Track 01: Design Thinking to Improve Creative Problem Solving

From Kindergarten to Higher Education

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As educators increasingly adopt design-based methods outside of design disciplines, we wondered about the impact of incorporating these approaches on students' and teachers' educative experiences. This track includes eleven articles that explore how children, youth, and teachers in schools and universities have taken up design thinking and other design-based models. The track also offers two design-based teaching models presented as workshops. In the following text, we present arguments that justify the incorporation of design in general education –both at the school and university level–, synthesize some empirical evidence from the scientific literature, present the contributions gathered in our track, and offer some questions to guide future research.

Keywords: design thinking, design-based teaching and learning, general education

According to the Nobel Laureate in Economics Herbert Simon (1996), when any professionals carry out actions tending to change existing situations into preferred ones, they are involved in design. In this sense, design would be the core of all professional training and the element that distinguishes the professions and the sciences. In the same line, Donald Schön (1983) suggested that despite the differences between the various professional activities, there is a generic process underlying all professions that deal with solving complex problems. For him, activities such as architecture (and, of course, design) could serve as a prototype for other professionals to develop problem-framing skills. Perhaps this would explain the proliferation of methods and tools based on design applied to professional areas such as business, management, healthcare, and education. During the last decade, design has gained popularity to address complex problems and foster innovation in different contexts, including general educational settings. In fact, a growing number of academic and professional publications have reported diverse experiences where design-based methods and tools are used to address pedagogical issues, both at the K-12 (Gallagher & Thordarson, 2018; Goldman & Kabayadondo, 2017; Koh et al., 2015; McIntosh, 2016) and the higher education levels (Dunne & Martin, 2006; Hassi & Laakso, 2011; Martin & Martin, 2009; McLaughlan & Lodge, 2019; Revano & Garcia, 2020; Vaugh et al., 2020). Some examples of design-based methods are Design Thinking for Educators toolkit (IDEO, 2012), Design for Change (Allende, 2016; Design for Change, 2017), The Compass (Stenlev & Boegeskov, 2016), and FabLab Teacher Studio (Watson, 2015). At the higher education level, the Open University's distance Design Thinking (U101) course stands out since 2010 aimed at students of different ages and professional and educational backgrounds (Lloyd & Jones, 2013).

To better understand the enthusiasm that design provokes in general education, it is worth recalling what Nigel Cross pointed out in 1982, many years before these models attempted to replicate inside schools the way designers, engineers, and architects think and solve complex problems. In his paper entitled "Designerly ways of knowing", Cross advocated for incorporating design into general education together with sciences and humanities, arguing that design develops innate abilities in solving ill-defined problems, sustains concrete and visual modes of cognition, and offers opportunities for developing a wide range of nonverbal thoughts and communication abilities. In the same way, the Open University began offering courses on design in 1975

seeking to teach students about design and the design process as a general phenomenon, but not as a profession (Lloyd, 2013). More than thirty years after Cross' article, the interest in incorporating design into general education remained, but the expectations widened by including a critical and sustainable approach. The DRS // Cumulus Conference in 2013 at Oslo promoted the cooperation between designers and the general public as a precondition to building a better and greener tomorrow and fostered teaching a critical design approach among consumers, producers, and decision-makers (Nielsen, 2013).

Design-based teaching and learning in school settings

Nowadays, design-based learning has been described as a learning-by-doing methodology that enables students to integrate knowledge from different areas through problem-solving. It is used both in technology-related subjects –such as STEM, informatics, and Maker education– and in other areas of the curriculum. It aims to develop both thinking skills –such as problem-solving, inquiry, and creativity– and socio-emotional skills –such as empathy, collaboration, self-efficacy, and frustration tolerance– by embracing 'failure' as part of the learning experience (Carroll et al., 2010; Carroll, 2015; Davis, 2004, 2017; Retna, 2016; Woo et al., 2017; Zupan et al., 2018). According to Goldman and Kabayadondo (2017), it has the power to flip students' mindsets from passive and tentative toward active and decisive.

In school settings, design thinking can operate both as a methodology to ground students' learning and help teachers think through issues of practice. According to Goodyear (2015), unlike the classical instructional design, which focuses on optimizing instruction for a single or simple objective, the design for learning approach is characterized by broadening the understanding of the problem to see it as a symptom of a larger issue. At the initial teacher training level, Jordan (2016) has suggested that a design-based approach enables teachers to be more flexible, adaptive, and open to exploring. At the same time, Henriksen (2017) has observed that design thinking provides an accessible structure that enables school teachers to creatively face the great variety of problems that they must solve daily. In the same way, Goldman and collaborators (2020) have observed that using tools based on design thinking helps educators to think holistically about the special educational needs of their students. Also, at the school level, but from an organizational perspective, Mintrop, Órdenes, and Madero (2018) suggest that design-based approaches have the virtue of integrating improvement dynamics from outside the school –such as new education policies– with school improvement initiatives coming from teachers and school leaders. For them, design-based school improvement follows the logic of continuous enhancement.

