INTEGRATING DESIGN THINKING IN TEACHER EDUCATION TO FOSTER CREATIVITY

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This paper discusses how design thinking was used in a one-semester education course at the University of Calgary with prospective secondary school teachers of different disciplinary backgrounds and high school subject specializations. It presents some key characteristics of design thinking and their relationship to creativity and students' learning. It shares ways in which a sample of the student teachers engaged in design thinking, which stimulated their creativity and resulted in new thinking that included the development of classroom instructional strategies and products to support creativity in students' learning of mathematics and science.

Keywords: Design thinking; prospective teachers; teacher education; creativity

INTRODUCTION

In today's global economy and highly technological world, there is a need for students to develop skills in school that will enable them to respond reflexively to complex problems. These skills include being able to work collaboratively and to think creatively, analytically, and practically. As Lipman (2003) suggested, students must be independent thinkers, going beyond content knowledge toward anticipative creative solutions to problems. More recently, design thinking has been promoted as one of these skills given its connection to creative thinking, critical thinking and problem-solving thinking, which are all related. For example, Razzouk and Shute (2012) explained that design thinking

> can have a positive influence on 21st century education across disciplines because it involves creative thinking in generating solutions for problems. … Thus, to help students succeed in this interconnected, digital world we live in, educators should support students in developing and honing 21st century skills (e.g., design thinking, systems thinking, and teamwork skills) that enhance their problem-solving skills. (p.331)

This perspective of skills that are important for students to develop suggests the need for teacher education programs to help teachers to understand the nature of these skills and be able to engage students in ways that meaningfully support the development of these skills. In this paper, we focus on design thinking in a teacher education program at the University of Calgary. The paper discusses how design thinking was used in an education course with secondary school student teachers. It identifies some key characteristics and processes of design thinking and their relationships to creativity and learning. It reports on the experiences of a sample of students of the course who are also co-authors of this paper, regarding their engagement with design thinking and the relationship to their creativity in developing products for teaching mathematics and science.

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DESIGN THINKING AND CREATIVITY

Design thinking has received a lot of attention in the research literature regarding its nature and use in different fields (Ambrose & Harris, 2009; Brown, 2008; Owen, 2007). Creativity is a central aspect of design thinking (Dorst & Cross, 2001; Rauth, Köppen, Jobst, & Meinel, 2010; Razzouk & Shute, 2012; Vanada, 2014) given its focus on practical, creative resolution of problems and creation of solutions that benefit the end user. Based on their study, Razzouk and Shute (2012) defined design thinking as "an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign" (p.330). It is action-oriented, solution-oriented, and draws on imagination and intuition to explore possibilities and to create desired outcomes. It "involves personality and dispositional traits such as persistence and creativity" (Razzouk & Shute, 2012, p. 345).

From a different perspective, Rauth, et al. (2010) proposed a definition of design thinking within the teaching context as "a learning model which supports design creativity, utilizing a project and process based learning process by emphasizing creative confidence and competence" (p.7). They found that "there are different levels of creative knowledge, skills and mindsets that can be achieved by design thinking education, culminating in a capability that is called 'creative confidence'" (p. 1). They demonstrated how design education contributes to both the development and understanding of design creativity. They concluded that design thinking is an approach to learning that focuses on developing students' creative confidence, which is an essential part of learning.

Table 1.

Design Thinking Process

Components	Description
Empathize	Understanding the people (users) for whom something is being designed. This includes observing their behaviour in relevant contexts and connecting with them through interviews/conversations.
Define	Bringing clarity and focus to what is being designed; determining the specific meaningful challenge to take on. This includes selecting one or more "needs" of the users that the designers think are important to address and articulating an actionable problem to solve.
Ideate	Generating ideas. This includes brainstorming of the group of designers to reach new ideas and/or sketching or physically making something that encourages new ideas to emerge.
Prototype	Generating artifacts intended to answer questions and get feedback from users that gets the designers closer to their final solution. This involves building something that will answer particular questions when tested.
Test	Soliciting feedback about the prototypes from users. This includes allowing the testers to experience the prototype without designers explaining it (i.e., testers get to interpret the prototype for themselves) and observing their behaviour with it and listening to what they say about it and the questions they have.

