IDENTIFYING SECONDARY SCHOOL TEACHERS' UNDERSTANDINGS AND IMPLEMENTATIONS OF DESIGN THINKING WITHIN A DESIGN-BASED RESEARCH APPROACH

by

Serveh Naghshbandi

M.A., Tehran University of Art, 2006

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in

THE COLLEGE OF GRADUATE STUDIES

(Education)

THE UNIVERSITY OF BRITISH COLUMBIA

(Okanagan)

December 2014

Abstract

Drawing from a Design-Based Research (DBR) approach this qualitative study examines the impact of a Maker Day Professional Development event on secondary school participant teachers' understandings of design thinking. It also explores participants' envisioning strategies to implement the introduced concepts. Findings generate contextual design principles for more improvement in the next iterations.

Design thinking, as a human-centered approach which considers empathy supports constructionist learning and encourages students and educators to identify real-world problems and offer solutions through prototyping. By using this approach in educational settings, teachers can design learning environments, and broader sets of 21st century's required skills can be cultivated in students.

In the British Columbia's Educational Plan teachers are being asked to move towards designing 21st century's learning environments. To support educators in making changes to their teaching practices, the Maker Days were developed to introduce design thinking and prototyping. Within the framework of DBR, data was collected from a Maker Day through sequential phases including pre- and post-event surveys and interviews concerning to what extent the Maker Day influenced participants' understandings of design thinking, and whether the participants envision bringing the concepts into their classrooms. Drawing from a DBR approach, data was analyzed through retrospective and cross-iteration comparisons.

Findings suggest the Maker Day influenced participants' understandings of design thinking by reinforcing the values of experiential learning, introducing human-centeredness, and improving participants' perceptions of problem finding. Notions of iteration and refinement in a design process were identified as missed points; also, design thinking was perceived more as a making-oriented action rather than challenge-oriented process.

Findings also suggest participants were not passive recipients of the knowledge. They facilitated a similar process for students, and also designed a cross-curriculum course collaboratively. However, teachers have not found an effective way to integrate design thinking with the content knowledge of specific subjects but, they are interested in moving forward with their rough ideas and trying design thinking. Findings generate contextual design principles to optimize the Maker Days. These principles provide recommendations for the decision makers, researchers, and educators to be tested and validated in other contexts.

Preface

This thesis is an original intellectual product of the author, Serveh Naghshbandi. The research reported in Chapters 3 to 5 was conducted through the protocols of The University of British Columbia's Okanagan Campus Behavioural Research Ethics Board (BREB) under the project title: Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach , Certificate Number: H14-00624 (see Appendix B).

As per UBC's BREB guidelines, the data collection was conducted by Serveh Naghshbandi under supervision of the Principal Investigator, Dr. Sharon McCoubrey and the thesis committee. The committee for this project included:

- Dr. Sharon McCoubrey

Graduate Supervisor and Principal Investigator
Associate Professor, Faculty of Education, UBC's Okanagan Campus

- Dr. Susan Crichton

Associate Professor, Faculty of Education, UBC's Okanagan Campus

- Dr. Margaret Macintyre Latta

Professor, Faculty of Education, UBC's Okanagan Campus

Table of Contents

List of Tables

List of Figures

Acknowledgements

It would not have been possible to conduct this thesis without the help and support of the kind people around me, only some of whom it is possible to give particular mention here.

My sincere gratitude goes to my graduate supervisor, Dr. Sharon McCoubrey, for her help, guidance, and patience. She generously shared her time, knowledge, and great wisdom with me throughout my Masters study.

I would also like to sincerely thank my thesis committee members. Thanks to Dr. Susan Crichton, the Director of the Innovative Learning Centre (ILC), for giving me the chance to be part of the Maker Day research in ILC and for her caring, enthusiastic, and motivating approach. Thanks also to Dr. Margaret Macintyre Latta for her deeply insightful comments and suggestions; every single word in her comments took me a step forward in my research.

I would like to thank Glenn Borthistle, the Superintendent of Schools in School District #83, for his permission to conduct my research in this context. I would also like to thank Scott Anderson for his kind support. Many thanks are owed to the participants in my study, secondary school teachers in School District #83, for taking the time to share their insights.

Special acknowledgement goes to Desiree Marshall-Peer, the Professional Development Chairperson in School District # 83. I appreciate her effort and commitment for distributing and collecting the surveys and consent forms of the study.

Thanks to Deb Carter, a fellow PhD candidate and the Research Project Coordinator in the ILC, for her great support and the conversations we had on the topic of design thinking. Thanks also to Amanda Hancock for her kind offer, and the time and effort she put into editing my thesis. I would like to thank Lindsay Cox, Angela Finley, Kim Ondrik, professors and staff in the Faculty of Education, and my graduate cohort without whom this process would not have been the same. I feel so happy to have done my Masters within such an inspiring learning community.

In addition, I would like to extend a special acknowledgement to my family in Iran and Canada for their constant care and encouragement. Also, I acknowledge my spouse, Mohammad, and thank him for his love, care, and support.

Dedication

To my spouse, who was my support and motivation for the work I did

Chapter 1: Introduction

1.1 Overview of Chapter 1

Chapter 1 outlines the key elements of the study. It includes: an overview of the study; context of the study; the significance and purpose of the study; research questions and research paradigm; an overview of research methodology and research design; outcome of the study; the study's limitations; and an overview of the researcher's motivation to conduct this research.

1.2 An Overview of the Study

Twenty first century is demanding a different set of skills and competencies to cope with new challenges (Pink, 2005; Wagner 2010; Gardner 2007). Therefore, educational systems have started providing teachers and students with the experiences to acquire the required skills. Teachers are being asked to change their roles towards designing and facilitating learning environments to connect the 21st century's competencies with the curriculum.

Accordingly, in The British Columbia's Education Plan from the Ministry of Education (2010a), educators are being asked to move toward designing their learning environments in order to better meet the 21st century's competencies. To support educators to make sustainable changes to their practices, the Innovative Learning Centre (ILC) within the Faculty of Education at the University of British Columbia – Okanagan, collaborated with the Industry Training Authority (ITA). The ILC and ITA conceptualized and developed Maker Day Professional Development events across British Columbia. The aim of these events was to introduce teachers to design thinking and the concept of making as an innovative pedagogical approach to 21st century's teaching and learning; thus encouraging them to experience the concepts directly at the events and start bringing them into their classroom.

Design thinking, as a human-centered approach to design, has started to receive significant attention in 21st century's educational settings. Design thinking can influence not only how teachers teach, but also how students learn. Integrating design thinking to the Maker Movement provides possibilities to find problems and offer solutions to them through creating prototypes. It can be applied purposefully in educational settings in order to make

meaning through creating something. This approach provides opportunities to learn, and to build knowledge upon prior knowledge, which aligns with constructionist learning.

This study follows participants of a Maker Day, which was developed for secondary school teachers in School District #83 in North Okanagan. It aims to evaluate the event and generate contextual design principles for the future.

1.3 Context of the Study

This research is situated in a real educational context in School District # 83 in British Columbia, and focuses on a Maker Day. Maker Days were designed to inform the teachers of the potential values of design thinking and making by actively experience the process of designing and prototyping, and encourage them to bring the concepts to their classroom.

During the Maker Day events, educators experienced design thinking, inquiry, and experimental learning through small groups to solve a design problem. By engaging in the iterative d.School's design thinking model (see Appendix J), the educators used the main scenario, which was created to gain empathy for the person they were designing for, and to get feedback. Stanford d.School's design thinking model "is a 90-minute fast-paced project though a full design cycle. Students pair up to interview each other, create a point-of-view, ideate, and make a new solution to their partner" (Stanford University, 2009). After completing the design thinking activity, and defining the design problem, participants drew from a bank of materials to imagine, tinker, design, and create a prototype. The prototypes they made were the possible solutions to the problems they identified in the design thinking process.

This study investigates the impact of the Maker Day experience on participant teachers' understandings of design thinking. Also, it explores the possible ways that the participant teachers integrate the concepts into their classroom.

1.4 Significance of the Study

Increasingly, teachers are being asked to change their approach to creating learning environments to enable their students to develop the 21st century's skills and competencies. The required skills include critical thinking and problem solving, creativity and innovation, social responsibility, global awareness, communication, digital literacy, and collaboration (Zhao, 2009). Schools are expected to be the best places where these competencies and skills can be learned.

In the British Columbia's Education Plan (2010a), educators are being asked to move toward designing the learning environments, rather than going through step by step preplanned lessons in the classroom in order to better meet the 21st century's competencies. It is worth acknowledging that not all teachers have been using step by step preplanned lessons; what educators are being asked to do is to more provide students with the environments where the 21st century' skills are integrated with the curriculum.

To support educators in making changes to their teaching practices, Maker Days have been conceptualized and developed to introduce teachers to design thinking and making as innovative pedagogical approaches to 21st century's teaching and learning.

This research as a micro-cycle study of a Maker Day in School District #83 documents and evaluates the event and reflects upon it by following the participant teachers to provide some insight into the Professional Development event. It seeks to determine if the Maker Day has met the pre- determined intentions and whether the participants imagine bringing the concepts into their classroom. This study generates contextual recommendations for improvement and refinement of such events in the future to better meet the needs of the educators and prepare them well in a supportive environment to start designing the appropriate learning practices for 21st century's education.

1.5 Purpose of the Study

This study follows a Maker Day which was developed as an experiential and immersive in-service Professional Development event for secondary school teachers in the North Okanagan region of British Columbia. It evaluates the potential impact of the Maker Day on the participants, and also, explores how they might use the introduced concepts in their classroom. The aim of the study is to examine the impact of the event on the participants' understandings of design thinking, identifying teachers' needs and offer recommendations on the content, and organization of the event. Examining the results generates design principles for more efficiency and improvement for the next cycle of design in Maker Day research.

Guskey's (2000) model of five critical levels of Professional Development evaluation is used as a guideline in this study. This study collected data from a Maker Day and analyzed data qualitatively, focusing on Level 2: Participants' Learning, and Level 4: Participants' Use of New Knowledge.

1.6 Research Questions

This study explores the impact of a Maker Day Professional Development event through the following research questions:

1. What are the secondary school teachers' understandings of design thinking prior to, and after the Maker Day Professional Development event?
2. How might the participant teachers envision implementing design thinking concepts into their classroom?

1.7 Research Paradigm

This study focuses on generating knowledge about a Maker Day from reflections of participants. It is conducted within a social constructivist epistemology. This theory considers that people construct meaning together in relation to their engagement with the human world (Crotty, 1998). According to Koro-Ljungberg et al. (2009), educational research within social constructionist approach is multifaceted and generates knowledge from groups of participants in order to transform the practice.

Data analysis is conducted within an overall interpretivist paradigm, which assumes that a primary aim of social science is to understand what people mean, and intend by what they say and do, and to locate those understandings within the situational context (Moss et al., 2009).

1.8 Overview of Research Methodology and Research Design

This study draws on a Design-Based Research (DBR) approach. DBR is a systematic and flexible methodology to improve educational practices that are developed through iterative cycle of analysis, design, development, and implementation (Plomp, 2007).

The tenants of this study align with the basic characteristics of DBR, which are pragmatic, grounded, interactive, iterative and flexible, integrative, and contextual (Wang and Hannafin, 2005). Also, the study interconnects with the framework of DBR from different perspectives including the existing larger scale study of Maker Day research; development of the study and design, from where I identified the problem -to proposal preparation- to revisions- to data collection- and to analysis; and the actual process of study including data collection phases, and data analysis strategies. In Chapter 3 these interconnections are visualized and described in detail.

The study is a qualitative study, and used a number of data collection methods. Sequential phases of design included pre-event survey, post-event survey, and in-depth interviews. Drawing from DBR approach, data collection and analysis of procedures were interdependent with the needs of the design (Wang & Hannafin, 2005). Continuous documentation occurred throughout the study, and the collected data from each stage was analyzed tentatively in order to refine the needs of study, choose the method for collecting data in the next step, and design the subsequent step. Data analysis took the form of retrospective and cross-iteration approach drawing from a DBR approach (Cobb et al., 2003).

Findings from pre- and post-event surveys plus the complementary data from interviews explore and compare participants' understandings of design thinking before, and after experiencing it. This part includes a semi-summative evaluation to conclude whether the Maker Day met the predetermined specifications. It also ties to the first research question, which is "What are the secondary school teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event?" Examining the results from this section provides recommendations for improvement of content in the next Maker Days but, still requires more evidence from the formative evaluation (McKenney, 2001). A formative evaluation of the Maker Day is conducted by examining the findings from the interviews.

Findings from the interviews, which explore whether participants envision bringing the new knowledge into their classrooms includes a formative evaluation of the Maker Day. This part ties to the second research question which is "How might the participant teachers envision implementing design thinking concepts into their classroom?" The results of semi-summative and formative evaluation generate design principles and guidelines to optimize the design of Maker Day for more efficiency and improvement for the next cycle of design.

1.9 Research Outcomes

Plomp (2007) believes the outputs of design-based research could be categorized into three groups: interventions (program, product, and process), design principles, and professional development of the participants involved in the research. The output of this study would be contextual design principles to be applied in the next cycles of design and inquiry.

Design principle is a term that Van den Akker (1999), Reeves (2006), and Wademan (2005) use when they refer to the theoretical outputs of design-based research. Other authors

call it domain specific theory (Gravemeijer & Cobb, 2006), design theory (Wademan, 2005), or lessons learned (Van den Akker et al. 2006). If the emerging design principles work and validate in other contexts, then they will be additionally powerful.

1.10 Limitations

This study was conducted within the framework of a Design-Based Research approach in a specific context, and with a small number of participants. Research participants were secondary school teachers in School District # 83 in British Columbia who attended a Maker Day Professional Development event. Therefore, findings in this study are not suitable for generalization. Drawing from DBR approach, generalization of the findings increases when they are tested and validated in more cycles of design, and in more contexts. Design principles generated from this study can be used as working hypothesis, not a conclusion.

Another limitation is related to availability of research participants in the designated time for data collection and its influence on the data collection timing. Because of the teachers' strike in British Columbia, participants of the Maker Day were not accessible in the designated time for data collection. The delay that occurred between the event and data collection may have influenced teachers' perceptions about design thinking after the Maker Day.

Finally, as a researcher, I am totally new to British Columbia's educational and cultural context. I do not have firsthand experience in this educational setting in comparison to a person who grew up and was schooled here. This lack of information in my background may have influenced the interpretations of findings.

1.11 Researcher's Motivation

My motivation for conducting this research originates from my personal interest, educational background, and professional experiences in design and design education. My formal educational background in Industrial Design (BA), a MA in Art Studies in addition to several years of experience as a designer and design educator, caused me to increasingly question my social role as a designer. This led me to return to academia, where I began investigating those questions in the Faculty of Education at the University of British Columbia. In this research, I explore the potential possibilities of design thinking as a creative meaning-making process to re-conceptualize teaching and learning in the 21st century.

1.12 Organization of the Thesis

Chapter 1 outlined the key elements of the study. Chapter 2 discusses the literature surrounding the topic and the theoretical framework upon which the study was developed. Chapter 3 presents the research methodology and research design. The findings are presented and discussed in Chapter 4. Chapter 5 concludes the thesis with a discussion of the results.

Chapter 2: Literature Review

2.1 Overview of Chapter 2

In this chapter, I am presenting a review of the related research in the field of design thinking and its possibilities in educational settings. The purpose of this chapter is to review the theoretical and pedagogical literature on design thinking, to address how the philosophical and theoretical frameworks underpin the study, and to outline the possibilities and restrictions of design thinking by critically analyzing some experiences with implementing design thinking as an approach to learning.

2.2 Scope of the Literature Review

The research questions guided the literature review include "What are the secondary teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event?", and "How might the participant teachers envision implementing design thinking concepts within their classroom's teaching and learning practices?"

Focusing on the first question, I review the literature on design thinking. To introduce the topic, I set up a definition of design thinking as a human-centered approach to design. I follow this with a discussion of 21st century's assumptions regarding required skills, and the pedagogical approach to design thinking as a possibility in learning and teaching to prepare students and teachers for 21st century's life. Then, I explain the notion of the Maker Movement and describe how it ties to design thinking as a complementary concept. Finally, I introduce studio-based learning as the "signature pedagogy" of design education where learning by designing can be developed. This part summarizes and synthesizes the relevant research on design thinking in order to better understand its characteristics, and its potentials in educational settings of the 21st century.

To review the philosophical and theoretical frameworks of the study, I explain the involving theories of philosophical learning theory, grand learning theory, and intermediate learning theory based on Design-Based Research (DBR) approach upon which this study has been developed.

The second research question directs the literature review to the experimental studies on using design thinking in learning settings. I critically review the literature on experimental research conducted in realistic situations. In this part, I discuss possibilities, potential values, and also restrictions of implementing design thinking in the classroom.

Figure 2.1 illustrates a schematic overview of different theories and research contributing to the structure of this study, and the interconnection of different scopes.

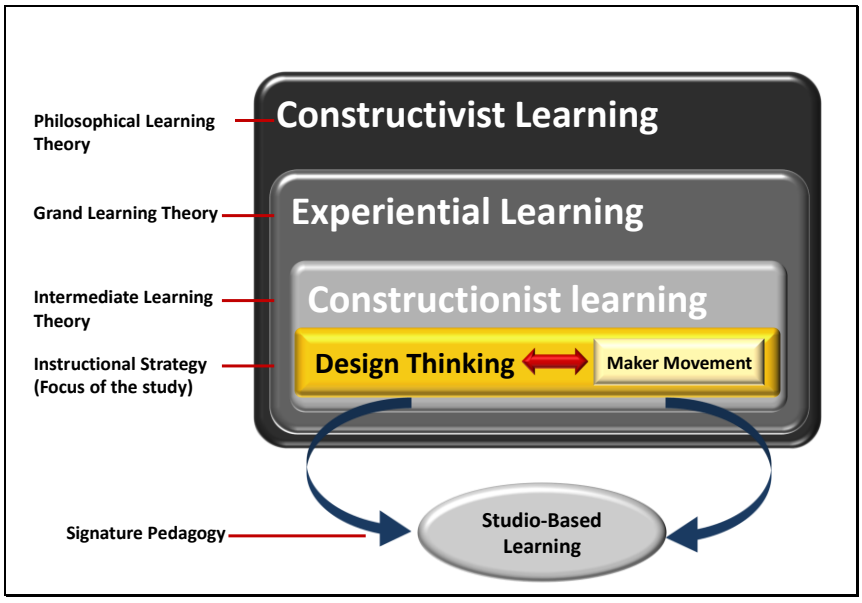


Figure 2.1 Schematic overview of different scopes of literature review in this study

2.3 Design Thinking

Design thinking is an iterative and interactive process where designers observe, come up with ideas to solve the problems, and see what they can conclude to inform further design efforts (Razzouk & Shute, 2012). Rauth et al. (2010) state that design thinking is a holistic concept of design cognition and intends to offer concrete solutions to complex problems in everyday life. Rittel (1972) term these complex problems, which are difficult to solve, as "wicked problems". Hence, design thinking tries to identify wicked problems, and find novel solutions including "products, services, or systems" (Rauth et al., 2010, p.2) for those problems.