The following two articles present experiences in a school context, while the third refers to a teacher professional development program for inclusive education at schools. All of them feature student learning needs as both the starting and ending point in a productive design thinking process. In addition, all three suggest that instructional designers –whether young people, teachers, curriculum developers, or teachers in training– can leverage the design thinking process to deepen learners' knowledge and skills.

The first paper, entitled **"End Users in Students' Participatory Design Process"** by Noora Bosch, Tellervo Härkki, and Pirita Seitamaa-Hakkarainen, offers fascinating insights into how young designers (ages 14 and 15 years old female students from a public secondary school) took stock of their end-users' (16 kindergarten students and their two teachers at a nearby elementary school) wishes and needs as they developed a specific product for them. Over a three-month period, the teen designers from two teams designed, prototyped, and tested their ideas for e-textile creations. The researchers' captured how the teen designers determined and acted upon their end-users' requirements. Specifically, they asked, "What kind of end-user-related design discussions did the students have?" And, "In which way are the end-users or their stated needs, wishes, and feedback acknowledged in the final design products?" The researchers documented design discussions related to various functional, technical, and visual/aesthetic features, and traced back many features and solutions (both concrete & abstract) of the final products to the users' stated and/or presumed needs. The researchers conclude that the concrete direct contact that the teen designers had with their kindergarten clients was instrumental in both the process and the product outcomes, and they encourage further research documenting student development of design skills such as empathy, creativity, communication, and collaboration.

The second contribution, **"Integrating Design Thinking into STEAM Education: The Design of STEAM Education Platform and Course Based on Creativity Elements"** by Xuejiao Yin, Shumeng Hou, and Qingxuan Chen, addresses the knowledge and skills that students might develop through design thinking-based learning platforms. This paper presents evidence that design thinking promotes deep and meaningful learning for students, and three dimensions of creativity in particular – curiosity, flexibility, and risk-taking – which the authors link to positive learning outcomes. One hundred fifty-one school-age children (10–12 years old) from

Shenzhen, China participated in the study which involved engaging in several online Science, Technology, Engineering, Art and Mathematics (STEAM) instructional modules (based on the Design for Change model) and a battery of assessments to measure student creativity, self-efficacy, and academic performance. This study has important implications for ways young people might effectively learn particular anchor skills related to design thinking. Furthermore, this study suggests that the integration of STEAM education and design thinking could push on the traditional ways we conceive of and represent knowledge and skills.

The third offering, Úrsula Bravo and Maritza Rivera's paper, **"Inclusive education driven by design: The case of a graduate seminar course"**, is a rich qualitative case study describing how the course's driving question, "How can a design-based approach contribute to the development of strategies for inclusive education?" played out with educators and their focus students. Thirty-five educators in their last year of a master's degree focused on inclusive education participated in the study, and the researchers selected three specific examples to illustrate how the interdisciplinary design thinking approach to frame and address students' special learning needs unfolded through the use of various design tools. This study shows how teachers might tackle a wide variety of complex problems through a design process that puts the student and their learning needs at the center and relies on educators as active agents capable of visualizing, supporting, and reflecting on a learning process that will benefit the student in a particular context.

Design-based teaching and learning in Higher Education

At the higher education level Meredith Davis (1998, 2004, 2017) has demonstrated the value that design-based teaching and learning practices have to promote critical and creative thinking, as well as many other "twenty-first century skills" (e.g., problem-solving, communication, collaboration) essential to tackling the large, complex, and systemic challenges facing humanity. Additionally, Davis has shown that educators in different fields, "when presented with concrete [design-based] teaching strategies, can adapt design approaches to disciplinary content to achieve the· higher-order thinking skills demanded by a knowledge economy" (2017, p. 169). Expanding the scope of skills developed through design-based learning, Goldman and colleagues (2012), have proposed that adult learners, as they become design thinkers, change their behaviour and mental structures in four distinct ways (what the authors call "Design Thinking Mindshifts"): learners become "human-centered, experimental, collaborative, and metacognitive" (p. 30).

