos in the DT approach to a complex real-world problem. This contrasts with a challenge centred on the development of an innovative product, where students typically default to their defined roles: the designer makes it pretty, the engineer figures out the technical aspects and the business student analyzes the market. Real world challenges that involve multiple stakeholders and partners from the corporate and non-profit sectors challenge students to become adaptive and not rely on their disciplinary methods. As we observed in our study, a multidisciplinary approach to complex cases in cross-registered DT courses can "bridge between disciplinary boundaries and establish new forms of logic flow from this greater understanding of who has what skills, the answers they need, and how best to communicate with practitioners of those various disciplines." [20].

6 CONCLUSION

The majority of efforts to integrate DT knowledge in non-design disciplines has been through individual courses, and efforts to connect design with business and engineering programmes has been "almost entirely practitioner wisdom" [10]. Notably, the inclusion of DT in engineering and business curricula has not been a transient phenomenon, but rather, DT has been taught for over a decade in many academic institutions. We hypothesized that the growing interest in DT among non-design disciplines may have had important benefits in academia that are worth considering.

The description of DT tools in the literature has often been contextualized solely by the designer's way of thinking and method of problem solving. The design discipline "needs better tools and methods, more theory, more analytical techniques," as stated by Norman and Klemmer [10]. DT courses can be a platform for knowledge transfer to integrate relevant design, business and engineering tools for the product design process. As explained in Lean Canvas, each particular discipline's tools can be adapted for the benefit of all stakeholders. We submit that the design discipline can benefit from multidisciplinary instructional approaches developed in non-design DT courses. Business and engineering tools can facilitate and cause the advancement of the DT process, specifically in convergent thinking and deductive reasoning.

The interviews in this study revealed that DT has led to a cultural shift in business and engineering perceptions towards design knowledge, and therefore, has created an especially conducive

environment for transdisciplinary collaboration. The practices of non-design instructors studied here offer practical examples of transdisciplinary efforts in academia, in which the knowledge of one discipline has been invited and integrated into the knowledge of another discipline. In fact, DT courses bring together learners across different disciplines and create positive perceptions, provide a shared problem-solving framework, and foster inter-cluster collaboration between the parties [13]. This approach increases the acquisition of knowledge by all individuals within the cluster [13].
Case-based learning was identified as a collective technique across disciplines for teaching the DT approach to tackling complex real world problems. The instructors we interviewed experienced that real-life non-product-focused cases greatly enhanced transdisciplinary collaboration. They observed that, as cases became more complex with different stakeholders, students grew more attentive to bridging the disciplinary boundaries and seeking an innovative approach as a team.
To increase the number of reviewed DT courses and interviews, this study is intended to continue collection of data from a larger number of instructors in the future.

REFERENCES

[1] Beckman, S. L., & Barry, M. (2007). Innovation as a learning process: Embedding DT. *California management review*, *50*(1), 25-56.
[2] Brown, T. (2008). DT. *Harvard business review*, *86*(6), 84.
[3] Brown, T., & Wyatt, J. (2015). DT for social innovation. *Annual Review of Policy Design*, *3*(1), 1-10.
[4] Buchbinder, S. B., Alt, P. M., Eskow, K., Forbes, W., Hester, E., Struck, M., & Taylor, D. (2005). Creating learning prisms with an interdisciplinary case study workshop. *Innovative Higher Education*, *29*(4), 257-274.
[5] Dorst, K. (2011). The core of ‘DT’ and its application. *Design studies*, *32*(6), 521-532.
[6] Gill, C., & Graell, M. (2016). Teaching DT: evolution of a teaching collaboration across disciplinary, academic and cultural boundaries. In *DS 83: Proceedings of the 18th International Conference on Engineering and Product Design Education (E&PDE16), Design Education: Collaboration and Cross-Disciplinarily, Aalborg, Denmark, 8th-9th September 2016*.
[7] Griffin, A., & Hauser, J. R. (1993). The voice of the customer. *Marketing science*, *12*(1), 1-27.
[8] Luchs, M. G., Griffin, A., Noble, C. H., Swan, S., & Durmusoglu, S. S. (2015). *DT: new product development essentials from the PDMA*. John Wiley & Sons.
[9] Noble, C. H., & Durmusoglu, S. S. (2015). *DT: new product development essentials from the PDMA*. John Wiley & Sons.
[10] Norman, D., & Klemmer, S. (2014). State of design: How design education must change. *Linkedin, Donald Norman. Pieejams: https://www.linkedin.com/today/post/article/20140325102438-12181762-state-of-design-how-design-education-must-change Skatīts*, *10*, 2015.
[11] Ogilvie, T., & Liedtka, J. (2011*). Designing for growth: A DT toolkit for managers.* Columbia University Press.
[12] Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons.
[13] Pinch, S., Henry, N., Jenkins, M., & Tallman, S. (2003). From ‘industrial districts’ to ‘knowledge clusters’: a model of knowledge dissemination and competitive advantage in industrial agglomerations. *Journal of economic geography*, *3*(4), 373-388.
[14] Plattner, H., Meinel, C., & Leifer, L. (Eds.). (2015). *DT research: making DT foundational.* Springer.
[15] Rotherham, A. J., & Willingham, D. T. (2010). “21st-century” skills. *American Educator*, 17
[16] Sarkisian, E. (1993). Case discussions on teaching. *Change*, *25*(6), 42–43.
[17] Syke, G., & Bird., T. (1992). Teacher education and the case idea. *Review of Research in Education*, *18,* 457–521.
[18] Scheer, A., Noweski, C., & Meinel, C. (2012). Transforming constructivist learning into action: DT in education. *Design and Technology Education*, 17(3), 8-19.
[19] Wasserman, S. (1994). *Introduction to case method teaching: A guide to the galaxy*. New York, NY: Teachers College Press.
[20] Welsh, M. A., & Dehler, G. E. (2013). Combining critical reflection and DT to develop integrative learners. *Journal of Management Education*, *37*(6), 771-802.