Design thinking has received a lot of attention in fields other than design, such as engineering, business, and science because it can influence how people learn and solve problems (Dym, Agogino, Eris, Frey, & Leifer, 2005; Fricke, 1999; Nagai & Nagouchi, 2003). It has started to receive increased attention in educational settings too. Features and characteristics of design thinking process have begun to be considered and integrated intentionally in learning environments in order to promote students' skills that are needed to succeed in the 21st century.

2.3.1 Theoretical Approach to Design: Design Thinking as a Human-Centered Approach

In this section, I clarify the act of designing and its position amongst other disciplines, and describe Human-Centered Design as a specific approach to designing which represents design thinking.

To identify the act of designing and its characteristics, Owen (2007) compared designing with other disciplines in content (symbolic versus real) and in process (analytic versus synthetic). He considered designing as highly synthetic and strongly concerned with the real world. However, as design related disciplines (urban design, architecture, industrial design, and graphic design) deal with communication and symbolism, he believes designing has a symbolic component as well. Furthermore, the act of designing requires analysis in order to complete synthesis. So, there is also an analytic component in the act of designing (Owen, 2007). Owen (2007) notes that other fields can be positioned on this map as well. However, mapping fields is not absolute, and this map just provides a way for comparing different fields with regard to two dimensions: content and process. For example, he mentions design, as a field, is more complementary to science than any other field. Figure 2.2 illustrates the adapted map from Owen (2007).

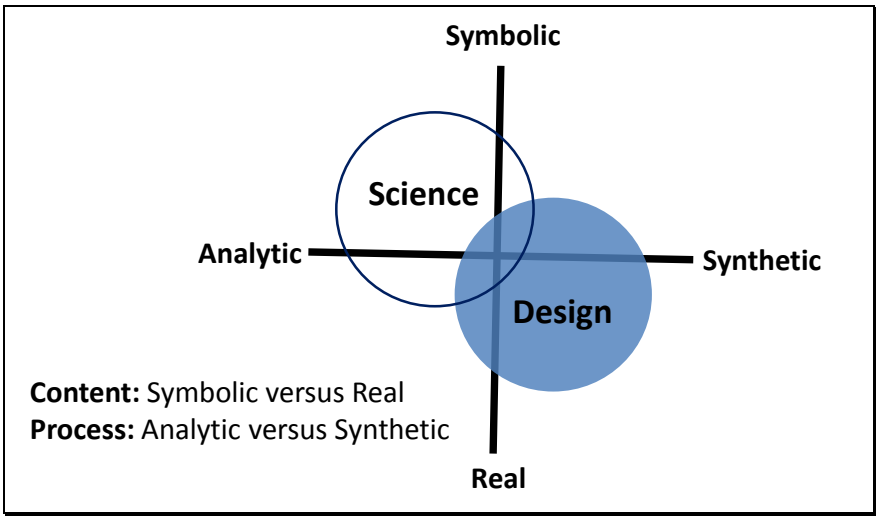


Figure 2.2 Conceptual representation of content and process in designing, adapted from Owen (2007)

At its core, design thinking refers to how designers see, how they think, and how they solve a problem. Design thinking is generally defined as a creative process, where designers are associated with situations based on identified needs that may lead to giving solutions through making artifacts (Siok, Lim, Lim-ratnam, & Atencio, 2007). The solutions may be different but, each includes phases such as problem statement, ideation, investigation, prototype, gather feedback, ongoing evaluation and redesign.

Design thinking typically uses a human-centered approach to design. Human-Centered Design is an iterative and multi-stage problem solving process in which designers analyze and predict how users likely use a product; and then tests the validity of their assumptions according to actual user's behavior in real situations. For example, software designers can achieve the goal of a product for their users through human-centered approach to design and iterative cycle of developing, testing, and redesigning. Human-Centered Design has been used as a method for addressing and interpreting real-world problems, and to ensure that the object being designed meets the needs of the user (Sanders, 2002). The main difference between Human-Centered Design and other design approaches is that Human-Centered Design tries to optimizing the product around users' needs, rather than forcing the users to change their behavior to fit in with the product. To clarify human-centered approach to design, Tom Kelley, IDEO founder and Stanford's d.School creator, and his brother David Kelley, claim design thinking combines empathy for the context of a problem, creativity in the generations of insights and solutions, and rationality in analyzing different solutions to the problem (Kelley & Kelley, 2013).

The integration of design thinking concepts with the applied social sciences is relatively new. In the early 1980s, design firms began doing design-driven experiments with the social sciences and the social scientists began to serve the design process (Sanders, 2002). Design thinking has started to receive increased attention in educational settings as well. Literature suggests design thinking has the potential to have a positive influence on 21st century education across disciplines because it involves creative thinking in generating solutions for problems (Razzouk & Shute, 2012; Carroll et al., 2010; Mathews, 2010).

2.3.2 Pedagogical Approach to Design Thinking: A Need for 21st Century Teaching and Learning

The 21st century increasingly is dominated by a different way of knowing, being and doing. It demands a very different set of skills and competencies from people in this age in order to cope with the challenges they encounter in their lives (Pink, 2005; Wagner 2010; Gardner 2007). Schools are supposed to be the best places where such competencies and skills can be learned. Therefore, educational systems began feeling the need to provide students with the experiences they needed in order to contribute actively to the new age (Noweski et al., 2012). To guide schools' decisions about what kinds of skills they should include in 21st century's curriculum, Zhao (2009) establishes five core assumptions:

> - Skills and knowledge that are not available at a cheaper price in other countries or that cannot be rendered useless by machines;
> - Creativity, interpreted as both ability and passion to make new things, and adapt to new situations;
> - New skills and knowledge that are needed for living in the global world and the virtual world (examples include foreign languages, global awareness, and multicultural literacy, and digital or technology literacy for the virtual world);
> - High-level cognitive skills such as problem solving and critical thinking;
> - Emotional intelligence; the ability and capacity to understand and manage emotions of self and others, the ability to interact with others, understand others, communicate with others, and manage one's own feelings (pp. 150-151).

To meet the expectations, in terms of required skills mentioned above, teachers have been asked to move from the existing teaching methods toward developing learning environments that are aimed at enriching needed skills of the learners. They have been asked to move toward a learner-centered environment, where they spend less time on explaining through instruction, and invest more of their time in experiential type of learning (Kwek, 2011). Thus, the assumptions made by Zhao (2009) are not unfamiliar; they support the ideas

from leading theorists like John Dewey who suggests that if useful knowledge constructs through an authentic context within a community of practice, then experience becomes "educative" (Dewey, 1938, p. 138). But, the critical question regarding the assumptions mentioned above is: 'How teachers can provide the students with this type of learning?' In the following subsections, I demonstrate the potential influence of design thinking on how teachers teach, as well as, how students learn 21st century's educational settings.

2.3.2.1 Design Thinking and How Teachers Teach: Teachers as Designers of Learning Environments

If the required change in 21st century's teaching and learning happens in the classroom, teachers must play an important new role to transform learning environments to better meet the required skills mentioned earlier. Clandinin and Connelly (1992) call the new role of teachers "curriculum makers"; a position beyond being transmitters or implementers. They believe teachers are an "integral part of the curriculum constructed and enacted in the classroom" (p. 363). Hardiman (2010) calls this transformation as moving from convergent thinking where tasks are persistent in the system to divergent thinking where multiple approaches to problem solving are generated. Therefore, teachers are being called to become designers of learning environments rather than going through step by step preplanned lessons in the classroom, and do the standardized tests to evaluate students' learning. Teachers have already begun shifting their practices from distributors of knowledge to facilitators of learning. However, they are increasingly challenged to exchange their existing plans with dynamic student-centered practices, where students can work independently, or collaboratively (Hawley & Valli, 1999).

There is no doubt that teachers should be helped to face these new challenges and demands. Noweski et al. (2012) claim teachers may have more or less personal experiences and a good will to change. This approach is naturally not successful on a broad scale and in long term. Longview Foundation (2008) advocates this claim and states: "Few teachers today are well prepared to educate students for this new global context" (p. 3). In order to prepare the teachers well to start designing the learning practices to better meet the new age's skills, new ways of professional development concerning the adoption of technologies and innovative practices must be developed. Crichton and Carter (Accepted 2014) suggest immersive, experiential and mindful professional learning experiences, in which teachers try

things first as learners before they use it as part of their instructional strategies. To encourage teachers to take risks, they need to move slowly and personally through the learning in a supportive environment.

Moreover, by redefining teachers' role toward designers of learning, teachers, themselves are asked to become 21st century constructivist thinkers and problem solvers. Designing learning environments with a large variety of variables, in which individual and collective learning must be supported, is a problem itself that needs to be solved by a learning designer/teacher.

In a case such as this, human-centered approach in design can turn into learner-centered approach to education. The involving aspects in learner-centered design approach are: the targeted audience, the central problem being addressed, and the underlying approach to address the problem (Quintana, Krajcik & Soloway, 2000). The first and second aspects can be compared to involving aspects in Human-Centered Design: users versus learners, and product versus learning practices and instruction. Design thinking can be considered an underlying approach to identify and address the problem in both. Learners as the targeted users of design can be the source of inspiration and direction for designing learning practices. Teachers may use the design thinking process to well define the learning problem and start giving solutions to it based on their background knowledge and experiences. Then they can develop their insights by practicing their new roles. This is consistent with the concept of reflective practice introduced by Donald Schon. Reflective practice is a mindful and critical consideration of one's action by investigating practice, which leads to developmental insight (Schon, 1996). Schon (1996) claims that professionals know more than what they can put into words. They present the knowing in practice, which is tacit in most cases. Indeed, practitioners often disclose a capacity for reflection on their knowing in action. They sometimes use this capacity to tackle the complicated, unique, and uncertain situations of practice. Schon (1996) used the term professional artistry to refer to the competence practitioners in those kinds of situations of practice. He described reflective practice as a "dialogue of thinking and doing through which I become more skillful" (Schon, 1996, p.31). Reflective practice has been recommended by Schon for novices in a field to recognize consonance between their own practices and expert practitioners (Schon, 1996). Referring to reflective practice concept, teachers can gain a better understanding of their new roles and

improve their knowledge and teaching capacities by designing and experiencing styles which meet the learners' needs, and reflecting upon them to develop better. Schon (1983) frames his view on designing as a reflective activity. He brings up designing as a conversation with the materials of a situation (Schon, 1983) and positions designing as a complex process with different variables, possible moves, norms, and interrelationships that can be represented in a final product or model. Teachers' constructive knowledge reveals in and by actual designing of learning environments and refection upon them; their knowledge produce work, and work is evaluated to construct knowledge. Kalantzis and Cope (2011) call the transformation in classroom environment, curriculum, and the role of teachers and learners as "pedagogy in the new media age". To support the new role of teachers as designers, they claim learning can be created by teachers with negotiation with learners in a more participatory approach in which learners are creators of their own meanings and understandings.

The new role of teachers, as designers of learning practices, has changed the role of students as well. It has shaped new types of learners who are not only the receivers of information being given but rather, they can act as co-designers of learning. Providing learners with real, intellectual and practical challenges encourages them to be more actively and purposefully engaged in their learning.

2.3.2.2 Design Thinking and How Students Learn

Mathews (2010) claims design thinking has been forwarded as a method to learning that includes central components of what it means to be literate in the 21st Century. This approach does not decrease the importance of reading and writing but instead, emphasizes that literacy involves the active and dynamic involvement in designing, and making new meanings by available resources (Kress, 2003; New London Group, 1996). In fact, the claimed literacy rooted in design suggests that students should be capable of finding complex problems that exist in real environments, and offering solutions to such complex, and open-ended problems collaboratively and creatively. However, 21st century learning must connect to outcomes and proficiency in both subject knowledge and the expected skills in new era. In this way, learning by designing implies more than simply engaging students in the production of products. Instead, it entails cultivating 21st century learning competencies including critical thinking and problem solving, creativity and innovation, social responsibility, global awareness, communication, digital literacy, and collaboration, and linking these competences

to the specific content knowledge. These all align with the five core assumptions on 21st century's curriculum made by Zhao, which was mentioned earlier.

Although problem solving has been addressed as a required skill in the 21st century, Carroll (2014) suggests that finding problems is as valuable as solving them. In the current research in Stanford University, where she uses design thinking in middle schools, she declares, "[i]n a world of increasing complexity, being able to define the problems worth solving can be the greatest challenge, and the greatest opportunity; learning to do that is an integral part of becoming an empowered 21st century thinker" (p.29). Owen's (2007) explanation of creative domains supports Carroll's claim. Owen (2007) states that creative people tend to work in two different ways: either as finders or as makers. Finders exercise their creativity through discovery and sensitive observation to understand, and to find problems that not well solved. To Owen (2007), makers are equally creative but, in a different way. They prove their creativity through invention by constructing tangible products. Figure 2.3 adapted from Owen (2007), shows two domains of creativity including finding problems through discovery, and making solutions through invention. Referring back to the Figure 2.2 and comparing it with two domains of creativity, it is worth mentioning that all the four quarters in Figure 2.2 and two domains in Figure 2.3 are important in 21st century's education because we want the students to develop higher-order thinking skills by analyzing, synthesizing, innovating, and likewise, dealing with real-world problems. Also, a key connection of Owen's (2007) claim on creativity domains in finding and making to design thinking process is that fostering creativity is not only to solve problems, but to find and well define the problems.

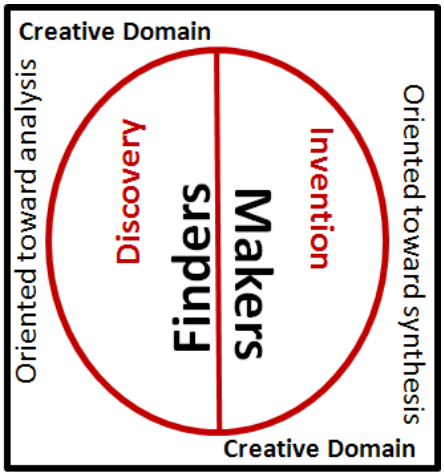


Figure 2.3 Domains of creativity adapted from Owen (2007)

The Hasso Plattner Institute of Design or d.school is a design school based at Stanford University in cooperation with the German Hasso Plattner Institute of University of Potsdam, explores the possibilities of design thinking as a new way to teach and learn. A design thinking process developed by this institute consists of six key components (Figure 2.4):

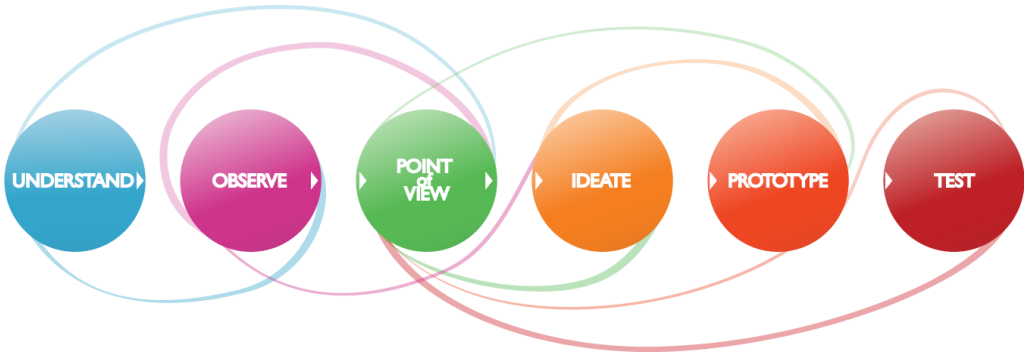


Figure 2.4 Design thinking process developed by Hasso Plattner Institute of Design at Stanford

Understand: During this phase, students immerse themselves in learning, talk to experts and conduct research to develop background knowledge.

Observe: Students become keen people and place watchers in the observation phase of the design thinking process. They talk to people about what they are doing, ask questions and reflect on what they see. The understanding and observation phases help students develop a sense of empathy.

Point of view: The focus is on becoming aware of peoples' needs and developing insights. The formula for this phase is**:** User + Need + Insight. This statement ends with a suggestion about how to make changes that will have an impact on peoples' experiences.

Ideate: In this phase quantity is encouraged. Students may be asked to generate a hundred ideas in a single session. They become silly, savvy, risk takers, wishful thinkers and dreamers of the impossible and the possible.

Prototype: Prototyping is a rough and rapid portion of the design process. Students learn that it is better to fail early and often as they create prototypes.

Test: Testing is part of an iterative process that provides students with feedback. The purpose of testing is to learn what works and what doesn't, and then iterate. This means going back to your prototype and modifying it based on feedback. Testing ensures that

students learn what works and what doesn't work for their users (Hasso Plattner Institute of Design at Stanford, 2007).

Based on the illustrated process, Stanford's d.School has developed a facilitator's guide (Stanford University, 2009) to be modified and used as a pattern for conducting design thinking projects. Educators/ facilitators can follow the process step by step and develop a Human-Centered Design project. The focus of this approach is on the process in order to let the students define their own problems through gaining empathy to the context as well as the targeted user(s). Design challenges are created around an issue that has many potential solutions. The process and the facilitator guide mentioned above can be used as a template by educators in order to start designing learning practices through design thinking. Carroll et al. (2010), who have used this process in implementing design thinking in a middle school state that "through a series of design challenges, students learn the six components of this process, and the design thinking mindsets that underlie this approach to learning" (p.40).

Hasso Plattner Institute of Design at Stanford (2007) has identified key components of this process including human-centered, action oriented, and mindful of process. In such a Human-Centered Design process, students can develop a deep understanding of the context. As well they build empathy with the users, define a design problem, and offer different solutions through meaningful hands-on projects, prototyping and collaboration.

Design thinking process includes making and prototyping, which occurs near the end of the process. After identifying the problem through inquiry, observation, developing a point of view, and addressing needs through empathy, and then generating different ideas, a prototype should be made as the generated solution to the identified problem. If the prototype does not meet the intended objectives in the testing stage then the process should be iterated as many cycles as needed to meet those objectives. The prototype can be a sketch or a two- or three- dimensional model made out of diverse materials. Digital prototyping is an alternative that actual designers use in industry to design, iterate, optimize, validate, and visualize their products throughout the product development process. In order to use the possibilities of technology, digital prototyping can be applied in teaching and learning settings as well. Instead of building multiple physical prototypes and then testing them to see if they work, a digital prototype reduces the number of physical prototypes needed to validate

the design. Digital prototyping could be an appropriate response to what Zhao (2009) assumes by digital or technology literacy for the virtual world.

Making and creating prototypes are the best ways to convey the ideas and communicate, and to suggest the solution(s) to the design problem. Carroll (2014) supports this by claiming "the power of embracing prototyping mindset". She believes a prototyping mindset emphasizes on the notion that if you try something and it doesn't work, you simply learn from it and try it again. This mindset is an essential part of design thinking. It is about failing fast and failing forward. Unlimited access to information on the internet, as well as increasingly reasonably priced powerful tools, has eased the process of making. Here is where design thinking and making prototypes tie nicely together to create something meaningful in learning environments.

In the following section, I explain what the Maker Movement has brought into the digital age, and clarify how it can be partnered with design thinking, as a complementary concept in conducting meaningful design type practices in educational settings.