Design-based teaching and learning at general professional training

The following four articles explore and expand on ideas from the literature on design-based teaching and learning and contribute to our track through a series of reflections, empirical studies, and innovations in the classroom. In particular, these articles explore the integration of Human-Centered Design approaches in higher education courses; study the use of design thinking methods to promote effective and meaningful learning; investigate the concept of "grit" and how to promote it in the academic design studio; and propose new design-based approaches to higher education to equip students with the skills, knowledge, and perspectives to thrive in a volatile, uncertain, complex, and ambiguous world.

In the paper **"Measuring the Impact of Integrating Human-Centered Design in Existing Higher Education Courses"**, the authors Saadeddine Shehab and Carol Guo introduce and discuss a survey intended to measure the impact of integrating Human-Centered Design (HCD) on students' knowledge of performing the HCD processes. By presenting this survey, the authors intend to promote the integration of Human-Centered Design in higher education courses by providing an effective tool to measure the impact of these interventions on students' skills and knowledge. By pursuing this goal, Shehab and Guo make an important contribution to our track, which is intended to improve our understanding of the impact of incorporating design thinking and design-based practices on students' learning experiences.

The following contribution is from Juan Li, Shuo-Fang Liu, Meng-xun Ho, and Zhe Li. Their paper is entitled: **"Assessing Learning Performance and Using Preference of Design Thinking Methods in Graduate Interdisciplinary Online Course"**. Juan Li and colleagues explore the application of four widely used design methods in an interdisciplinary online course for graduate students from two prominent universities in China and Japan. The methods implemented in different moments of the course and studied by the authors include Brainstorming, Crazy8, User Journey Mapping, and Storyboarding. Through a series of quantitative analyses, the authors find that Brainstorming and Storyboarding improve students' learning performance in the analyzed educational context. In conclusion, the authors suggest that applying some design thinking methods in graduate interdisciplinary online courses is feasible and promotes effective learning practices. In their paper, Juan Li and colleagues contribute to our track by addressing a question that explores the experience of educators, that is, "which design-based teaching methods have been most effective for teachers, in what areas

of the curriculum, and at what educational levels?"

The paper submitted by Zhengping Liow is entitled **"I Can and I Will: A Study of 'Grit' in a Collaborative Team Learning Studio Pedagogical Cultures"**. This paper explores the concept of 'grit' (passion and perseverance for long-term goals) as a predictor for academic success in an architecture program. The paper presents a three-year longitudinal study comparing the capacity to instill grit of two different pedagogical approaches. The study compared the students' level of grit in two groups exposed to CTL (Collaborative Team Learning, considered a heterarchical pedagogy) and to OOO (One-on-One, considered an authoritarian pedagogy). Through a series of statistical analyses, the researchers determined that there was little correlation between students' level of grit with academic scores and the two pedagogical approaches implemented. To conclude, the author discusses potential causes for obtaining these results, emphasizes the problematic nature of tutor-centered practices in design education, and highlights the importance of continuing the study of heterarchical pedagogies from both a qualitative and a quantitative approach. Even though the scope of this paper goes beyond the questions posed for our track, it investigates the construct of grit and has received limited attention in design education. Additionally, the article poses very interesting, pertinent, and timely questions and reflections about design pedagogies in the face of an ever-changing world and an increasingly uncertain future.

Kirsten Bonde Sørensen provides a paper entitled **"Nordic Life Design: A holistic approach and attitude to life"**. The article discusses the need for new and more holistic approaches to higher education in the face of the challenges posed to newer generations of students by a complex reality and by increasing mental health issues. Specifically, the author presents and describes the Nordic Life Design as a "learning concept that aims at helping and empowering students to become better prepared for a complex, ambiguous and ever-changing world... [and] at enlarging students' perspectives and relationships to others and to themselves." According to the author, at the core of this concept lies the idea that students need both life mastery skills and concrete knowledge to deal with the VUCA world (an acronym describing the world as Volatile, Uncertain, Complex, and Ambiguous), and that life is a creative learning process that can be designed and co-designed by people. The author illustrates and exemplifies this concept with a series of educational experiences in which the Nordic Life Design was implemented and in which the reactions and opinions of students were collected. In conclusion, Sørensen offers a series of recommendations and invitations for educators to expand the scope of their curricula so that they offer students the skills they need to thrive in an ever-changing world.

Design disciplines professional training

Particularly in professional training related to creative and project-based disciplines, the design thinking approach has contributed to enrich each of the phases and deepen the development of a problem-solving mentality. The following four articles present research on fundamental aspects of the design process and tools that can be applied to enhance creative problem-solving. The main topics addressed are: generating iterative ideation through a Creative Problem-Solving Course, using morphological analysis to assess products, applying a specific design model to guide students to address both consumers and the enterprise during their design processes, and using a design model based on Bloom's Taxonomy to keep the product's inherent characteristics and users' demands present while designing.