The design thinking process defined by the Hasso Platter Design Institute (2010) consists of the five components shown in Table 1. In this process, designers begin with obtaining

empathy for the users of the product; that is, developing an understanding of users from their perspectives. For example, in the case of education, if the users are students in the classroom, then teachers as designers need to understand them as learners from their perspectives in order to design appropriate instructional/learning activities for them. In the define stage, the designers identify the problem/challenge to take on based on what they learned about the users and about the context. In the ideate stage, the designers generate ideas for potential solutions to the problem. The goal is to obtain a wide range of possible ideas from which to select by combining the designers' understanding of the problem and users with their imagination and creativity. In the prototype phase, the designers create a product users can experience based on the idea they agreed upon from the ideate stage. Finally, in the testing stage, the designers test the prototype to receive meaningful feedback about the users, the problem, and the potential solutions in order to refine and improve the solutions. This 5-stage process is not linear in that one can go back and forth between two components before moving to the next. Linking the test back to the empathy stage is critical. As the Hasso Platter Design Institute (2010) noted, "Iteration is a fundamental of good design. Iterate both by cycling through the process multiple times, and also by iterating within a step—for example by creating multiple prototypes or trying variations of a brainstorming topics with multiple groups" (p. 6).

The preceding perspectives of design thinking and the design process indicate that there is a direct relationship between design thinking and creativity in which design thinking cannot occur without creativity. Thus, engaging students at any level in learning for and through design thinking will also engage them in a way that requires them to be creative and potentially enhances their ability to be creative.

LEARNING FOR/THROUGH DESIGN THINKING

There is growing evidence that design thinking is a powerful and meaningful tool for transforming learning in schools, supporting diversity in the ways students learn, and developing more relevant skills for dealing with real-world situations (Davis, Hawley, McMullan, & Spilka, 1997; Goldman, 2002; Teixeira, 2010). Design thinking has an impact on the ways that students engage in the learning process. It challenges them to work collaboratively, think in new ways, and take risks. It gives students a highly creative experience in seeing a subject area come alive. Through meaningful, hands-on projects, students develop deep understanding of a topic, skills in building empathy with users, collaboration, and prototyping. It "develops both their inductive and deductive reasoning along with intuition (abductive thinking), concept development through ideation and brainstorming, collaboration and risk-taking, and improved crafts[person]ship as attached to empathic, deep meaning" (Vanada, 2014, p. 23). It "involves in-depth cognitive processes—which may help our students build their critical thinking skills (e.g., reasoning and analysis)" (Razzouk & Shute, 2012, p. 345). Rauth et al. (2010) found that "by experiencing the "process" of design thinking over and over again, students develop a trust in their creative skills, since these were the only ones that could help them to solve the problems they were exposed to" (p. 6). In general, as Razzouk and Shute (2012) explained:

> Helping students to think like designers may better prepare them to deal with difficult situations and to solve complex problems in school, in their careers, and in life in general. … Students will be more ready to face problems, think outside of the box, and come up with innovative solutions. (p. 343)

Design thinking is aligned with active and experiential learning. Thus, as Razzouk and Shute (2012) explained:

> Pedagogical approaches that involve problem-based learning, project-based learning, and inquiry-based learning can be used to enhance students' design thinking skills. … Such learner-centred approaches can help to raise students' awareness about good design processes and generally enhance their interest in solving complex problems (p. 343).

In addition, these authors suggest that "enhancing students' design thinking skills may be achieved through incorporating authentic and intriguing tasks into the classroom and providing many opportunities to apply design processes" (p. 344). These perspectives of how to engage students in design thinking were incorporated into the education course discussed next.

ENGAGING STUDENT TEACHERS IN DESIGN THINKING

This section provides an overview of the teacher education course in which a major theme was design thinking. The first author was the instructor with the co-authors as five of the students of the course. The course occurred in semester 4 of the two-year Bachelor of Education program after two rounds of practice teaching but before the final round of practice teaching in schools. It provided opportunities for students to explore and engage in mathematical thinking, scientific thinking, and design thinking, regardless of their subject areas of specialization. Thus, the class consisted of students of different backgrounds and high school subject specializations. The co-authors represent backgrounds in English, social studies, music, and biology.

The course content included readings and hands-on tasks/activities, some of which will be described later, to understand the nature of mathematical, scientific, and design thinking, and the relationships among these different types of thinking. Required course readings on design thinking included Briggs (2013), the Hasso Platter Design Institute (2010), and Riddle (n.d.). Students worked collaboratively in groups of four and five on assigned, in-class learning tasks and graded course assignments. Group presentations and whole-class discussions allowed them to learn from each other. In general, they were treated as autonomous learners who took control of their learning through independent research and development of ideas. This freedom allowed them to be creative in their own ways and resulted in unpredictable outcomes for the assigned tasks.

The intent of this paper is not an evaluation of the course or tasks but an illustration of students' learning and creativity based on the five student co-authors' perspectives of their experiences with design thinking and their resulting written work and products created during the course. After the course ended and grades were received, the students volunteered to participate in a presentation (Chapman et al., 2016) of their work and experiences with the course at the University of Calgary Conference on Postsecondary Learning and Teaching, which resulted in this paper. Individually and as a group, and based on the them of the conference, they reflected on and documented their experiences with design thinking in the course and prepared their portion of the presentation independent of the instructor. Conclusions made about their learning are based on information and artifacts obtained from them.