2.3.3 Maker Movement and its Integration with Design Thinking

Humans have a desire to make things and then improve them by remaking. Martinez and Stager (2013) mention art and science, craft and engineering, and personal expression have existed in communities, culture, commerce and academia throughout history. They also believe a technological and creative revolution has started, and as a result, we all have the opportunity to turn into makers because of access to the new tools and materials. Hatch (2014), author of the Maker Manifesto, states human beings are experiencing a new industrial revolution in digital age; the first revolution was by steam power and development of machine tools, the second was by electricity.

As mentioned before, humans have a desire to make things; from food and crafts to electronics and woodworks. Maker Movement has rekindled that interest in humans and celebrated it by adding technology and extending the options for making in a new age. It can be positioned as the improved version of Do-It-Yourself (DIY) culture in the digital age. Emergence of Maker Space and Maker Fairs aiming at increasing the number of DIY-ers, who want to make something rather than buy it, has been the basis for the Maker Movement. Make Magazine is considered a central organ of the Maker Movement. The launch of MAKE Magazine in 2005 provided making opportunities for a tech-influenced DIY community that

has come to be identified as the Maker Movement. The magazine launched a public annual event to celebrate arts, crafts, engineering, science projects and the Do-It-Yourself (DIY) mindset called Maker Fairs. The maker culture is a contemporary subculture of people interested in electronics, robotics, 3D printing and also, more traditional activities such as metalworking, woodworking and in general, arts and crafts, all in a DIY mindset (Presterud, 2013).

In education, the Maker Movement overlaps with the power of learning by doing. To support this approach in learning, the Maker Movement can be integrated with design thinking. Integrating design thinking to making helps makers finding the problem first, and thinking about what is worth making. As Owen (2007) claims, creative people tend to work in two different ways: either as finders or as makers. Finding real-world problems is an important first step before finding any solutions. Finding problems requires precise observation, exploration, creativity, and critical thinking. Design thinking allows makers to "creatively attack the world's greatest problems and meet people's most urgent needs" (Hatch, 2014, p.10). Intersection of Maker Movement with design thinking makes the connection between inquiry, problem finding, problem solving, and prototyping. This integration can empower students to see that they can find problems in their environment, bring their ideas to life, and make new things to solve the identified problems.

Learning by designing and making needs to be applied through an appropriate pedagogy which fits to the design practices, and in the similar environment where real designers and makers work. Shulman (2005) refers to the forms or styles of teaching and instruction that are common to specific disciplines, areas of study, or professions. He calls this specific style of teaching "signature pedagogy". To Shulman (2005), "signature pedagogy" helps students build habits of minds that allow them to think and act in the same manner as experts in the field.

Studio is an environment where design projects are defined, students work on design projects individually or collaboratively, and the educator facilitates the design project. Crowther (2013) believes studio is the "signature pedagogy" of design education. Studio-based pedagogy is a method that has the potential to help students to develop their understandings of design, and foster their thinking about designing (Kuhn, 1998; Cox, Harrison, & Hoadley, 2009; Schön, 1983; Kafai, 1995). In the following section, I talk about

studio-based learning as the "signature pedagogy" for design education, and describe how studio can be improved with a variety of tools and digital technologies, as Maker Movement wishes for digital age.

2.3.4 Signature Pedagogy of Design Education: Studio-Based Learning

The design studio appeared as the basis for industrial design education during the early 1900s from Bauhaus in Germany (Bayer 1975). The studio commonly has been used in design related curriculum in the areas of architectural design, landscape design, interior design, and industrial design. Studio is a place where students set up their own workspaces, plus create and present their designs (Schon, 1983). In studio style classes, students are introduced to a design problem then they work individually or in groups to solve the given problem. There are no lectures in studios instead, the educator facilitates and leads students to new insights in their work (Cennamo et al., 2011). Students work on design tasks in a common space and develop a community of practice in which they support each other and provide feedback. The instructor provides students with a description of an ill-structured problem and then students must provide solutions through their design work (Brandt et al., 2011). Schon (1983) claims that studio-based design instruction can be used for all students in order to learn the practices of a discipline. In fact, he extends his hypothesis of studio-based learning to other professions and claims that all professions are "designlike". According to Schon's hypothesis, central features of education could be understood in design. Studio-based activities can link theory and practice by bridging scientific activities with creativity. Moreover, Crowther (2013) clarifies studio education can be seen to accommodate three types of learning: learning about design (the development of knowledge), learning to design (the development of skills), and learning to become a designer. In learning by designing activities for K-12 students, we don't necessarily train actual designers or architects; instead, we try to cultivate and improve potential mindsets of designing (knowing about design and being able to find and solve problems creatively) which align to required skills in 21st century.

Rethinking teaching and learning in 21st century - transforming constructionist learning into action in studio culture - requires rethinking the physical learning spaces to better match with the design types of activities. Dougherty, well known leader of the Maker Movement in the United States, suggests adding makerspaces within schools (Dougherty,

n.d.). By makerspace he means a variety of options for physical learning spaces that include "some aspects of the shop, home economics class, studio, and science labs where materials, tools and expertise are available" (p. 1). The makerspace suggested by Dougherty is pretty similar to what design studio looks like; except, makerspace provides more tools and materials for making and prototyping. Providing a variety of materials is essential because materials are used as languages to express ideas and have the potential to be used in learning different concepts. The totality of the final artifact in the studio/makerspace includes a combination of the materials and a sense of purposes and constraints. Providing a variety of tools and materials of many types and function invites students to explore more. It offers them more opportunities to experiment and develop with, and as a result, enriches their learning. In general, a studio/makerspace should optimize to allow for more flexibility and functionality, and also to encourage creativity.

Learning by designing and making is consistent with constructionist learning defined by Papert (1990). Constructionist learning emphasizes on making something meaningful in order to construct knowledge. Constructionism as a mode of experiential learning follows constructivism as a larger scope of philosophical theory. In the following section, I explain how the theoretical framework of this study has been structured from Design-Based Research Approach. I also explain different scopes of the involving theories in the study, as well as their interrelationship.

2.4 Theoretical Framework

This study draws on a Design-Based Research (DBR) approach. DBR has a pragmatic desire to create particular forms of learning practices and environments based on learning theories. It refines these learning practices and environments in iterative cycles of design. Thus, DBR is theory-oriented and should be grounded in the relevant "research, theory and practice" (Wang & Hannafin, 2005). Identifying the philosophical learning theories through which the design can be developed and analyzed is important in DBR. However, the philosophical theories usually do not provide concrete indications to designing and implementing the practices. In fact, the critical question in using the grand philosophical theories is "How the designer/researcher can put those kinds of theories in practice?" diSessa (1991) argues that rather than fundamental theories of learning, design experiments need

intermediate theoretical scopes because the grand theories may be difficult to project into specific realistic situations.

This study focuses on learning by designing and supports constructionist learning claimed by Papert (1990). Papert takes an experiential stand acknowledging the power of making something meaningful individually or collaboratively that comes from a question. Constructionism takes the grand philosophical learning theories a step further toward action. Thus, drawing from DBR approach of the study, I address it as the intermediate scope of theory in the study. Papert establishes his theory based upon Dewey's experiential learning. It also follows constructivist theorists who believe knowledge is not delivered, but constructed based on experiences, interactions, and interpretations.

To review the literature of theoretical framework, and to better explain the interconnection of the involving theories mentioned above, I examined the theories sequentially from constructivism (philosophical learning theory) to experiential learning (grand learning theory), and to constructionism (intermediate learning theory).

2.4.1 Philosophical Learning Theory: Constructivist Learning

Constructivism, as a philosophical learning theory refers to how people learn. It argues humans generate knowledge from the interaction between their experiences and their ideas. Constructivist learning theory offers a different view of learning from the traditional education methods claiming learning is an active, individual experience, where people build their own notions or meanings of concepts based on their own experiences (Sullivan, 2009). According to constructivist learning, each person has a different interpretation of a phenomenon or topic, makes meaning, and constructs knowledge based on experiences and interpretations. Thus, learning is unpredictable, and knowledge constantly transformed through new insights, which are achieved through individual experiences in the learning process (Kolb, 1984).

Theories about learning by Jean Piaget, Jerome Bruner, and Lev Vygotsky serve as a basis for constructivist learning theory. Piaget, Bruner and Vygotsky are cognitive constructivists, and their learning theories are based upon sequential development of mental processes (Piaget, 1926; Bruner, 1960; Vygotsky, 1962).

To Piaget, knowledge is not delivering the information at one end, and memorizing and applying it at the other end. Instead, knowledge is the experience that is generated

through interaction with the world, people and things (Ackermann, 2001). In the educational setting, the more a student questions and experiences, the more the information makes sense and is remembered. He suggests using concrete situations and real problems in learning settings. When the problem comes from a concrete situation, or is related to a different interest, students may show an entirely different attitude to the subject.

A major theme of constructivist learning theory, as interpreted by Bruner, suggests that learning is an active process where learners construct new ideas or concepts based upon their prior knowledge (Bruner, 1960). Relying on a cognitive structure, the learner picks and transforms the information and makes individual meanings. To Bruner, interpretation of the information and experiences are important in learning as it may be different from person to person. He also believes instruction should be going beyond the information given and be concerned with the experiences and contexts that make the student interested and able to learn (Huitt, 2009). In other words, Bruner suggests that educators encourage students to discover principles by themselves, based on their own interests, and examine how they process information effectively.

By doing so, metacognitive skills and thoughtfulness are improved in learners. Metacognitive skills refer to learners' ability to understand and manipulate the cognitive processes. They involve thinking about thinking and purposely making changes in the way of thinking (Tan et al., 2003). Through constructive education students develop skills and habits of minds for more self-directed learning.

Vygotsky, who is considered a social constructivist, identifies constructivism in the social settings where knowledge is constructed collaboratively in groups, and where shared meanings are created (Vygotsky, 1978). To Vygotsky, the social and cultural environments influence the learning process where individuals question, share findings, discuss and collaborate to accomplish a task. As a result, instructional strategies that encourage students to work together and share their ideas to complete a task create collaborative learning environments where students learn from each other.

Educators who use constructivism as their didactic methodology advocate for the use of discovery learning where students are involved in experimental learning instead of using reading and lecturing. However, constructivism is not a method or a universal model for teaching and learning. It does not provide teaching strategies for the teachers to implement in

the classroom. A teacher needs to make such learning situations happen and engage students in the learning process; a teacher needs to involves students in the learning process and allows them to experience in real life situations in order to "balance instruction and construction" (Dewey, 1931). It is the art of teaching to find the balance between making an instruction frame and offering freedom for construction within the frame. Dewey (1931) called it "construction through instruction". Teachers should be prepared in subject content as well as, in meta-competency skills, like designing the learning environment and facilitating the learning experiences. Designing constructivist learning environments positions teachers as constructivist thinkers. They actively design practices that make more sense to the learners and make the connections. Constructivist teaching is not only providing learning opportunities for students; teachers also learn and construct knowledge by designing practices, solving the problems, and experiencing.

An interaction between the learner as observer and the observed world with all its complexity arises in constructivism. John Dewey (1916) believes this interaction is essential for gaining knowledge; it produces experiences which create further interactions. Hence, he has been known for developing experiential learning as a constructivist theory of learning through real life experiences and making meaning from direct experience.

2.4.2 Grand Learning Theory: Experiential Learning and John Dewey's Approach

John Dewey is the most important proponent of experiential learning. Dewey's philosophy and methodology of experiential learning implies that the strict authoritarian approach of traditional education was overly concerned with delivering preordained knowledge. It was not focused enough on students' actual learning experiences. He claims students should be given the opportunity to apply their knowledge and skills through connections to the real world situations, reflect on their actions and construct more knowledge (Dewey, 1938). Experiential learning is also referred to learning by doing, learning through action, and learning through experience. In fact, by applying experiential learning, educators are asked to engage students in purposeful activities and reflection in order to increase knowledge and develop skills. Experiential learning is learner centered and activity-oriented with the emphasis on the process of learning, rather than the product.

Dewey (1938) presents two significant principles for education based on experience: continuity and interaction. Dewey's principle of continuity indicates all experiences (past and

present) are carried forward and influence future experiences and decisions (Dewey, 1938, p. 35). Dewey's principle of interaction refers to the objective and internal conditions of an experience (Dewey, 1938, p. 42). To him, knowledge is continuously derived from the learner's experiences, and learning happens in a meaningful process by continuity of experiences. The interaction between the student and the environment in the process is an important factor that contributes to student's learning. This approach focuses on the process of learning rather than the outcomes, and distinguishes experiential learning from the traditional approach to education. Continuity and interaction ties to the constructivist learning where knowledge is generated through interactions with the environment (Piaget, 1926), and other people (Vygotsky, 1978) based upon the prior knowledge (Bruner, 1960).

Dewey's approach of experiential learning aims at engaging the student in the learning process to experience real life situations. Students applying this approach are involved in lifelike learning processes. It follows a constructivist perspective in learning and the role of the teacher is facilitating the learning process, rather than providing information.

There are several forms of experiential learning that currently being used in educational settings. Problem-based learning (Barrows, 1980), inquiry based learning (Schwab, 1960), Reggio-inspired learning (Edwards, Gandini & Forman, 1998), and constructionist (Papert, 1980) as experiential types of learning are grounded in constructivism, reclaim Dewey's approach, and try to turn the theory in practice.

Finding the real-world problems and offering suggestions to such complex problems through designing and making prototypes is grounded in constructivist learning and it can be positioned as a form of experiential learning. Offering concrete solutions to a real-world complex problem has the potential to train certain skills like motivation for exploration, openness for new ideas, creative thinking and other meta-cognitive competences (Noweski et al., 2012). Within this line of learning, students and teachers interact, construct knowledge, reflect and create meaning in appropriate learning practice to better understand a concept. According to DBR approach in this study, I address constructionist learning theory as an intermediate scope of theory to turn the philosophical learning theory (constructivism) and grand learning the theory (experiential learning) in practice.

2.4.3 Intermediate Learning Theory: Constructionist Learning

Building upon constructivism in learning and John Dewey's experiential approach, Seymour Papert develops a theory in learning called constructionism. Constructionism by Papert is more pragmatic and applicable than constructivist learning theory. Constructivism refers to building knowledge in your head. However, constructionism focuses on building something meaningful outside of your head.

Constructionist learning can be simply formulated as learning by making or learning by designing. Within a constructivist and experiential approach, constructionist learning theory advocates that knowledge is not available and pre-built. Instead, ideas are constructed by creating objects with tools; knowledge is built by the learner through making meaning and relating those meaning to previous meanings in one's own context. The process of meaning making in constructionist learning happens when something concrete is created. Learners build models from part of their real world in order to understand its meaning, substance, and dynamics. To support this claim, Papert (1990) explains learning by designing "leads us to a model of using a cycle of internalization of what is outside, then externalization of what is inside" (p. 3). In fact, learners construct knowledge through internalization of actions in a context, where they engage in making 'a public entity, whether it is a sand castle on the beach or a theory of the universe" (Papert, 1991, p.1). Expressing ideas and projecting the inner feelings are key factors in learning. Projecting out students' ideas on the objects that they create makes their ideas tangible and sharable, and helps them communicate.

To design and make something meaningful, one needs tools. But, rather than concrete tools, the act of building may occur by using words, diagrams, and sounds. Papret also brings up using technology an emerging tool in our digital age. He mentions the important role and influence of technology and computers in the coming learning settings. To prove this concept, Papert and his team in MIT's Artificial Intelligence Department developed a new computer language called LOGO in the 1980s. LOGO as a programming system was interfaced with LEGO building blocks to create all sorts of objects (Papert, 1990).

Learning by designing and making reclaims experiential type of learning and follows the philosophy of constructivist theorists about learning. It reminds educators not to offer students only the pre-organized concepts and information, but rather provide students with meaningful learning practices and an active learning environment. Constructionism through

learning by designing also ties to STEM (Science, Technology, Engineering, and Mathematics) education. STEM supports bringing engineering and design within each of the other subjects at younger ages in educational settings. Martinez and Stager (2013), suggest making as an appropriate way to bring STEM into learning environments.

Making integrates imagination and creativity. But, prior to making, one needs to explore why to make, and what is worth making. Finding a problem, designing, and giving solutions to solve the problem, is an authentic way to approach making. Applying design thinking, inquiry and brainstorming prior to making an object, makes the process purposeful, and also makes the object as the specific solution to the identified problem. Conducting a Human-Centered Design process prior to making lets the learners focus on the value of empathy and not go immediately to the solution.

2.5 Taking Design Thinking into the Classroom

To meet 21st century expectations in education we need to re-conceptualize teaching and learning, and develop learning situations needed for the learners. Some parts of the previous and current practices have included the types of learning that are part of 21st century learning now, such as meaning making, creativity and innovation in the visual arts. Dewey is one of the theorists in the 20th century who suggests turning toward the arts as a representation of adapting, and building of meaning that constitutes experience (Dewey, 1938). He suggests the real art is the experience of making or encountering the object not the art objects. Integrating the arts to education has suggested ways of thinking that value learners as makers of meaning and creators of knowledge instead of receivers of the information.

Eisner (1998) relays the importance of educating artistic vision. His investigation of the artistry of education shares a number of important themes on experience, creativity and art with Dewey's approach. Eisner sees the educational experiences as artistry; he suggests considering education as the process of creating art allows us to look beyond the technical aspects and to develop more creative responses to the situations that educators and learners encounter.

There are shared commitments in artistic vision to education and the design thinking approach. They both acknowledge the cognitive function of education and the process, where meaning is made, and knowledge is constructed and shared. What is needed to re-

conceptualize teaching and learning in the 21st century is to cultivate a broader set of required skill in this age, and integrate them within the curriculum.

Design thinking, as a process for Human-Centered Design with consideration of gaining empathy to the targeted user(s) supports constructionist approach to learning, encourages students and educators to find and identify real world problem in the real situations, and to create prototypes as the possible solutions to those issues. The process of meaning making in constructionist learning happens when something concrete is created.

Schools can become the places where students practice their roles and develop their skills that they will need to apply later in life. As mentioned before, learning through design type of activities can support constructionist learning, which claims learning happens by creating something meaningful rather than learning by being told. Taking design thinking and making to schools, as appropriate complementary partners, supports a constructionism approach; it encourages students to find real world issues in the environment and to create products as the solutions to those issues. The aim of taking making and design thinking into the classroom is not by adding another course to the curriculum. Instead, the aim is to support personalized constructionist learning within the current curriculum. Crichton and Carter (Accepted 2014) believe taking this approach to the schools may just begin to answer the question of how to provide authentic and personalized learning opportunities for students.

In the following subsection, I am going to review multiple experimental research projects on design thinking which have been conducted in the real situations discussing possibilities and potential values, and restrictions of applying design thinking in learning settings.

2.5.1 Possibilities and Potential Values of Design Thinking in the Classroom

Design thinking has been considered as an approach to learning that can foster the required 21st century's skills. It has started to receive a lot of attention by researchers and practitioners in education. Design thinking involves observing carefully, thinking creatively, reasoning logically, and working collaboratively to generate solutions for complex problems. Razzouk and Shute (2012) believe if we prepare the environment for the students to apply processes and methods that designers use to ideate, and help them experience how designers approach problems, they will be more ready to face problems. They will be able to think outside of the box and come up with innovative solutions.