The paper **"Different Ideas, Lots of Ideas: A design course that enhances the creative abilities of college students"**, written by Jody Nyboer and Brad Hokanson, frames the concept of creativity through relevant and up-to-date literature about the benefits, methods, and limitations to develop this fundamental skill. It focuses on learning creative thinking in higher education to face the world of work and life in general. The paper describes the structure and outcomes of the course Creative Problem Solving (CPS) using data analysis from nine different offerings of the course. It then deepens in the methodology of the course by describing its challenge-based structure which utilizes generative learning based on the 'do something different' (DSD) approach. In order to design unique and pertinent solutions, students are encouraged to define the contextual meaning of each challenge, and to question how cultural, social, and personal norms limit their ideas. TTCT is used to measure their creative thinking skills at the beginning and end of the course. Detailed results of data analysis suggest that the creative abilities of students are significantly increased by taking Creative Problem Solving (CPS). And, as stated by Schön (1983), the authors agree on the need and desirability of highly developed creative skills to solve complex problems among the entrant workforce for industries both inside and outside design. This paper is relevant for the track as it addresses key questions such as: Why have design methods been adopted in higher education? And how have these methods been applied and adapted? Furthermore, it explores the context where creativity takes place, and about what is considered creative depending on students' own cultural, habitual, and normal patterns of behavior.

Farzaneh Eftekhari, Mohammad Jahanbakht, and Farnoosh Sharbafi's paper, titled "Assessment of Ideation Effectiveness in Design Thinking: The Impact of Morphological Analysis in the Process of Creative Problem Solving", addresses the question: How can design help teachers and communities formulate solutions to problems? presented by the track. It evaluates the effectiveness of creative problem solving (CPS), recognized as a critical soft skill for students. The authors developed a study to determine the effectiveness of the ideation phase in a design thinking process applied by junior design students. They applied the MA (morphological analysis) method to observe students' ideation processes and their creative thinking by using four measures of novelty, quality, quantity, and variety, using quantitative and qualitative methods. The study suggests the use of the morphological analysis (MA) method to promote novelty in the ideation process and supports the positive impact of MA method in CPS process. The authors suggest using the measures mentioned before to assess other phases of the creative problem-solving methods in design thinking courses, as a way to inform educators about students' creativity performance. The paper contributes to the discussion of the conference's main topic (i.e., challenges in design education), but also to the specific theme track "Design Thinking to Improve Creative Problem-solving,". Additionally, the paper makes a significant contribution to design educators and educational researchers interested in studying the ways in which design thinking-based learning enables students to integrate knowledge from different areas through problem-solving, promoting an active and decisive mindset (Goldman & Kabayadondo, 2017).

In their article: **"Study on the Implementation of the Innovative Enterprise Product Design Model for Industrial Design Students''**, Shuo-Fang Liu, Jui-Feng Chang, and Chang-Tzuoh Wu, sustain that industrial design education often prompts students to focus on creativity and user needs, and lacks knowledge and concepts in marketing and sales. The authors propose the Innovative Enterprise Product Design Model for Industrial Design Students, as a method to guide students to address both consumers and the enterprise during their design processes. Students worked on applying this model in a specific design project through an eleven-week course. Content included the theoretical knowledge and application methods of the model. The products were assessed by the students themselves, groups of experts and the professors, showing an overall positive result after the model implementation. Findings raise relevant issues in design education from a robust methodological approach (i.e., the disconnect between some design curricula and current industry needs and practices). These include the need to emphasize teamwork, interdisciplinary communication and coordination abilities, as well as foster cooperation between design students and the industry (Yenilmez & Bağlı, 2020). Students self-reported that they performed well and improved their innovation ability, product strategy formulation, and design maturity after using the model. Experts agreed on the quality of the design achievements, which altogether prove the feasibility of this design model.

In **"A New Design Thinking Model Based on Bloom's Taxonomy"** authors Fan Wu, Yang Cheng Lin, and Peng Lu explain that although there are many design thinking models around the world, they ignore the product's inherent characteristics and users' demands. This paper proposes a step-by-step design thinking model based on Bloom's taxonomy to assist with the use of Design Thinking Models in product design education. The paper provides an interesting, novel approach to integrating design thinking into product design education by taking a quantitative statistical approach to defining product characteristics. The paper combines numerous product engineering approaches to improve the implementation of design thinking by focusing on Bloom's taxonomy as an overall structure to achieve learning outcomes. The authors conclude that the proposed DTM can help students to carry out design activities step by step to obtain an accurate functional system, reasonable structural configuration, and therefore design the best solution that meets the real demands of users. The authors affirm that the model enhances the possibility of transforming conceptual design into commodities.