OUTCOME OF THE STUDENT TEACHERS' LEARNING AND CREATIVITY

This section provides examples of the tasks used in the course with a focus on the five student teachers' interpretations of these tasks and the products they created to illustrate their learning and creativity. Given the limitation on space, brief summaries are presented on three of the in-class inquiry tasks that preceded the design thinking course assignment. The five student teachers belonged to two different groups in working on these tasks and will be referred to as Group 1 and Group 2. The tasks were presented to students as problems to solve with no explanation of how to generate a solution. The student teachers had to interpret the tasks in their own ways, supported by connections to real-world contexts.

Task 1. Task 1 engaged the students in building a model of the tallest free-standing structure possible, using only the limited piece of construction paper, tape and the scissors provided to the students. The two groups interpreted the task differently with different goals. Group 1 focused on a structure with personal meaning to them and were not competitive regarding height. Group 2 focused on a structure that would be stable and competitive in height relative to the rest of the class. This resulted in Group 1 having the shortest and sturdiest structure with symbolic meaning for them, while Group 2 had the tallest and least sturdy structure in the class. All of the structures in the class were designed differently, which demonstrated the students' imagination and creativity.

Task 2. Task 2 engaged the students in designing a mathematical model to determine the degree of left-handedness or right-handedness of a person. The initial approach of both groups was to write something. They were prompted to be more creative by restricting the use of writing in their approaches. After much discussion and testing of initial ideas, Group 1 decided on a model that used chopsticks to pick up different small objects of different weights, sizes, and shapes with each hand and compared the percentage of success. Group 2 decided to throw a small paper ball at a target at the other end of the classroom with each hand, and compare the percentage of success and the speed of the throw. Both groups tested their models with other students in the class.

Task 3. Task 3 engaged the students in playing a mathematics board game that required the use of integer operations and substitution in algebraic expressions. After the game, the groups reflected on and described the process that they thought the designer might have used to create the board game and the connection to the intended users of the game.

The students' engagement in these tasks was based on their sense-making and intuition, as opposed to following a formal, prescribed process. Reflecting on the experience after each task, they identified processes that were later connected to readings on mathematical and scientific thinking/inquiry, design thinking, and skills students need to succeed in and out of the classroom. They also discussed how they could transform tasks 1 and 2 into design thinking tasks.

The five students' perspectives suggested that these activities played an important role in helping the students to understand the different ways of thinking. They also experienced being challenged to use their imagination and creativity in their learning and consider how to more meaningfully engage their future students. This view of their learning was reflected in their choice of activities for their final graded course assignment on design thinking.

Design thinking group assignment. The final course assignment consisted of two parts. For part 1, the students were required to use the design thinking process to create a product to teach a mathematics or science concept for a secondary school grade of their choice. For part 2,

they were required to create a product that demonstrated the use of mathematical/scientific and design thinking processes in learning and teaching a curriculum topic in secondary school mathematics, science, or kinesiology in relation to physical education with relevant, appropriate and useful real-world connections. They were to draw on their knowledge of secondary school students from their practice teaching experiences for use in the design thinking process.

For part 1, Group 1 chose to design a game board for mathematics and Group 2 chose a game board for science. For part 2, Group 1 chose to design a new menu for Stampede and Group 2 chose a website for science teachers. In both cases, using the design thinking process in Table 1, the groups researched and created realistic, practical, and usable products. They also connected the products to the curriculum and students' engagement and expressed interest in using them in their future teaching. In designing these products, they also enhanced their mathematics and science knowledge for teaching. For example, Group 1, who expressed a dislike or fear of mathematics, developed a deeper understanding of probability in designing the game and became confident in engaging others in the game to learn the concepts involved. The five students expressed shifts in their thinking and appreciation of design thinking and the opportunities it can offer students to develop useful skills to support their learning.

CONCLUSION

The thinking and experiences of the student teachers addressed in this paper suggest that a focus on design thinking in a university education course for student teachers is a promising way to support creativity in their learning and potentially in their future teaching. They also suggest that open-ended, authentic, self-guided, design-oriented tasks are meaningful and useful tools to support students' understanding and application of design thinking. Creativity played a central role in all of the tasks and in providing the means for the students to think in ways that were different from their taken-for-granted approaches and to deal more meaningfully with subject matter that they had perceived to be beyond their capability or irrelevant to their future. In general, the thinking and written work of the five students suggested that engaging in design thinking helped them to think creatively, which resulted in the development of new knowledge and new ways of thinking that can be incorporated both in their instructional strategies and their students' approaches to learning.

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