Design thinking is built upon fundamental mindsets to learning including human-centeredness, empathy, mindfulness of process, culture of prototyping, show don't tell, bias toward action, and collaboration. In developing these mindsets, Stanford's Red lab has been studying the influence of design thinking in educational settings.

Research findings from Red lab shows that hands-on design projects that focus on empathy to solve a specific problem, develop children's creative confidence (Kwek, 2011; Carroll et al., 2010). The Hasso-Plattner Design Thinking Research Program in Germany supports this claim through conducting an empirical study. This empirical study clarifies that there are different levels of creative knowledge, skills, and mindsets that can be achieved by applying design thinking. The researchers call the highest level creative confidence, and suggest design thinking can be used as a learning model towards achieving creative confidence (Rauth et al., 2010). When the students tackle the challenge of identifying a problem and giving solution to it, they begin acquiring creative confidence; they trust themselves to act as change agents in their own environment.

Learning through designing can provide situations for learners to be better able to see the relevance of educational content, and take ownership over their learning. A research in Red lab describes in a design project even the purpose of reading changed from "I am reading because my teacher told me to" to "I am reading because I need it to solve this problem" (Design Thinking in the Classroom, 2009, p.1). Engagement in the classroom increases when the students become responsible for their own learning. Carroll et al. (2010) have discovered that a design project facilitates the engagement of students in a classroom's activities. It provides an opportunity for all students to express their voices and opinions. Moreover, public presentation of the design projects influences engagement of students in the classroom, and motivates them to participate in the learning. Kolodner et al. (2003) claim students in middle school enjoy being the center of attention during public presentations of their projects. Also they enjoy that they are able to provide an idea for someone else to use.

Collaboration as an essential part of design thinking aligns with social constructivism by Vygostky and has been highly valued in design thinking projects. Carroll (2004) describes how collaborative design activities can result in a classroom climate where others' knowledge is valued. She believes collaborative culture in the classroom is impacted by students' willingness to listen to other's ideas, to take risks and to share their ideas with

others. Designing and learning by designing are social processes where collaboration is needed. The multifaceted nature of designing encourages shared meaning-making through identifying and negotiating various alternatives, constraints, and possible solutions. In a collaborative human-centered approach to design, gaining empathy is a key part of designing something in order to meet the needs of the user. In the process of design thinking students understand human needs through gaining empathy for the user(s). Rauth et al. (2010) believe empathy develops through a process of need finding where students focus on discovering peoples' explicit and implicit needs.

To implement a design project, a teacher acts as a facilitator. S/he does not expect the students to follow a fixed path, instead, allows them to explore their own way through trial and error. Siok et al. (2007) emphasize the importance of interventions in a design process; they declare that intervention by teachers became the critical moments of design process, and it was significant to each student's design when they had dialogue with the teacher and received feedback. This aligns with Schon's (1996) claim, that design is learnable; it is not teachable by classroom methods. Therefore, the helpful interventions are more about coaching rather than teaching.

Coaching a design process well, and starting a conversation with the student to provide him/her with appropriate feedback requires both teaching and design skills. A designer or an architect may not be necessarily a good educator, and an experienced educator needs to acquire initial skills of designing in order to intervene effectively in an appropriate time. In Kangas et al. (2011) experimental study the design project was lead by an expert designer who worked in partnership with the teacher. In this case, someone with design background and skills helped the teacher in creating the design challenge, guide the design process, and intervene the process as a facilitator. These types of partnerships may find a good balance between the educator's and designer's expertise in order to better design and implement a design project in educational settings; especially when the teacher is still novice in implementing the design process. Teachers can eventually become experts in facilitating the design process by experiencing it themselves.

Even trained and qualified experts are not quite comfortable with the involving complexity and ambiguity in design. A recent research conducted in Stanford's Red lab (Carroll, 2014), Stanford students were introduced to design thinking and STEM learning,

and then they began to integrate the concepts in middle schools. The significant finding of this research is that they felt uncomfortable at the beginning, and it was not easy for the university students to show their vulnerability. But through experiencing prototyping mindset, and then taking risk and making mistakes with the students when the design challenge didn't work out quite the way they wanted, they were able to feel more comfortable. One of them mentioned: "This discomfort finds roots in a desire for something to be perfect" (p.2). At the end of this experience, student teachers discovered they learned as much from the middle school students as they taught them. Like in any learning situation, over time beginning discomfort changes to confidence and skill.

The goal of teaching and learning design thinking is beyond just designing and problem solving; it could be an approach to learn the content knowledge as well. In Carroll's et al. (2010) project, design thinking became part of the classroom's instructional practices. In this project, design thinking was used as a connection to a geography course. So, the teacher needed to make the connection between the design challenge and the content knowledge of the course.

Three major themes emerged from Carroll et al. (2010) research that categorizes the different goals of applying design thinking in the classroom. Those themes are as follows:

- Design as exploring (understanding design): It highlights the ways that students engage in collaborative design activities and prototype-driven projects, and experience the design process. Design process gives an opportunity for inquiry and exploration and does not jump to immediate solutions.

- Design as connecting: (affect and design): It focuses on the powerful role of design in developing students' creative confidence, giving voice to students to express their ideas, encouraging risk taking, developing a successful collaborative environment, empathetic thinking, and problem solving.

- Design as intersecting (design thinking and content learning): This theme highlights the relationship between design thinking process and content knowledge of the specific subject. Integrating design thinking and academic content has been problematic and challenging for the teachers who are interested in using design thinking in their classrooms. This part needs further experimental research to find out appropriate connections between design thinking and content learning in different levels of education.

Although design thinking has been addressed as an innovative instructional strategy and plays an important role in supporting constructivist teaching and learning, there are still restrictions and challenges in implementing it in real situations.

2.5.2 Restrictions of Applying Design Thinking in the Classroom

Research findings in Stanford's Red lab shows teachers have assigned design thinking in multiple ways to suit different learning contexts after being introduced to the concept. Even though this is the case, the mastery of core content still drives how design thinking is used to intersect with classroom learning. This research acknowledges that "design thinking should be used as a tool to intersect with the existing classroom learning culture and routines and emphasizes design thinking doesn't belong to every time, design thinking has a place at its time" (Kwet, 2011, p. 15). So, teachers need to invest extra time and energy to understand design thinking concepts deeply, experience it to become more comfortable with it, and then apply it in its right place and time to reformulate their current instruction.

In addition, adopting any innovation means departing from the familiar habits and practices. Kwek (2011), whose study is about using innovation in the classroom using design thinking, believes each teacher has a set of tried and tested methods and also routines that satisfy their needs in the classroom. Therefore, one may understand the value of design thinking in learning and teaching, but reject supporting it. Designing the design types of activities needs more time and effort, and it may conflict with the topics that teachers have to cover. Moreover, design skills and knowledge are required both for novice teachers as well as experts. If teachers are to assist students in the design process, it is important to have a deep understanding of design thinking, to be familiar with the related skills including visual skills and technical skills to lead the process, and to experience it in the classroom. Referring back to Schon's reflective practices (Schon, 1983) teachers can acquire those kinds of skills and construct more knowledge by experiencing design thinking in the classroom and then reflecting upon it. But, it requires extra time and effort.

2.6 Concluding Remarks for Chapter 2

Twenty first century demands a very different set of skills and competencies from people to deal with challenges in this age; required skills include critical thinking and problem solving, creativity and innovation, social responsibility, global awareness, communication, digital literacy, and collaboration. Schools are the best places to provide students with the opportunities to acquire these skills. Thus, teachers are being asked to change their roles towards designing and facilitating constructive learning environments to connect the 21st century's competencies with the curriculum; this has changed the role of learners as well. Learners are not only supposed to be the receivers of information, but also, play an important role as co-designers. Learners should take the responsibility and ownership of their learning.

Design thinking, as a human-centered approach to designing, started to receive significant attention in 21st century's educational settings in terms of how teachers teach, and also how students learn. Design thinking provides possibilities to find problems and present solutions to them. It consists of careful observation, creative thinking, logical reasoning, and collaborative working to generate solutions for complex problems through the creation of prototypes.

Design thinking can be integrated into the Maker Movement in the digital age in order to benefit from the possibilities of technology to make prototypes. This integration can be applied purposefully in educational settings in order to make meaning by creating something. This approach provides opportunities to learn, and to build knowledge upon prior knowledge which aligns with constructionist learning. Constructionist is rooted in experiential learning and follows constructivist approach to learning.

Researchers and educators who use design thinking in the classroom declare that design thinking has influenced student's engagement in the classroom, created creative confidence, developed collaborative culture, and helped students to gain empathy for other people. However, there have been obstacles and challenges in implementing it in different situations.

Making the connection between design thinking and content knowledge has been a challenge for educators. Also, teachers need to acquire initial knowledge and skills in designing to become more comfortable with design thinking process, experience it, and make

it more meaningful for themselves and for students. Solving such problems requires providing teachers with more opportunities for professional development in this field, a desire to change from teachers, extra time and effort by teachers to understand the concepts of design thinking deeply, to connect it to the content learning, and to apply it in appropriate times and places.

Chapter 3: Methodology

3.1 Overview of Chapter 3

This chapter explains the research methodology and the research design. First, an overview of the study, research objectives, research questions, and research paradigm will be outlined. Second, a description of the research methodology and how it is interrelated with the tenets of the study and the research questions will be discussed. Next, the relationship between research methodology and the larger scale, development, and design of the study will be discussed. Then, the actual procedures conducted within the framework of the methodology will be expressed in detail. Finally, validity and possible limitations of the study will be explained.

3.2 Overview of the Study

Twenty first century requires a different set of skills and competencies to cope with the challenges (Pink, 2005; Wagner 2010; Gardner 2007). Therefore, educational systems are trying to provide teachers and students with the experiences to acquire the required skills. Teachers are increasingly being asked to change their roles towards designing and facilitating learning environments to connect the 21st century's competencies with the curriculum.

Accordingly, in the British Columbia's Plan (2010a), educators are being asked to move toward designing the learning environments to connect the 21st century's competencies to the existing curriculum. To support educators in making changes to their practices, the Innovative Learning Centre (ILC) conceptualized and developed Maker Day Professional Development events. The aim of these events was to introduce teachers to design thinking and the concept of making as an innovative pedagogical approach to 21st century's teaching and learning; to encourage them to experience the concepts directly at the events and bring them into their classroom.

This study follows participants of a Maker Day, which was developed for secondary school teachers in School District #83 in the North Okanagan. It aims to evaluate the event and generate contextual design principles and recommendations for the future.

3.3 Purpose of the Study

This study follows a Maker Day, which was developed as an experiential and immersive in-service Professional Development event for secondary school teachers in the North Okanagan and evaluates the potential impact of the Maker Day on the participants' understandings of design thinking. It also explores how the participants might use the introduced concepts in their classroom.

Guskey's (2000) model of five critical levels of Professional Development evaluation is used as a guideline to evaluate the Maker Day in this study. This study collected and analyzed data qualitatively, with focuses on Level 2: Participants' Learning, and Level 4: Participants' Use of New Knowledge and Skills. Guskey (2000) argues Professional Development events usually are evaluated at Level 1 which is based on Initial Participants' Reactions. He claims that the data collected from Level 1 is not informative enough for measuring the impact of the event on subsequent practice.

3.4 Research Questions

This study explores the impact of a Maker Day through the following research questions:

1. What are the secondary teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event? and,
2. How might the participant teachers envision implementing design thinking concepts into their classroom?

3.5 Research Paradigm

This study, with its focus on generating knowledge about a Maker Day from reflections of participants, was conducted within a social constructivist epistemology. Social constructivist epistemology considers that people construct meaning together in relation to their engagement with the human world (Crotty, 1998). According to Koro-Ljungberg et al. (2009), educational research within social constructionist approach is multifaceted, and generates knowledge from groups of participants in order to transform the practice.

Data analysis is conducted within an overall interpretivist paradigm which assumes that a primary aim of social science is to understand what people mean, and intend, by what they say and do and to locate those understandings within the situational context (Moss et al., 2009).

3.6 Research Methodology

This study has been conducted within the framework of Design-Based Research (DBR). In the following sections, I introduce DBR, outline the interrelated characteristics of DBR and the tenets of the study, and explain how the research questions are connected to the DBR framework. Then, I explain the relationship of DBR with a larger scale study of Maker Days, and with the development of this study. Finally, I describe the research design and procedure within the framework of DBR.

3.6.1 An Overview of Design-Based Research

"Research for education" (Juuti & Lavonen, 2006, p. 54) has a pragmatic objective, often to improve teaching and learning through bridging the gaps between theory and practice. It is different from "research about education" (Juuti & Lavonen, 2006, p. 54), which has an intellectual aim to better understand teaching and learning. Design-Based Research has emerged as a methodology (Wang & Hannafin, 2005) for "Research for education" to link theory and practice within educational research, and as a way of generating useful knowledge to guide educational practice (Design-Based Research Collective, 2003; Lai, Calandra, & Ma, 2009; Ma & Harmon, 2009). Design-Based Research seeks to increase the impact of education research into further and better practice through generating "new theories, artifacts, and practices" (Barab &Squire, 2004, p.2), in iterative cycles of designing, evaluating, and redesigning.

Design-Based Research is grounded in the act of designing and includes aspects of design domain. It is represented by finding a design problem and offering solutions through a design process. It also creates interactive relationships among researching, designing and engineering. To support this claim Edelson (2002) declares that DBR is the combination of theory development, design process, and the design solution. He suggests "design research yields practical lessons that can be directly applied, and design research engages researchers in the direct improvement of educational practice" (p.105). The cycles of analysis, design, evaluation and revision are iterated until "a satisfying balance between ideals and realization has been achieved" (Plomp, 2007, p.13).

Historically, Brown (1992) and Collins (1992) were the first scholars to introduce the concept of DBR- called design experiments- in education research. It has received significant attention in educational research. Drawing from this approach, new learning practices are

designed, formative research is conducted for testing and refinement, and new design principles are generated.

Although DBR approach addresses a variety of educational problems and offers different kinds of solutions to those problems, it contains distinctive qualities that can be found in different situations. Wang and Hannafin (2005) assign the basic characteristics of DBR as: pragmatic, grounded, interactive, iterative and flexible, integrative, and contextual.

3.6.2 Interrelated Characteristics of Design-Based Research and This Study

In the following subsections, I compare the characteristics of DBR to the tenets of this study. The interconnected factors of DBR and this study are: grounding in theory and real practice; having a pragmatic stand; conducting iterative and flexible process; using multiple perspectives; integration of data sources; and connecting with the context.

3.6.2.1 The Substance of the Study Is Grounded in Concrete Realities of Practice and Theory

Design-Based Research is grounded in real-world educational contexts within design settings (Wang & Hannafin, 2005; Brown & Campione, 1996). Through this approach, researchers select a theory about learning and teaching, examine the literature, and then design/redesign a practice according to the identified needs. Then, they implement the practice in real situations.

This research is situated in School District # 83 in British Columbia, and follows a Maker Day. The Maker Day has been designed as an in-service Professional Development event for secondary school teachers to address associated needs in British Columbia's educational situation, and support professional learning for teachers to design 21st learning environments.

In addition, DBR is theory-driven and grounded in the relevant research, theory and practice (Wang & Hannafin, 2005). Philosophical theories are important to develop educational practice, but they often do not provide detailed guidance to organize the instruction. The critical question in applying the philosophical grand theories is how the general theory informs the practice. diSessa (1991) argues rather than fundamental theories of learning, that design experiments need an intermediate theoretical scope because the grand theories may be difficult to project into specific circumstances.

This research, as a micro-cycle study of the Maker Day, is grounded in philosophical and grand learning theories, as well as intermediate scope of learning theory. It explores potentials of learning by designing to cultivate broader sets of required skills in 21st century to integrate them with the curriculum. Acknowledging the power of designing and making something that comes from a question, supports constructionist learning, developed by Papert (1990). Papert establishes his theory based upon Dewey's (1916) experiential learning and follows constructivist theorists who believe knowledge is not delivered but rather constructed based on experiences, interactions, and interpretations (Piaget, 1926; Bruner, 1960; Vygotsky, 1962). Papert (1990) takes constructivist and experiential learning theories a step further toward action. Thus, drawing from DBR approach, I address constructionism as the intermediate scope of theory for the study, experiential learning as the grand framework of theory, and constructivism as the philosophical framework upon which this study has been developed. In Chapter 2, I reviewed the literature of theoretical framework for the study and explained the interconnection of the involving theories in detail.

Design thinking, which is the focus of this research, was used as an instructional strategy to put constructionist learning in practice and d.School's design thinking process (Stanford, 2009) (see Appendix J) was applied as a successful process reported in the literature. In this study, I explore understandings of teachers on design thinking concepts, as well as the ways that they might envision implementing them in educational settings.

3.6.2.2 The Theory and Practice Relationships Are Pragmatic on an Ongoing Basis

Design-Based Research takes a pragmatic stand, and aims to link the gap between educational research and practice by providing new possibilities in learning environments. It incorporates an educational artifact -which is grounded in relevant theories, research, and practice - and tries to refine both theory and practice continuously (Cobb et al., 2003).

This research investigates the impact of a Maker Day on participants' understandings of design thinking and their instructional strategies. Study of teachers' understandings of design thinking prior to, and following the Maker Day, and also investigating the strategies that the participant teachers envision implementing the concepts, are significant to improve the design of such events in future. It may be tailored to better meet the needs of the teachers. Results from this study also refine the process upon which Maker Day was developed.

Because of the dynamic and complex relationship between theory and practice (Wang & Hannafin, 2005), interaction of researchers and teachers is essential in DBR. Following up with the teachers in order to identify their understandings and practical approaches on design thinking is helpful to address the strengths and identify gaps in the content and organization of the Maker Day. It helps to generate contextual design principles for improvement of the event in the future designs.

3.6.2.3 Iterative and Flexible Structure through Interaction and Deliberation

DBR is an interactive process in which researchers/designers are working in collaboration with the practitioners. They work together to identify problems, give possible solutions, and develop the existing principles through iterative cycles of design, implementation, analysis, and redesign (Design-Based Research Collective, 2003). The process follows a flexible research strategy and multiple methods may be used for collecting data as new needs emerge. The recursive movement that ensues within the design process allows for flexibility. Moving from analysis-to-design-to-reflection-and-redesign creates room for continual refinement (DBR Collective, 2003). The iterative process of design involves featuring cycles of invention and revision.

Following up with participant teachers in the Maker Day helped to identify the contextual needs and give possible solutions to be applied in the next events. In this study data was collected through sequential phases based on the needs of study. The data analysis was conducted through an iterative cycle; coding and recoding of data have been done according to the information interpreted and the themes that emerged from the data. Tentative analysis of data in each phase guided the study to design the next phase. Also, data analysis was conducted through a retrospective and cross-iteration approach continuously and constantly.