Design-based teaching and learning workshops

The two workshops present design-based models developed in different contexts to teach children and young people to identify and solve problems coming from their communities. They include visual elements, like flow charts and pictograms, and keywords that help participants to remember the process. FIDS for Kids methodology by Design for Change (DFC) allows educators to bring their students into the design mindset with a simple and agile method composed of four stages: Feel, Imagine, Do, and Share (Design for Change, 2017). While the Compass created by The Index Project® is a problem-solving tool that uses criteria as form, impact, and context to evaluate each process stage: prepare, perceive, prototype, and produce (Stenlev & Boegeskov, 2016). These models seem to be powerful didactic resources transferable to the field of education, but it is worth emphasizing that they are not formulas or recipes: they indicate certain milestones that occur during the design process and not a path to follow in a strictly linear way (Bravo, 2016; Bravo & Bohemia, 2019). Natalia Allende and Ruthie Sobel Luttenberg's workshop entitled **"FIDS for Kids: Empowering Children**

through Design: A workshop on Design for Change's take on design thinking in education" is designed as a theoretical-practical tool for educators and parents to understand how to implement the DFC method into the classroom and beyond. Chosen by the United Nations as one of the ten initiatives around the world that will allow humanity to reach the global development goals, Design for Change offers a simple, flexible, practical, and meaningful tool inspired by design thinking in the classroom setting with children of any age from 7 to 18. The presenters deliver attendees a theoretical approach as well as a hands-on experience of this tool.

The workshop **"How to Design to Improve Life: The Compass, a problem-solving tool by The Index"**, facilitated by Catalina Cortés and Mariano Alesandro, aims to introduce the Compass as a flexible frame of action to organize, structure, and manage problem-solving processes. During the session, the instructors describe the four phases through visual material and discussions, revise a series of cases to assess coherence for sustainability, and disseminate the Compass as a frame of action to manage problem-solving processes. The difference between this method and other design thinking models is its focus on maintaining coherence between form, impact, and context in every phase of the design process to evaluate solutions holistically and sustainably to improve people's lives. In this way, the aspects of the development of a design solution are covered such as function, potential, level of innovation, propagation, and economic, environmental, and social sustainability of the proposed design.

Final remarks

Today, new design domains are emerging. The fields of service design, experience design, food design, information design, or even biomaterial design did not exist as specifically defined domains decades ago. Beyond specific design themes, the success of applying design as a general set of attitudes and approaches to other domains has led to a permanent extension of the design domain.

There is no doubt that design provokes enthusiasm in school settings, but this enthusiasm opens questions such as:

- To what extent are the expectations of its application in the educational context fulfilled?
- What core design competencies should be introduced in general education, and how might they be mastered and evaluated?
- When and how should these competencies be taught?
- Who should be responsible for introducing these competencies?

Cortés, Adlerstein & Bravo (2020) suggest that models of design thinking available for teachers do not necessarily incorporate tacit pedagogical knowledge or unexpected decisions that unfold when teachers design and deliver learning experiences. Further understanding of teachers' design thinking black box would also contribute to reconceptualizing the available design thinking models for teachers.

At the higher education level, the presented articles show an ongoing enthusiasm for incorporating design-based educational strategies in the classroom, for continuing improving educational practices within design programs, and for making a positive impact on society at large through design-based education. However, the scale and scope of the initiatives presented in these articles and most of the interventions described in the literature remain very modest. Most of the reported interventions happen at the project or classroom levels and have a short duration, thus, impacting a limited number of students for a short period of time.

The current context shaped by the Covid-19 pandemic has abruptly modified pedagogical practices at a global level (Hodges et al., 2020). Design education has also been part of this phenomenon forcing educators to face the challenge of having to become distance design educators and migrate from face-to-face to virtual formats almost instantaneously. There is no doubt that the future of higher education will be hybrid, an education that will combine face-to-face with synchronous and asynchronous virtual interactions at the same time. What are the main competencies needed by future designers that can be acquired through online design education? What is the potential for online design education to support fundamental design skills?

For more than 40 years, design-based interventions in K-12 and higher education have been reported with success and enthusiasm by researchers, educators, and designers (Davis et al., 1997). However, in order to share the benefits of design approaches to learning with a more significant number of people, it seems necessary that future studies and interventions have a larger scope, a longer time frame, more substantial resources, and even more ambitious goals. We welcome all the initiatives presented for our Track and look forward to being amazed by the future contributions submitted to the Learn X Design Conference in 2023.

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