3.6.2.4 Multiple Perspectives Ensure Integration of Data Sources

In DBR approach, multiple perspectives ensure integration of data sources, methods of data collection, and analysis of procedures that are interdependent with the needs (Wang & Hannafin, 2005). As mentioned before, this study is multi-phased research conducted in three sequential phases. In order to maximize the objectivity and applicability of the research, different methods of data collection have been used purposefully. The data has been collected from the pre-event surveys, the post-event surveys, and the semi-structure interviews. Pre-

event and post-event surveys provide the research with the teachers' understandings of design thinking prior to, and following the Maker Day experience, which tie to the first research question. The interviews have been conducted to give a more detailed and explanatory picture of the situation and to provide the study with in-depth understandings of secondary school teachers with regard to their instructional behavior and practical strategies in the classroom. This part ties to the exploration of the second research question.

3.6.2.5 Context Intentionally Connects the Design Process with Findings

Drawing from DBR approach, research findings and results are connected with research context, and with design process, through which findings are generated (Wang & Hannafin, 2005; van den Akker, 1999; Design-Based Research Collective, 2003). Therefore, documentation of the design process, and reflection upon it, play an important role in providing evidence, claims, and guidance for interested researchers/designers in order to develop new cycles of design. Shavelson et al. (2003) suggest documentation in DBR provides evidence and guidance on the use of resulting principles. Through systematic documentation, evaluation, and reflection interested researchers/designers can be informed, to follow, apply, test, and refine the principles.

This study is a micro-cycle of research, which documents and evaluates a Maker Day. Findings of the study connect with the context of the study in the School District # 83 in British Columbia, where the Maker Days have been developed. They provide evidence to inform policy makers in the province, school district decision makers, researchers, and educators with the contextual strengths and needs. The results connect to design process as well exploring the strengths, weaknesses and gaps in Maker Day activities. They provide evidence and guidance for designing such events in the next iterations.

Methodologically, this research is a case study (Stake, 2005; Yin, 2003), which followed a Professional Development event. Findings from this study can be examined and adapted to other contexts for their own purposes. It is important to note that they cannot be generalized to a larger universe. They must be tested through iterations in a second, third or more cases, with the purpose that the same results should occur (Yin, 2003). As van der Akker (1999) notes generalization of the findings in DBR increases when they are validated in "successful design of more interventions in more contexts" (p.9). Cronbach (1975)

clarifies "[w]hen we give proper weight to local conditions, any generalization is a working hypothesis, not a conclusion" (p.125).

3.6.3 Design-Based Research and its Interrelationship to Research Questions

Design-Based Research is conducted in iterative cycles of designing and refinement. Thus, conducting a systematic documentation and reflection upon design in each cycle is necessary in order to improve the design. Plomp (2007) believes the twofold product of DBR includes "research based interventions as well as knowledge about them" (p.13). Systematic reflection and documentation as the continuous activities should take place during the cycles of DBR.

This study tries to systematically document, reflect, and evaluate the Maker Day with specific focus on design thinking. It aims at producing knowledge about whether and why Maker Day as an intervention worked in the certain context, and develops contextual design principles for future cycles of design.

Based on DBR literature, Plomp (2007) concludes that DBR experiences comprise of the following three stages:

Preliminary research: includes needs and context analysis, literature review, and development of a theoretical framework for the study;

Prototyping phase: includes iterative design phase, each being a micro-cycle of research with formative evaluation intends to improve and refine the intervention; and,

Assessment phase: includes evaluation to conclude whether the solution or intervention meets the pre-determined characteristics.

Linking these categories by Plomp (2007) to the research questions, exploring and comparing the teachers' understandings about design thinking before, and after experiencing it, fits in the assessment stage. The assessment stage includes (semi-) summative evaluation to "conclude whether the intervention meets the predetermined specification" (P.15). The assessment stage also aligns with Level 2 of Guskey's (2000) Professional Development evaluation model, which is Participants' Learning.

The second research question is if the participant teachers envision implementing the learned lessons on design thinking in their own classrooms. It aligns with Level 4 of Guskey's (2000) model, which is Exploring Participants' Use of New Knowledge and Skills. It corresponds to the prototyping stage by Plomp'e (2007), and aims at drawing attentions for

more efficiency, and to improve the implementation of program content. The results of semi-summative and formative evaluation generate design principles and guidelines to optimize the design of Maker Day. Figure 3.1 illustrates a schematic overview of Plomp's (2007) stages of DBR and their linkages to the research questions in this study.

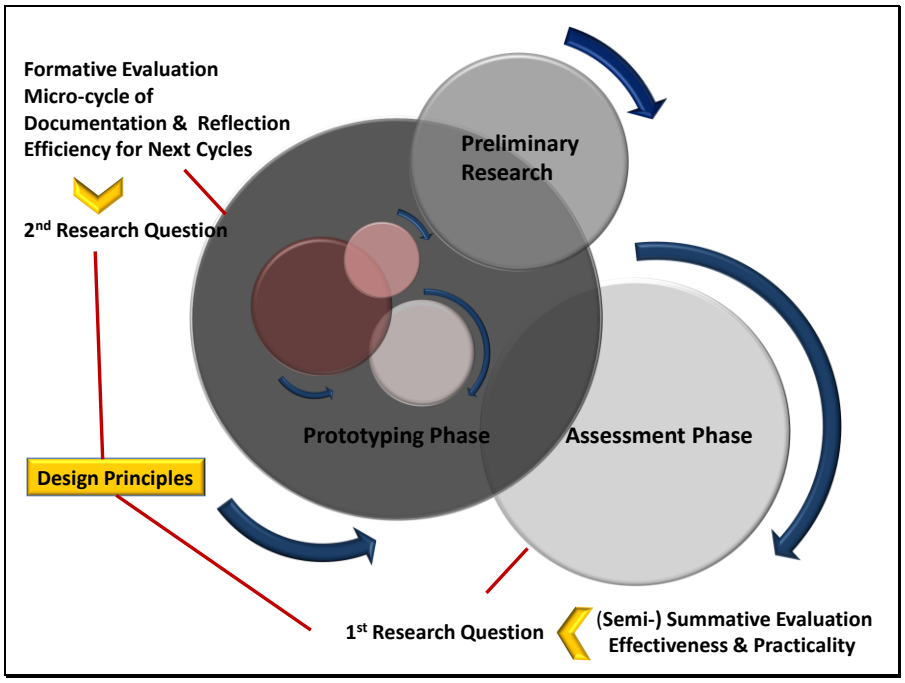


Figure 3.1 DBR stages by Plomp (2007) and their interrelationship to the research questions

3.7 Conducting the Study within the Framework of Design-Based Research

This study has been developed and conducted within the framework of DBR. A diagram suggested by Reeves (2006) is used as a structure to show the iterative cycles in this approach. First, I describe the relationship between DBR and the existing larger scale study of Maker Days upon which this research has been developed. Second, I compare the DBR process with development of the study from where I identified the problem -to proposal preparation- to revisions- to data collection- and to analysis. Finally, I explain the actual process of study including the context, participants, recruitment, data collection phases, and data analysis strategies.

3.7.1 Design-Based Research and its Relationship to the Larger Scale Study

This study sits within an existing larger scale research/practice of Maker Days. Maker Days have been designed to support British Columbia's Educational Plan (2010a), where educators are being asked to become designers of their learning environments. Figure 3.2 shows the relationship between four stages of Reeves's (2006) DBR diagram and the larger scale study of Maker Days.

As Plomp (2007) states, mindful reforms cannot be developed at the tables of government offices but instead, it should be considered as a call for systematic research to support the development and implementation of innovative processes in the context. Identifying the need for change in British Columbia's educational system connects to the first part of the DBR diagram identified by Reeves (2006), which is analysis of practical problems.

As prototypical products, Maker Days have been designed to solve a context-specific problem in British Columbia's educational setting**.** This stage in ILC's research connects to the development of solutions informed by existing principles and practical innovations in Reeves's (2006) stages.

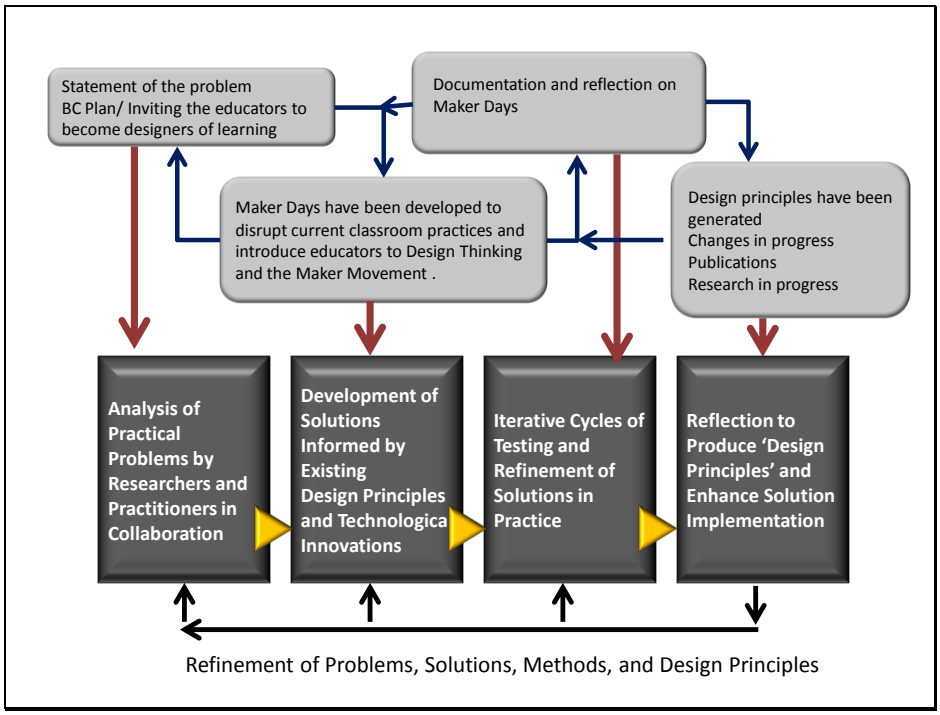


Figure 3.2 DBR approach (Reeves, 2006) and its relationship to the larger scale study

The Maker Day, which is the focus of this study, was the second one among other Maker Day events that have been developed in British Columbia. After the first event, documentation and reflection upon it was conducted. Findings from the first iteration propelled the ILC research to makes changes in the resources (i.e., problem sketch required editing, facilitators required a checklist, etc.), and changes to process (i.e., different materials available for prototyping, more time required for reflection in groups, etc.), and finally to the revision of the open access Maker Day Tool Kit (http://blogs.ubc.ca/centre/2013/11/18/maker-day-tool-kit/) (Carter et al., 2014). Findings from the first iteration have been reported and published; this process of designing and reflecting is a work in progress. This study with specific focus on design thinking aims to be of service to the second Maker Day by offering a descriptive and explanatory analysis for the second Maker Day. This iterative cycles of testing, refinement and reflection ties to the third and forth stage of Reeves's (2006) diagram.

3.7.2 Design-Based Research and its Relationship to Development of the Study

Herrington et al. (2007) identify Reeves's (2006) approach to DBR suitable for development of the doctoral thesis; they suggest following this approach assists the students developing their skills, and strategies to become researchers. They believe the four stages of Reeves's (2006) approach match with the stages of conducting a doctoral thesis.

I found the developmental stages by Reeves (2006) appropriate for developing this study as a Master's thesis as well. Figure 3.3 illustrates the relationship of the four stages of DBR by Reeves (2006) and the development process of this study.

At the first phase, the problem has been identified, the literature was reviewed preliminarily, and the research questions emerged. At the proposal stage, stage 2, the theoretical framework and research methodology were articulated. In the iterative cycle of development and revision of the proposal, stage 3, I revised the proposal several times, after I got the thesis committee's feedback. This was followed up by preparing the ethics, getting feedback from the Ethics Board, and making minor revisions of the ethics application.

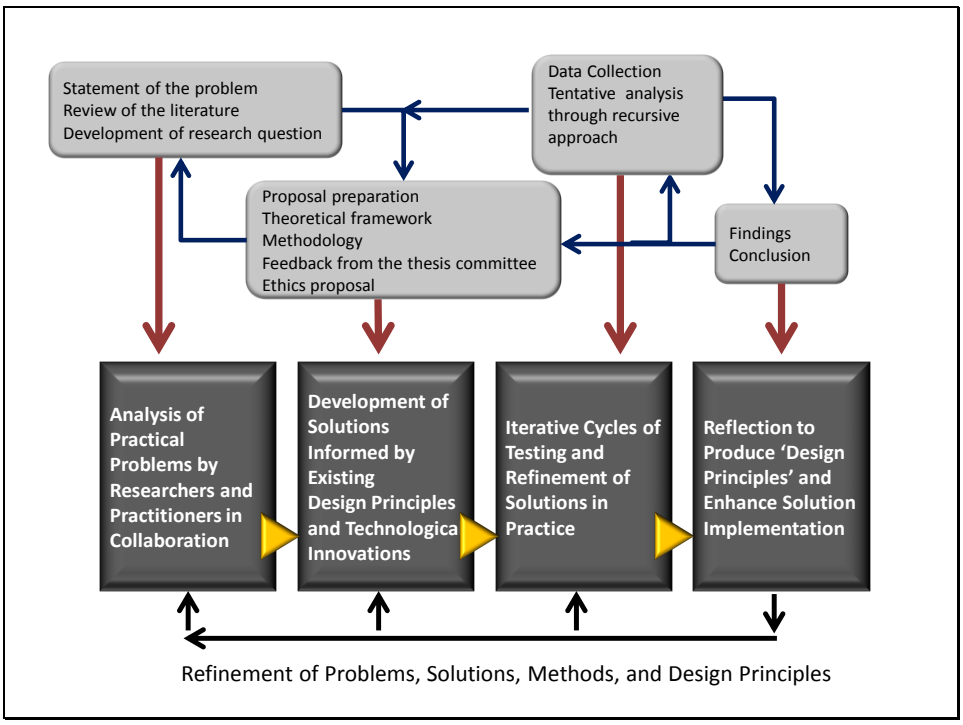


Figure 3.3 DBR approach (Reeves, 2006) and its relationship to development of the study

Data collection and tentative data analysis started in stage 3. Returning to the stage1 allowed for data collection decisions, as the study needed. After each phase of data

collection, going back to the theoretical framework, and literature in each phase of the study, helped me to analyze the data through a recursive approach, and based on the themes emerged. The iterations throughout the study allowed conducting tentative analysis of findings in each phase, and guided the study to reflection and generating design principles which aligns with stage 4 of Reeves's (2006) diagram.

3.7.3 Design-Based Research and its Relationship to the Process of the Research Design

Design-Based Research (DBR) approach structured the actual process of development and design of the study. In this section, I describe the process, through which this study was developed, within the framework of DBR. In this part, I use Reeves's (2006) stages of DBR approach as a guideline (see Figure 3.4).

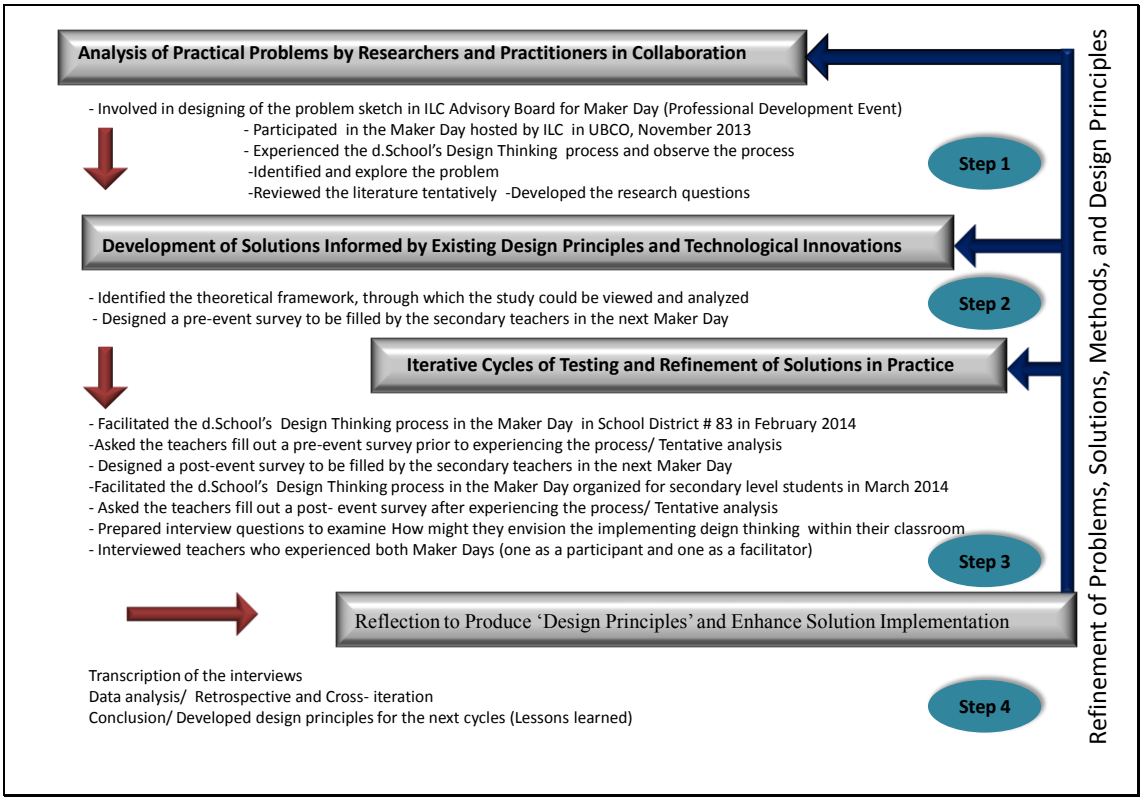


Figure 3.4 DBR approach (Reeves, 2006) and its relationship to the research design

Analysis of practical problem is the first step in Reeves's (2006) diagram. This step in my study started with the ILC Advisory Board, where I have been involved as a Graduate Students' Representative. Being introduced to Maker Day's aims and intentions, and the Stanford's design thinking process, the advisory board was involved in designing the problem sketch for the first Maker Day in November 2013. I participated in this event,

worked with the group members collaboratively to solve the design problem we were given, experienced the d.School's design thinking process, and observed how the process worked. According to my interest and background in industrial design, and my experiences as a designer and design educator, design thinking fascinated me. This led me to conduct my Master's thesis on this topic. To identify and explore the problem, I reviewed the literature and brought up two research questions: I was interested to explore the Maker Day's impact on teachers' understandings of design thinking; and, I also wanted to explore how they might have interpreted and brought the concepts into their classroom. Along the way, I had several discussions with my supervisor and thesis committee members. I also took a direct study course specifically on design thinking to have a deeper understanding of how design thinking might work as an instructional strategy in learning environments (see Step 1 in Figure 3.4).

Next step in Reeves' (2006) diagram includes development of solutions informed by existing design principles. At this stage, it was crucial to review the literature more deeply, and identify the theoretical frameworks through which the study was developed, designed, and analyzed. As I participated in the Maker Day experience, identifying the research questions, reviewing the literature and articulating the theoretical framework, I felt ready to start the data collection in a similar context. In the subsequent Maker Day for School District # 83 I designed the pre-event survey for this Maker Day to see what the understandings of teachers were prior to experiencing it (see Step 2 in Figure 3.4).

I attended a subsequent Maker Day in February 2014, which is the case for this study. I was involved as a facilitator in this event; I worked with a group of four secondary school teachers describing the design sketch, and facilitated the d.School's design thinking process. Before the event, I asked the teachers to fill out the pre-event surveys. After this event, I went back to the literature, and analyzed the data from the pre-event surveys tentatively, and designed a post-event survey based on needs of study, to be completed by the same teachers. The post-event survey was designed to examine participants' understandings of design thinking after experiencing it. I analyzed the data from the post-event surveys tentatively and this guided the study to the next step - to design the interview questions to see how they might implement the concepts in their own classes. The interviews also helped as a complementary source of data to the post-event surveys to explore participants' understandings of design thinking after experiencing it (see Step 3 in Figure 3.4).

Going forward to the next step, I started analyzing and synthesizing the data collected and reviewed from different phases of the study. Data analysis took the form of retrospective and cross-iteration comparisons. Design principles generated from analyzing the data need to be applied and tested in the next events (see Step 4 in Figure 3.4).

3.8 Actual Procedures of Study within the Framework of DBR

In this section, I explain how DBR, as a research methodology, guided the actual process of conducting this research. First, I explain the context of the study within the Maker Day, the involving participants in different phases of the study, and recruitment of the participants. Then, I describe different phases of data collection and data analysis strategies within the framework of DBR approach.

3.8.1 Context of the Study

It was mentioned earlier that DBR is grounded in real-world educational contexts within design settings. Drawing from DBR approach, this research is situated in a real educational context in School District # 83 and stands on an existing designed practice of Maker Day.

At the Maker Day, educators were introduced to design thinking, inquiry and experimental learning through small groups to solve a design problem. One of the goals of the event was to engage teachers in designing and making, in addition to, encouraging them integrate these practices into their classrooms. By engaging in the iterative d.School's design thinking model, the educators used the main scenario, which was created to gain empathy for the person they were designing for, and to get feedback. Stanford d.School's design thinking model "is a 90-minute fast-paced project though a full design cycle. Students pair up to interview each other, create a point-of-view, ideate, and make a new solution to their partner" (Stanford University, 2009). After completing the design thinking activity and defining the design problem participants drew from a bank of materials to create a prototype.

This study investigates the impact of the Maker Day experience on participant teachers' understandings of design thinking. Also, the study explores the probable ways that the participant teachers integrate the concepts into their classroom.

3.8.2 Participants

Drawing from a DBR approach and based on the needs of study, this research developed through three sequential phases. The participants of each phase are explained below.

The population of the first phase included thirteen voluntary teachers from secondary school in School District #83 who attended the Maker Day. At the event, they were asked to fill out a pre-event survey before experiencing the process of design thinking and prototyping.

The population of the second phase included seven teachers, who attended the Maker Day and completed the pre-event surveys. All the participants from the previous phase were asked to fill out a post-event survey and seven teachers voluntarily responded to the post-event survey.

The Professional Development Chairperson told me that the seven teachers who responded to this survey were the participants of the Maker Day who had developed a learning event similar to the Maker Day for secondary school students in School District # 83 one month after the event.

The population of the third phase included four voluntary teachers in secondary schools from School District #83. These teachers attended the Maker Day Professional Development event and completed the pre- and post-event surveys. All seven participants from the previous phase were given the opportunity to participate. The selection of the four teachers for this phase was based on their interest for being involved in the research. They were introduced to me by the Professional Development Chairperson for School District # 83. The interviewees were all secondary school teachers, and teach different subjects including Language Arts, Science, Math/Science, and Music.

3.8.3 Recruitment

In order to receive institutional permission to access the context of the study, and to conduct research in School District #83, I sent a request letter and a summary of proposed research to the Superintendent of Schools in School District #83 via email. I requested his consent and approval to conduct this research in School District #83.

As necessary, I applied to UBC's Behavioral Research Ethics Board (BREB) for their approval of this study. The research was considered 'Minimal Risk', and after minor

revisions, approval to conduct the study was obtained from the BREB in May 2014. The Certificate of Approval for this study can be found in Appendix B. As part of the required ethics process, the Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE) was also completed (see Appendix C).

After I received the ethics approval, I sent out the post-event surveys and the consent forms to the Professional Development Chairperson. The post-event survey can be found in Appendix F. The Chairperson distributed the documents to all the teachers who attended the Maker Day. Teachers who chose to participate signed the Consent Forms (see Appendix G) and returned them to the Chairperson. I also received the consents and the completed surveys from her.

As the Ethics Board required, I got consent from the participants, who had completed the pre-event surveys before. The teachers completed the pre-event survey, as a standard practice for the Innovative Learning Centre (ILC) for one of its Professional Development events. To use that data as the existing records in this study, I needed to get participants' consent. The pre-event survey and the teacher consent form to use the data can be found in Appendix D and E. Again, the Chairperson was the distributer and collector of the forms.

Teachers' participation in this study was voluntary. They were told that they could refuse participate, or withdraw from the study, at any time without giving a reason and without any negative consequences. The participants' identities in pre- and post-event surveys were anonymous. Teachers' names did not appear on the surveys, so there was no way to identify the teachers who responded to each survey. Participants in pre- and post-event surveys are assigned with numbers.

For the interview section, I asked the Professional Development Chairperson to introduce me to the four interested teachers whom completed both surveys. After receiving their contact information, I contacted them directly and set up a convenient interview time with them. In this phase, I knew the participants' identities but, I used a pseudonym at all times - when working with the data, when publishing, or when reporting the research findings. At the interview session, the participants each signed a consent form in order to use the data from the interview. The interview questions, and the related consent form, can be found in Appendix H and I. I sent out transcriptions of the interviews to each interviewee for confirmation of the content, and also asked them to provide me with their feedback.

Any information, such as the surveys or forms, went directly from the Professional Development Chairperson to the participants. The only time I emailed a participant directly was during phase three interviews, when I connected directly with the four teachers.

The Professional Development Chairperson knew the identity of the participants and was trusted to keep this information confidential. However, because she had this information, in the consent form for the Interviews I mentioned that there may be minimal risk because the confidentiality of their identity cannot be guaranteed absolutely.

After completion of each phase of the data collection, the information was coded anonymously for subsequent analyses. Also, the original data will be held confidentially for a period of five years after the study is published, or otherwise presented, at which point hard copies of the original data will be shredded and recorded interview data will be deleted.

3.8.4 Data Collection

As mentioned earlier, drawing from DBR, methods of data collection and analysis of procedures are interdependent with the needs of the design (Wang & Hannafin, 2005). Multiple research methods are used systematically and purposefully in different levels of study. Research methods also are aligned with data analysis and refinement needs of the design. Shavelson et al. (2003) suggest continuous documentation is needed throughout the study to conduct retrospective analysis in DBR.

In this study, qualitative data, collected from the participant teachers through different data collection methods, proceeded through three phases. Different methods of data collection were implemented based on the needs of design. Sequential phases of design included pre-event survey, post-event survey, and in-depth interviews.

Pre-event and post-event surveys provided the research with the teachers' understandings of design thinking prior to, and following, the Maker Day experience. Qualitatively analyzing the data from both surveys provided information to discuss the first research question, which is "What are the secondary teachers' perceptions of design thinking prior to and after the Maker Day Professional Development event?" As mentioned earlier, drawing from DBR approach, this part is a semi-summative evaluation of the Maker Day to explore the effectiveness and practicality of the Maker Day on the participant teachers. It also ties to the Level 2 of Guskey's (2000) model of Professional Development evaluation, which is Participants' Learning.

Semi-structure interviews were conducted in the next stage, and the results form them used as a complementary source of data to explore teachers' understandings of design thinking after the event. Findings from the interviews gave a more detailed and explanatory picture of the situation. It also provided a better understanding of secondary school teachers' conceptions of design thinking with regard to their instructional and practical strategies in the classroom. By qualitatively analyzing the interviews, I explored the ways that participants envisioned implementing design thinking concepts in their classrooms. This part ties to the second research question which is "How might the participant teachers envision implementing design thinking concepts?" It aligns to the Level 4 of Guskey's (2000) Professional Development evaluation model, which is Exploring Participants' Use of New Knowledge and Skills.

Details of pre- and post-event survey's design and the interview questions are explained below.

3.8.4.1 Pre- Event Survey

The pre-event survey was designed to collect qualitative data in order to examine the teachers' understandings of design thinking before experiencing it. The pre-event survey included background and demographic questions, such as gender, age, teaching area, field of educational study, and years of teaching experience. It was followed by questions concerning prior knowledge of teachers on design thinking in relation to where and how they acquired the knowledge. Then, they were asked to answer general open-ended questions about design thinking. Questions like, "How do you define design thinking?", or, "What kinds of skills do you assume you need to apply design thinking?" I did not ask detailed questions about design thinking concepts and mindsets because they had not experienced the intervention yet, I did not want to influence them by asking specific questions about the concepts (see Appendix D)

3.8.4.2 Post-Event Survey

The second source of qualitative data came from the post-event surveys. They were completed by seven voluntary teachers, who attended the Maker Day Professional Development event and filled out the pre-event surveys. The post-event survey was designed based on the needs of the design after tentative analysis of the pre-event surveys, and comparing the results with the literature. The post-event survey's focus was on: the details of design thinking in relation to education with regard to the missed points in pre-event survey's

findings; and needed skills to apply design thinking in learning settings. Also, details of the emerged codes from the pre-event surveys' findings, and complementary codes from the literature were considered in designing the post-event survey.

The post-event survey was designed as a 7 point Likert Scale survey to investigate secondary school teachers' current conceptions of design thinking. Likert Scale was used as a tool to examine attitudes and beliefs of teachers on design thinking. As this type of measure does not require participants to provide a concrete yes-no answer through the black-and-white view, it made answering easier to respondents; it also allowed them to respond quickly and efficiently in 7 degree of disagree /agree spectrum. They could offer neutral feelings too. The post-event survey consisted of four sections:

Section A: The demographic section, which was the same as the pre-event survey. The purpose of this section was to recognize the teachers who filled out both surveys based on their gender, age, teaching area, field of educational study, and years of experience. To compare the teachers' understandings of design thinking one by one, I matched the surveys based on demographic section because identities of the participants were anonymous in these stages.

Section B: The second part consisted of 18 disagree /agree Likert Scale statements to examine the teachers' perceptions with regard to general domain of design thinking. The statements reflected the theoretical and practical aspects of design thinking in general domain. They were developed according to themes from literature, the emerged codes, and the missed codes from the previous analysis.

Section C: The third section included 20 disagree /agree Likert Scale statements to examine the teachers' understandings of design thinking in relation to learning environments. The statements were developed according to themes from literature, the emerged codes, and missed codes from the previous analysis.

Statements in Section B and C comprised right and wrong statements randomly distributed in each section. They were carefully designed to ensure that the positive or negative wording gave no indication of the correctness of the statements. There was no pattern in the order of correct and wrong statements.

Section D: The fourth section included 22 disagree /agree Likert Scale statements about required skills for designing. They were developed drawing from Hoadley and Cox's

(2009) divisions of design knowledge including problem finding skills for refinement, design techniques for production of iterations; and interpretation and incorporation of data to offer solutions. Problem finding corresponds to the setting of values; whereas, techniques refer to the knowledge-in-practice of how to accomplish things such as sketching. Problem solving skills corresponds to the notion of concepts in order to solve problems. Designing requires a careful balance between all three of these skill types. This section included one statement asking: "Based on your teaching experience, to what extent are the following skills and habits important in design thinking?" A list of skills followed the statement and the teacher needed to circle the most appropriate number that closely represented their response (see Appendix .F).

3.8.4.3 Semi-Structured Interviews

Interview is one of the qualitative research methods assisting the researcher learn from the qualities of experiences, look for deep insights and/or interpret for meaning through purposefully conducted interviews and attentive listening (Mears, 2012).

The third source of qualitative data came from the semi-structured interviews with four volunteer participants. The semi-structured interviews with open-ended questions allowed participants to create their responses without being forced into predetermined possibilities. The interviewees all completed the pre- and post-event surveys before. In this phase, four individual 45 minute interviews included a series of open ended questions. Interviews provided descriptive information and complementary data to the post-event survey with regard to how participants perceived design thinking. In addition, the interviews provided the study with explanatory expressions regarding how they wanted to bring design thinking concepts into their teaching and learning settings.

The open-ended questions used to conduct the interviews inquired: if participants applied design thinking before the Maker Day; if they envisioned bringing it to their classroom; what are the best strategies to apply it in secondary level?; and, what are the restrictions of using design thinking in their subject area? (see Appendix H)

Data collection in DBR is often limited to small samples (van den Akker, 2007*).* The number of people who were involved in this study was small but purposive. Maker Day was developed for a small number of people, eighteen (including teachers and non-teachers), in a rural area of BC. I was seeking teachers' perceptions on design thinking who attended the

Maker Day, and thirteen teachers responded to the first survey. Among this number, seven teachers responded to the second survey; and among those seven teachers, four were interested in being interviewed.

3.8.5 Data Analysis

Drawing from Design-Based Research approach, continuous documentation was performed throughout the study, and the collected data from each stage was analyzed tentatively in order to refine the needs of study; choose the method for collecting data in the next step; and, design the subsequent step. The tentative analysis informed a retrospective analysis and cross-iteration comparison in this study.

The retrospective and cross-iteration comparison is the characteristic of DBR approach (Cobb et al., 2003). Based on the needs of design, data was collected in a sequential process of three phases, and data analysis occurred ongoing, and simultaneously with data collection. Analysis conducted tentatively as the study moved through the interrelated phases. Qualitative data from each phase was analyzed through iterative cycles of coding, going back to the data and recoding based on emerging themes. There was a constant comparison of existing codes with the new codes conducted throughout the process. In each phase data was compared with the previous levels and the knowledge from the literature.

In this study, qualitative data analysis was conducted to: examine the impact of the Maker Day on secondary school teachers' understandings of design thinking; and, to explore the ways that participants envisioned implementing design thinking in their teaching and learning practices.

Findings from the pre-event and post-event surveys, with the complementary data from the interviews were analyzed to evaluate the impact of the Maker Day on participants' understandings of design thinking. The aim was to give recommendations for improvement of content, format, and organization in the next design cycles. Interviews were analyzed to examine the ways that participants envisioned implementing design thinking in their classroom. The aim of this stage was to generate contextual design principles and recommendations to improve the program.

Findings from the analysis of pre-event and post-event surveys were presented in Word Cloud style format; the complementary findings from the interviews were presented in a concept map format. These findings were explained, and compared descriptively to

examine: how Maker Day experience influenced participants' understandings of design thinking; to identify the gaps in the content and format of the Maker Day; and to offer recommendations for improvement in the next cycles of design. In order to gain as much insight as possible, data was cross-checked through one by one comparisons of the pre- and post-event survey for each participant who had completed the both surveys.

Findings from interviews also clarified how participants wanted to use the knowledge and to bring the concepts into their classroom. The same iterative process of coding and recoding was conducted to analyze the interviews. Findings from the interviews were illustrated in a concept map and explained descriptively. The aim of analyzing the interviews during this stage was to generate contextual design principles for future.

Writing the results conducted in a reflective and iterative cycle as well. As the findings were written up, analysis continued with reflection on the results, returning to the analysis, writing up some of the findings, reflecting back to the results, and so on. Graphical representations, data visualization, and quoted responses were used in all sections to represent data. In post-event surveys, which were Likert Scale, data was visualized quantitatively and interpreted and described qualitatively.

Figure 3.5 illustrates a schematic overview of the sequential phases of data collection, and retrospective and iterative cycles of data analysis.

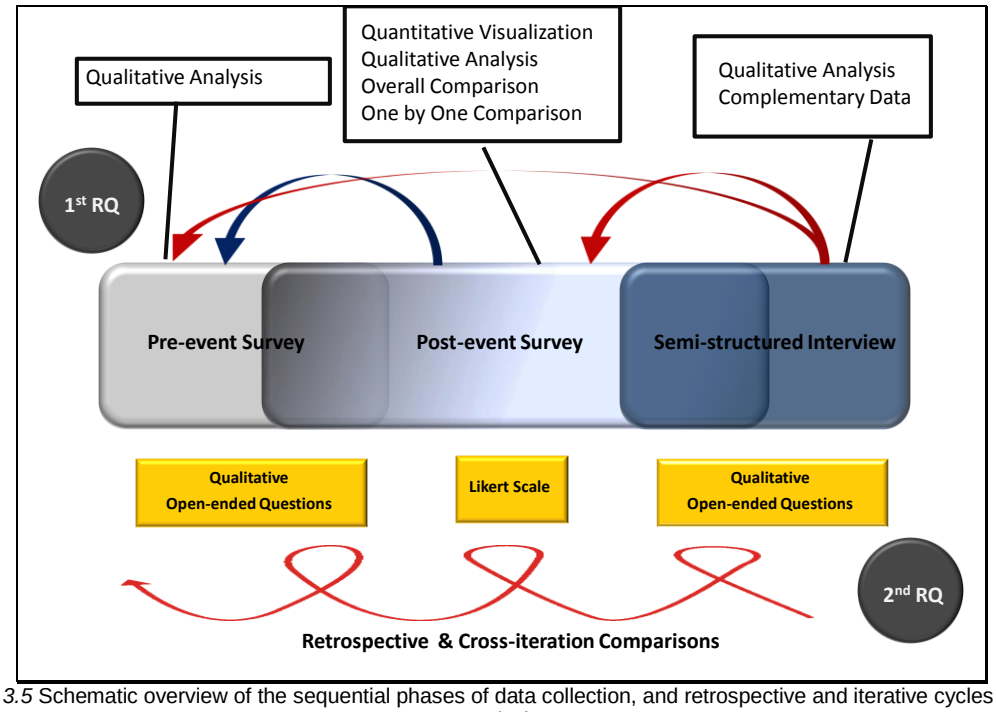


Figure 3.5 Schematic overview of the sequential phases of data collection, and retrospective and iterative cycles of data analysis

3.9 Validity

The validity of the study was considered in the research design. In order to ensure as much validity as possible, triangulation, or the "using multiple data collection strategies" (Gay, et al., 2012, p.393) was used. Triangulation was achieved by employing the two research instruments, the surveys and the in depth interviews. Also recursive approach and cross-iteration comparisons were conducted in analyzing the data in order to gain as much insight as possible on the topic. Triangulation and the iterative process in data analysis provided a deeper understanding of the research data.

The research instruments were vetted through the BREB at UBCO. As pre- and post-event surveys were anonymous, it is hoped that participants were able to respond truthfully to the questionnaire (Gay, et al., 2012). In terms of the interview data, I asked each participant to view and confirm the collected data for accuracy.

3.10 Limitations

Despite all precautions taken to ensure a strong study, it is inevitable that there have been some shortcomings in this study. This section addresses some of the limitations of this study.

First of all, this study was conducted within the framework of Design-Based Research in a specific context, and with a small number of participants. Involved participants were secondary svhool teachers from School District # 83 in British Columbia who attended the Maker Day Professional Development event. Therefore, findings in this study are not suitable for generalization. Drawing from DBR approach, generalization of the findings increases when they are tested and validated in more cycles of design in more contexts. Design principles generated from this study can be used as working hypothesis, not conclusion.

Another limitation is related to availability of research participants in the designated time for data collection, and its influence on the data collection timing. After the Maker Day, I gave the post-event surveys to the Professional Development Chairperson to be distributed among participants. In that time, teachers were involved in job action and on strike across British Columbian public school system. The Chairperson did not have access to the participants in the designated time. But, she tried her best to find teachers and asked them if they were interested to complete the surveys and sign the consent forms. She gave me the completed post-event surveys, signed forms, and interviewees' contact information one

month later than what I expected. Subsequently, I conducted the four interviews later than the research timeline. This delay that occurred between the event and data collection may have influenced teachers' perceptions about design thinking.

Finally, as a researcher, I am totally new to British Columbia's educational and cultural context, and I do not have firsthand experience in this educational setting, as compared to a person who grew up and was schooled here. This lack of information in my background may have influenced the interpretations of findings.

3.11 Concluding Remarks for Chapter 3

This study draws on a Design-Based Research approach. DBR is a systematic and flexible methodology to improve educational practices which are developed through iterative cycle of analysis, design, development, and implementation (Wang & Hannafin, 2005). Through this approach, design principles are generated for the future cycles of design.

Within the framework of Design-Based Research (DBR) approach, this study was designed and developed to qualitatively analyze perceptions of participants of a Maker Day about design thinking prior to, and after the event; and to explore the probable ways that the participants envisioned bringing the introduced concepts to their classroom.

The study is a qualitative study. Data collection methods included a pre-event survey, a post-event survey and in-depth interviews. Drawing on DBR, data collection and analysis of procedures were interdependent with the needs of the design. Continuous documentation occurred throughout the study. The collected data from each stage was analyzed tentatively in order to refine the needs of study, choose the method for collecting data in the next step, and design the subsequent step. Data analysis took the form of retrospective and cross-iteration approaches.

Pre-event and post-event surveys provided the research with the teachers' understandings of design thinking prior to, and after the event. Data from the interviews was used to triangulate the surveys data and to gain as much insight as possible on teachers' understandings of design thinking after the Maker Day. This part is a semi-summative assessment of the Maker day and explores whether the Maker Day met the predetermined specifications. Through a qualitative form of analysis, this part gives recommendations for improvement of content, format, and organization for the next design cycles.

Interviews explored participants' use of new knowledge and skills. Findings from the interviews with the results from the semi-summative evaluation generate design principles and guidelines to optimize the design of Maker Day for more improvement in the next cycles of design.

Chapter 4: Discussion of Findings

4.1 Overview of Chapter 4

Chapter 4 outlines and discusses the findings of the study. In this study, within the framework of Design-Based Research, secondary school teachers who participated in a Maker Day Professional Development event, were surveyed and interviewed in order to collect their perceptions of design thinking prior to, and after experiencing the event and to examine their ideas of how they may implement it as a future possibility.

Findings from the surveys and the interviews are summarized in this chapter. To begin, the findings from the pre-event and post-event surveys are presented and discussed. They are then compared to identify the differences of the teachers' understandings about design thinking before and after the event. There are two main comparisons of teachers' understandings examined with this study: an overall comparison of teachers' understandings before and after the event, plus a one-by-one comparison of each teacher's pre- and post-event survey collected from teachers who completed both. The one-by-one comparison is conducted to cross-check the findings. Then, findings from the interviews are presented. Interviews are used as a complementary source of data to the post-event surveys to identify the teachers' perceptions of design thinking after experiencing the Maker Day. In addition, interviews provide clearer explanations and descriptions to identify their perceptions about design thinking.

The findings from the interviews are analyzed and discussed to discover if participants envision implementing the concepts in their classroom, and how they wish to apply them. Graphical representations, data visualization, and quoted responses are used in all sections to represent the data.

4.2. Tentative Analysis: Retrospective and Cross-Iteration Approach

Drawing from a Design-Based Research approach, continuous documentation occurred throughout this study. In addition, data analysis was ongoing throughout the study. Preliminary analysis began after the Maker Day, when teachers completed the pre-event surveys, and further analysis continued through iterative cycles of initial and focused coding. This was used to inform data collection decisions in subsequent steps. Constant comparison of new data against previously collected data occurred during the process. There was a

comparison of existing codes against new codes, and new categories emerged throughout the process. Tentative and iterative analysis guided the study as it moved forward from analysis-to-design-and to-reflection-to-design and created room for continual refinement in data collection and analysis.

The analysis took the form of retrospective and cross-iteration comparisons, which is the characteristic of DBR approach (Cobb et al., 2003). The analysis was conducted through iterative cycles of coding, going back to the data, and then recoding according to the emerged themes. As data allowed, I coded and recoded the data depending on the emerged codes. During the analysis, codes and patterns emerged from the data rather than being imposed prior to data collection. Findings from each phase of the study compared consistently with the literature, guided the study to the next phase, and made room for new codes. Complementary codes and patterns were established based on the theoretical framework of the study, and the themes that emerged from the literature.

Writing the results conducted in reflective and iterative cycle as well. As the findings were written up, analysis continued with reflection on the results, returning to the analysis, writing up some of the findings, reflecting back to the results, and so on. This chapter encompasses all the results written at various stages of analysis and reflection on the findings. As the findings were constantly compared to the literature throughout the process, findings are discussed in multiple sections of this chapter.

4.3 Data from Pre-Event Surveys

In this section, data from the pre-event surveys is presented and discussed. Participants, survey design, survey demographics and findings from surveys are examined in the following subsections.

4.3.1 Participants in Pre-Event Surveys

The population in this phase included thirteen secondary school teachers who attended the Maker Day Professional Development event. They voluntarily responded to the survey and they described their perceptions of design thinking prior to experiencing it in the event. Participants in this phase of the study are assigned with numbers from Participant #1 to Participant # 13. All participants' voices are considered, quoted and discussed.

4.3.2 Pre-Event Survey Design

The pre-event survey was designed to collect qualitative data in order to examine the teachers' understandings of design thinking before experiencing it in the Maker Day. The pre-event survey included demographic questions. It was followed by questions concerning prior knowledge of design thinking in relation to how and how long the participants had been familiar with design thinking. Then, they were asked to answer general and open-ended questions about design thinking. One question on the survey was, "How do you define design thinking?" (See Appendix D) I did not ask detailed questions about design thinking because they had not experienced the process yet and I did not want to influence them by asking specific questions about the concepts.

4.3.3 Demographics

In the pre-event survey, participants were asked a number of demographic questions including: gender, age, years of teaching experience, grade of teaching, teaching subject, and their level of education obtained. The study's demographic questions were asked to identify the background of participants, and to match the participants who completed the post-event surveys in the next stage. Teachers' identities were anonymous in pre- and post-event surveys and I matched the surveys based on the demographic information they provided.

Detailed information about the survey demographics follows. Pie charts are used to visualize the data, and to give a quick overview of each section.

The first demographic question asked was the gender of survey participants. Nine out of thirteen participants were males, and four were females that attended the Maker Day (Figure 4.1). The second demographic question asked about the age of survey participants. The majority of participants were between 40-50 years old (Figure 4.2).

The third, forth, and fifth demographic questions were questions about the number of years of teaching experience, the grade that participants teach, and their teaching subject(s). The least number of teaching years totaled 5 years, and the largest was 30 years (Figure 4.3). All the participants were teachers of Grades 8-12. The teaching subject most commonly reported was Math and Science with 7 respondents, followed by Language Arts with 3 respondents. Trade, Music, and Social Studies each had one respondent (Figure 4.4).

The sixth and seventh demographic questions inquired about the degree major and the highest level of education they had completed. In terms of degree major, there was a

diversity of disciplines including Spanish, Trades, Anthropology, Social Studies, Math, Engineering, and Language Arts, each with one respondent, and Science with four respondents. Two participants did not fill out this part (Figure 4.5). Most of the participants (8 out of 13) completed a Bachelor degree, one participant completed a Master's degree, and four teachers were Master's students (Figure 4.6).

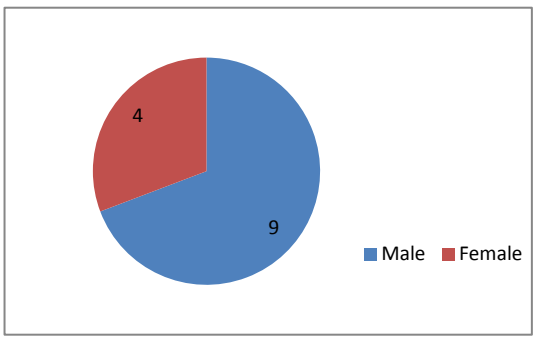


Figure 4.1 Gender distribution

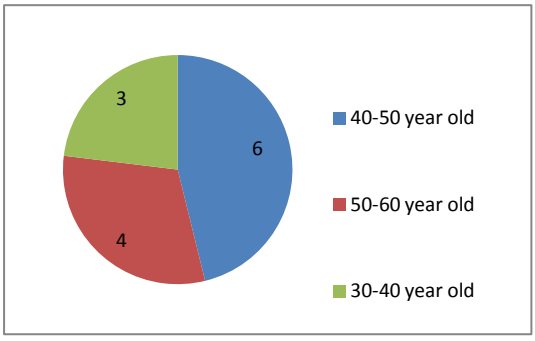


Figure 4.2 Participants' ages

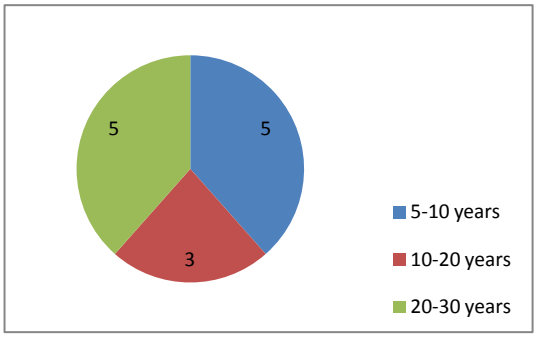


Figure 4.3 Years of teaching experience

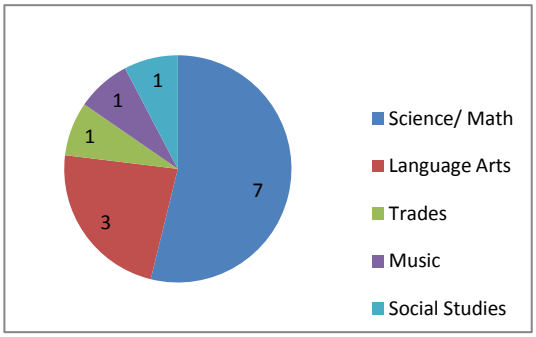


Figure 4.4 Teaching subjects

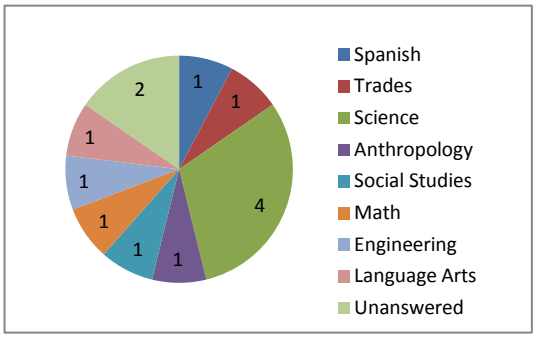


Figure 4.5 Degree Major

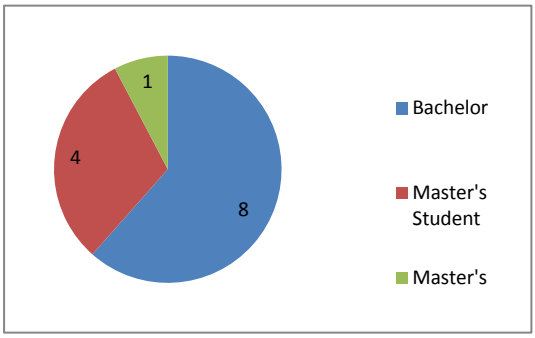


Figure 4.6 Level of education

4.3.4 Background Knowledge

In the pre-event survey, following the demographic questions, participants were asked three questions about their background knowledge of design thinking including: if they had heard about the concept before and if so, where and when?

Ten out of thirteen participants had heard about design thinking before attending the Maker Day (Figure 4.7). Most indicated that they had been familiar with design thinking for less than one year. There were two teachers who heard about the concept a long time ago; one had been familiar with design thinking 20 years ago, and the other 35 years ago (Figure 4.8).

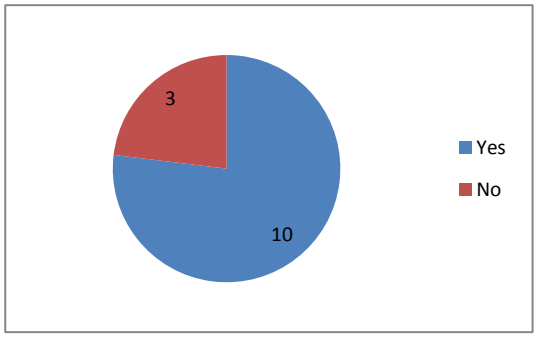


Figure 4.7 If participants heard about design thinking before

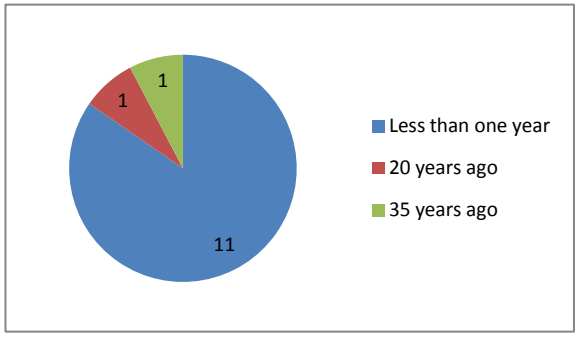


Figure 4.8 How long participants had been familiar with it

Seven out of thirteen participant teachers at the Maker Day had heard about design thinking concepts from their colleagues, and two of them had heard about the conceptsat their school. There was one teacher who said that he had been familiar with design thinking from related text books and online resources. There was a teacher with an Engineering background who stated he had become familiar with the concept in Engineering School 35 years ago. Also, one participant who studied Science 20 years ago had heard about design thinking in the engineering lab practiced during that study time (Figure 4.9).

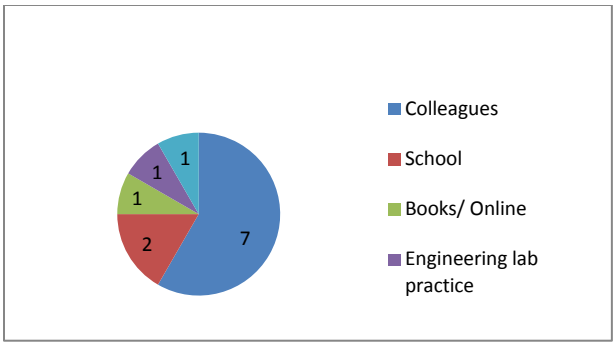


Figure 4.9 Where did participants hear about design thinking

In terms of prior knowledge, at the end of the pre-event survey, participants were asked two open-ended questions about whether or not they had been trained in any other related sessions before. In addition, they were asked why they chose the Maker Day as a Professional Development event. Only two participants mentioned that they attended a relating training session (Figure 4.10); one participant said that he attended the Rhino workshop in United States about 3-dimentional drafting and modeling with 3D software and 3D printers. The other participant mentioned that he had attended a Professional Development event about backward design.

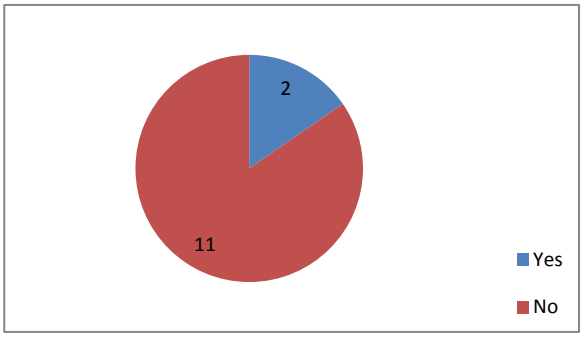


Figure 4.10 Related training before the Maker Day

4.3.5 Findings from Open-Ended Questions on Design Thinking

This section presents the findings from the six open-ended questions in the pre-event survey (see Appendix D). In these questions, the participants were asked to define design thinking; explain their thoughts about the connection between design thinking and education; describe if they had applied it before and how they had done it; and, explain what the most important aspect of their experience had been. Finally, they were asked to describe the required skills they felt they would require to be able to apply design thinking in their classroom.

The open-ended questions' responses were coded and recoded iteratively. Srivastava and Hopwood (2009) clarify reflexive iteration is at the heart of visiting and revisiting the data, and connecting them with the insights, thus leading to refined focus and understanding.

The first open-ended question asked participants, "How do you define design thinking?" I reviewed all the responses to this question with attention to repeated meanings and links between the answers. Participants' answers to this question were then coded in the first iteration. "Making" arose as the main theme repeated in ten definitions of design thinking in participants' answers. The majority of participants used words such as "make", "build", "create", "construct", and "produce" in their definition of design thinking. This guided me to go back to the data and to start recoding.

The cycle of reading, linking, coding and noting was repeated several times (see Figure 4.11). This approach allowed the new codes to emerge from the data. The subsequent codes that emerged from the data through the iterative cycles of coding were: "refining" (5 times), "problem solving" (5times), "learning" (4 times), and "thinking" (4 times).

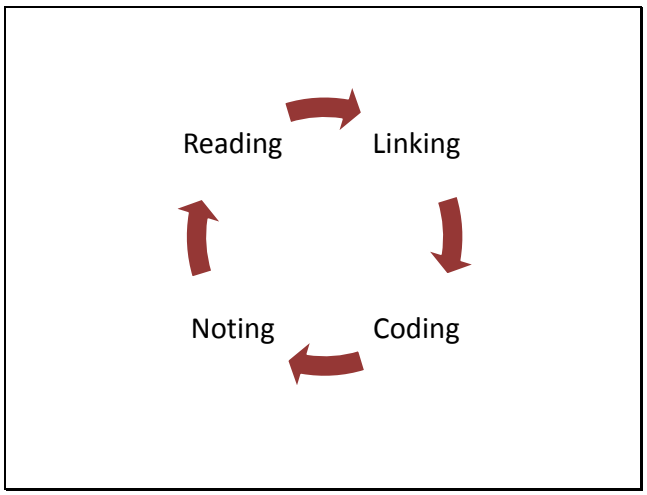


Figure 4.11. Iterative cycle of coding and recoding

Examples of direct quotes from the participants who mentioned "refining", "problem solving", "learning", and "thinking" in their definitions can be seen in Table 4.1. By cross checking the themes in Table 4.1, a new code emerged: "collaboration" (2 times), which is displayed with a circle in Table 4.1.

Considering the emerged codes from the first question, I moved forward to the next question which asked, "What is the connection between design thinking and education in your opinion?" New codes emerged and similar codes to the previous question were found by

cross checking the answers. The new codes were: “student-centeredness” (2), “building knowledge” (2), and “putting theory in practice” (2). Similar codes to the previous question emerged as well: “refining” (once), “problem solving” (once), “learning” (3), and “thinking” (one), and “making” (once). They are shown in Table 4.1 with the direct quotes from the participants, and distinguished by using a different color at the end of the table.

Table 4.1
Definition of design thinking and its connection to education categorized based on emerged themes

Refining	Problem Solving	Learning	Thinking
making and remaking to learn	problem solving that requires the process of inventing	learning by making in group	concrete leads thinking
refinement of the idea and anticipating problems	beginning with a problem and critical question	learning through hands-on activities	making thinking visible
systematic refining of an idea	problem solving/ seeing problems/ thinking through solutions	making and remaking to learn	using a pattern to follow leads thinking
building repeatedly with increasing consideration of details	anticipating problems	thinking about learning	thinking about learning
revisions and refinements throughout	working collaboratively to create a product to solve the problem	ability to demonstrate learning	think through a solution
connected by asking how can I make it better	a way to experience problems	learning happens through making something concrete	
		a real measure of what kids learn	

In the second question, teachers were asked to mention the connection between design thinking and education. Not all the teachers answered the second question. Two teachers left this part blank. One of those mentioned “You have to understand it well first”. Another said “Unsure” and one more mentioned “It is connected to education in many ways” but, did not say how. Two participants answered this question more fully, stating: “Intrinsically connected by asking "How can I make … better.", and “Design thinking is the application of knowledge/ also a way to experience problems + think through a solution”.

In the next question, teachers were asked if they had ever applied design thinking in their classroom. Ten out of thirteen answered that they had applied design thinking before (Figure 4.12).

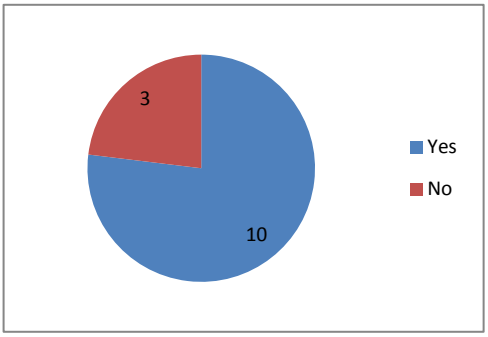


Figure 4.12 Number of participants who said they had applied design thinking before

In the third open-ended question, participants were asked to describe how they applied design thinking. The first emerging code in the first iteration was "making models" with eight respondants. The codes that emerged in the next iteration were: "projects", and "3D modeling". Table 4.2 shows the emerged codes with the relevant direct quotes from the participants. Also, two participants mentioned the importance of "student-centeredness", and "collaboration" in their experiences.

Table 4.2

Emerged codes from teachers' relevant experiences to design thinking

Making Models	
Projects	3-D Modeling
"Project-Based Learning"	"When the 3D drafting didn't work, kids had to progress to the 3D representation of their work as a 3D object."
"I had students design and build musical instruments for sound project"	
"In cooking project, kids choose a favorite food and I challenge them to recreate the recipe and make it healthy"	
"In swing project, they create their own patterns with recycle stuff"	

In the fourth open-ended question, participants were asked to describe the most important aspect of their experience in applying design thinking. "Ownership of learning",

which was repeated three times in the responses, emerged as a first code. “Risk taking” and “creativity” emerged in the next iteration. One participant brought up “collaboration” as a positive aspect of design thinking; however, one participant described a challenge in the collaborative work he had, which was “difficulties of group work and group dynamics”.

The emerged codes (ownership of learning, risk taking, collaboration) were brought up as a positive impact of the environment in which design thinking was applied. These codes guided me to the next iteration of coding to see how they provided students with design thinking activities. In fact, they all mentioned the potential impact of design thinking on “how students learn” before, and I wanted to see if they considered using design thinking as “how teachers teach” too? Participant # 3 mentioned, “Listening to students’ ideas” as an important aspect of design thinking in learning settings. Also, Participant # 13 put “planning an area of interest”.

The last open-ended question asked, “What kind of skills do you assume you need to apply design thinking in your classroom?” “problem solving”, ”creativity”, “open-mindedness”, “willingness”, and “experience” were the codes that emerged from the data as the required skills teachers assumed they need. Two teachers assumed “Nothing”, and two left this section blank.

At the end of the pre-event survey I asked the participants, “Why did you choose Maker Day as a Professional Development Activity?” Three teachers responded because it was in my school/ close to home/ go with the flow, three said because it sounded new and interesting, and five wanted to try it out and see how it works. Two participants chose to come to the Maker Day with specific aims: one came to the Maker Day “to come out with a personal project for Maker Project Course”, and the other chose to come to “build skills for new science lab”. Also, there was a different answer from a participant who wanted to “feel the discomfort of not knowing.”

4.3.6 Representation of Pre-Event Surveys’ Findings

As mentioned before, preliminary analysis of the pre-event surveys was conducted after collecting the data in this phase of the study. Then, as findings were written up, analysis continued with: reflection on the results, returning to the analysis, writing up some of the findings, reflecting back to the results, and then continuing with the iteration process. Figure 4.13 displays an overview of the iterations in pre-event surveys.

To present the final findings, I used Word Clouds as an additional support to present data, and to highlight the main emerged codes. This provided direction for detailed analysis, parallel comparison, and interpretation of findings in the following stages. McNaught and Lam (2010) suggest Word Clouds can be a useful research tool to assist educational research, and quickly visualize some general patterns in text. The Word Cloud in Figure 4.14 presents the main codes that emerged from the iterations in pre-event surveys. Each word or phrase represents the unit of meaning emerged from data; and the font size indicates the quantity of content item in participants' answers to open-ended questions in pre-event surveys.

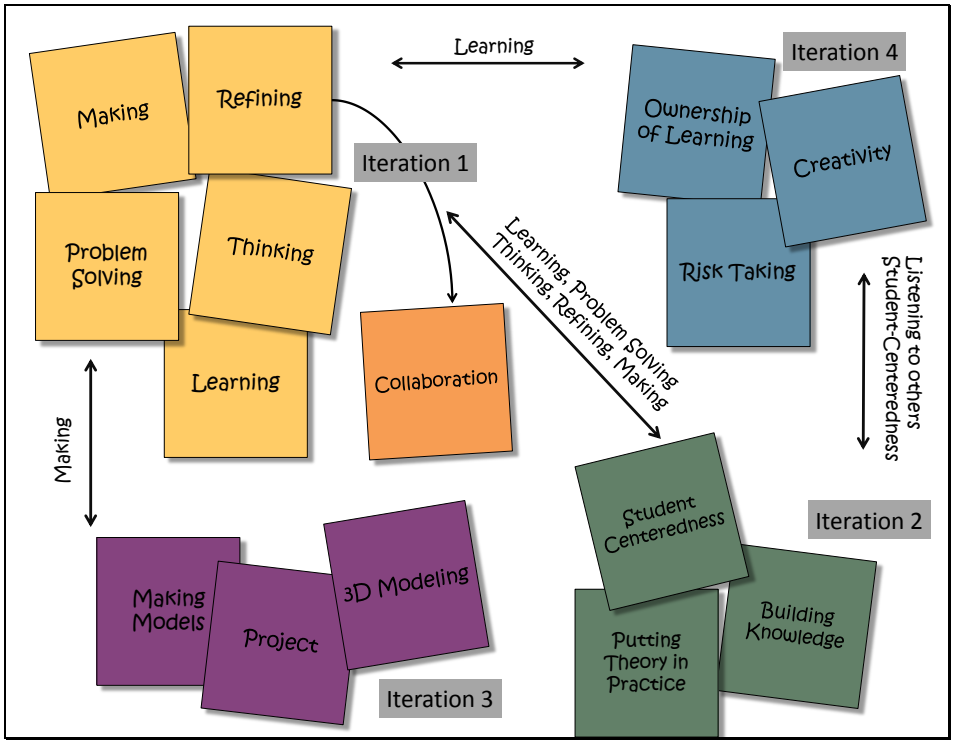


Figure 4.13 Overview of the iterations in preliminary analysis of pre-event surveys

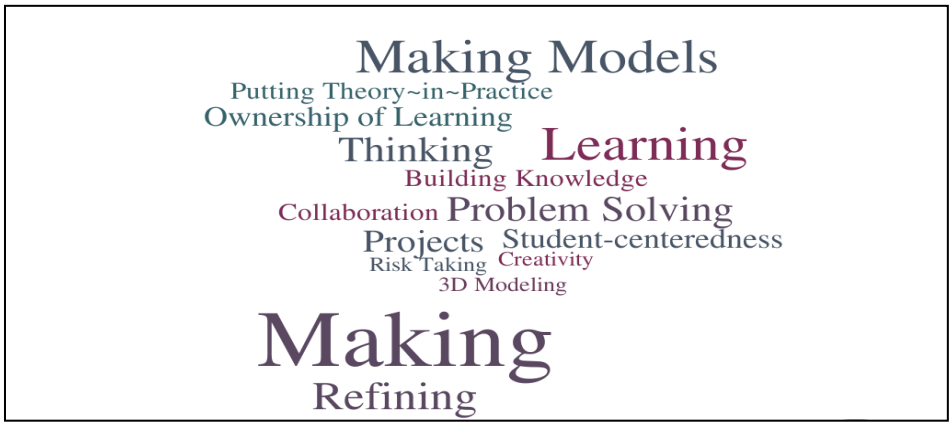


Figure 4.14 Word Cloud represents units of meaning emerged from preliminary analysis of pre-event surveys

4.3.7 Discussion on the Pre-Event Surveys' Findings

The analysis of pre-event surveys suggested eight significant points.

1. The concept of design thinking was not new to the majority of participants.

Ten out of thirteen participants had heard about design thinking before the event. They shared their definitions of design thinking. These definitions included not all, but parts of design thinking definitions that are presented in the existing literature. Participant #10, whose background was in engineering, defined design thinking as "a systematic refining of an idea by building repeatedly with increasing consideration of details." This definition aligns with Razzouk and Shute's (2012) definition that suggests design thinking is an iterative process where designers observe, come up with ideas to solve the problem and see what they can conclude to inform further design efforts. Participant #11, with Science background, defined design thinking as "problem solving that requires the process of inventing; troubleshooting and construction of finished working prototypes." He brought up troubleshooting in his definition, which is called problem finding in design thinking literature. The definitions mentioned above were the most precise ones and were brought up by participants with the related background knowledge of design thinking; one had heard about design thinking 35 years ago in Engineering School, and the other had heard about it 25 years ago in Engineering practice lab (see Figure 4.8 and 4.9).

2. *Design as Exploring* was the dominant goal of design thinking in learning settings according to the participants.

Making artifacts was repeated the most throughout the pre-event surveys. Experiencing design process through making objects gives opportunities for inquiry and exploration. It aligns with *Design as Exploring* as a goal of design thinking application (Carroll et al., 2010).

3. Participants believed in the positive influences of design thinking in the classroom.

They mentioned the powerful role of design thinking in developing "creativity", "collaboration", and "ownership of learning", encouraging "risk taking", and "problem solving". These are all aligned to *Design as Connecting* as one of the goals of applying design thinking in the classroom, as suggested by Carroll et al. (2010).

4. Problem finding and refining seem to be missed.

Making-driven projects were the dominant examples noted by participants according to their experiences and their perceptions about design thinking. There are two points that are worth mentioning:

First, making two- or three-dimensional models is just one part of a design thinking process. The part that seems missing here is discovering what we need to make. Problem finding and defining problems worth solving is another part of design thinking. As mentioned before, just one participant brought up the importance of problem finding before making in a design thinking process.

Second, design thinking is a prototype-driven process; it is not making-driven. A prototype may not be the final product of a design thinking process. It is a rough and preliminary model of the design process, made as the generated solution to the identified problem, and needs to be refined iteratively. As Figure 4.14 shows, "refining" is one of the main codes that emerged from the data. In definitions of design thinking, participants noted the iterative process in design thinking; but they did not mention how they used this notion in their actual experiences they had before. The focus was more on making something, which is demonstrated in Figure 4.14.

5. Participants assumed that design thinking was Project-Based Learning.

Participants expressed the similar experiences they had before. In addition, they expressed about the different hands-on "projects" they did in their classroom were considered as design thinking practices. The significant difference between design thinking and Project-Based Learning is that usually project tends to explore a narrow pre-set subject area which guides learning into a pre-defined path. Also, identifying and finding a real problem, and then refining the solution may not necessarily exist within a project.

6. There was one quote that included the notion of empathy.

Participant #4 mentioned the important aspect of design thinking is "listening to others". There was not any other record from the other participants indicating the notion of empathy in the entire data.

7. Participants were not sure how to incorporate design thinking with the curriculum.

There was no example for *Design as Intersecting*, which is about the relationship between design thinking process and content knowledge of the specific subject (Carroll et al.,

2010). Participants brought up fairly good definitions of design thinking; they also mentioned the impact of design thinking on developing creativity and collaborative work. But, they were not sure enough about the incorporation of design thinking with the curriculum. Participant # 11 wrote, "Currently very little connection [between design thinking and curriculum]. Almost no practical application of theory is possible with curriculum." *Design as Intersecting* directly ties to the second research question: how might the participant teachers envision implementing design thinking concepts into their classroom? So, in the interviews, I explored participants' opinions and ideas after they had enough time to reflect on the experience of Maker Day.

8. Participants considered the potential impact of design thinking only on how students learn, not on how teachers teach.

They shared their ideas about how design thinking might influence students' learning through making artifacts. It is worth mentioning that design thinking, as a human-centered approach, is a useful strategy to tackle the unknown in designing 21st century's learning environments, and it can influence how teachers teach and how they design 21st century's learning environments as well. There were two quotes that could be interpreted as the influence of design thinking on how teachers teach: "Listening to students' ideas" and "Planning an area of interest".

The tentative analysis of the pre-event surveys, and the comparison the results with related literature showed that participants already knew some main aspects of design thinking theory. Therefore, in designing the post-event survey I focused more on some details of design thinking and its relation to educational settings according to the literature. Also, missing concepts such as "problem finding" were explored more deeply. The emerged themes were considered in designing the post-event survey as well; they were used to see how participants' perceptions on those concepts were changed or improved after the event.

Findings from this phase also guided the study to add a separate section in the post-event survey with regard to the skills needed for designing, plus specific considerations of applying design thinking in learning settings. This part was added to the post-event survey for two reasons: First, participants brought up some general skills of teaching and designing, when they were asked to mention the needed skills to apply design thinking in the classroom. Second, as they focused more on design thinking and how students learn and I wanted to

explore what kinds of skills they assumed they needed to acquire as designers of learning environments in the 21st century.

4.4 Data from Post-Event Surveys

In this section, participants of the post-event survey and the survey design are described. Then, data from the post-event surveys is presented and discussed.

4.4.1 Participants in Post-Event Surveys

The population of this phase included seven secondary school teachers in School District #83, who attended the Maker Day Professional Development event and completed the pre-event surveys. They responded to a 7 point Likert Scale survey. The aim was to examine their understandings of design thinking after they had experienced it. Participants in this phase of the study were assigned with numbers from Participant #1 to Participant # 7.

The Professional Development Chairperson told me that the seven teachers were the participants of the Maker Day who had developed a learning event similar to the Maker Day for secondary school students in School District # 83 one month after the event.

The learning event was developed by School District # 83, and it was held in partnership with UBC's Innovative Learning Centre (ILC) one month after the Professional Development event. It was the first Maker Day with students in B.C; more than 60 students from five different schools came together to engage in the design thinking and prototyping activity.

4.4.2 Post-Event Survey Design

Tentative analysis of the pre-event surveys and comparing the results with the literature guided the study to design a post-event survey considering the emerged codes and missed codes from the previous stage, and also complementary codes from the literature. In addition, based on the needs of design, a separate section regarding the specific considerations to apply design thinking and required skills for designing was added to the post-event survey.

The post-event survey was designed as a 7 point Likert Scale survey (See Appendix F). Likert Scale was used as a tool to examine attitudes and beliefs of teachers about design thinking. Since this type of measure does not require participants to provide a concrete yes-no answer through a black-and-white view; it made answering easier for respondents and

allowed them to respond quickly and efficiently in 7 degree of disagree/agree spectrum. They could also offer neutral feelings.

The post-event survey consisted of four sections: Section A was Demographic, which was the same as the section used in the pre-event survey. Section B consisted of 18 disagree/agree detailed Likert Scale statements on general domain of design thinking; Section C included 20 disagree/agree detailed Likert Scale statements on design thinking in relation to education; and Section D included 22 disagree/agree Likert Scale statements on specific considerations to applying design thinking and required skills for designing.

Statements were comprised of right and wrong statements randomly distributed in each section. They were carefully designed so that, the positive or negative wording gave no indication of the correctness of the statements. Also, there was no pattern in the order of correct and wrong statements.

Statements reflected the missed points from the pre-event surveys (problem finding, refining), emerged codes from previous phase (making, problem solving, learning, collaboration, creativity), and design thinking key components from the literature (human-centeredness, action- oriented, mindful of process) identified by Hasso Plattner Institute of Design at Stanford (2007). Tables 4.3, 4.4, and 4.5 respectively show the reflection of the emerged codes, missed points from pre-event surveys, and the emerged codes.

Table 4.3

Reflection of the emerged codes from previous stage on developing statements

Emerged Code	Making	Problem Solving	Learning	Collaboration	Creativity
Statement Number	12	22	29	17	11
	31	28	30	23	16
	32		33	38	
	39		35		
	40		41		
	44		42		
			43		
			45		
			46		
			48		

According to Hasso Plattner Institute of Design at Stanford (2007), human-centeredness, action-oriented, and mindful of process are the key components of design thinking. Regarding the fact that design thinking is applied to find the problems and specific needs of human beings, statements reflecting human-centeredness were the same statements that reflected "problem finding". And, as design thinking is a cycle and process of iterations, statements reflected mindful of process were the same ones that reflected "refining". Also, design thinking is a prototype-driven approach. So, statements reflected action-oriented were the same ones that reflected "making" (Tables 4.4 and 4.5).

Table 4.4

Reflection of the missed codes from previous stage on developing statements

Missed point	Refining	Problem Finding
Statement Number	13	14
	24	15
	27	17
	32	18
		20
		21
		23
		33

Table 4.5

Reflection of design thinking key components from literature on developing statements

Design Thinking Key Components	Human-Centeredness	Action-Oriented	Mindful of Process
Statement Number	15	12	13
	17	31	24
	18	32	27
	20	39	32
	21	40	
	23	44	

4.4.3 Findings from Likert Scale Statements

This section presents the findings for Likert Scale statement in section B, C, and D of the post-event survey (see Appendix F). Results for the Likert Scale questions were tabulated for descriptive and graphical analysis by Microsoft Excel. Wrong statements, which were included intentionally, were tabulated with inversed responses in order to make consistent and reasonable comparisons and visualizations. For example, if a participant chose Strongly Agree for a wrong statement, it is equal to choosing Strongly Disagree for a right statement. Inversing the answer in wrong statement (7 to 1, 6 to 2, 5 to 3, 4=4, 3 to 5, 2 to 6, and 1 to 7), and assuming that the statement is inversed too, made the answers all integrated for visualization and analysis.

In this phase, data was visualized quantitatively in the related columns, and it was analyzed qualitatively and explained in an explanatory and descriptive manner.

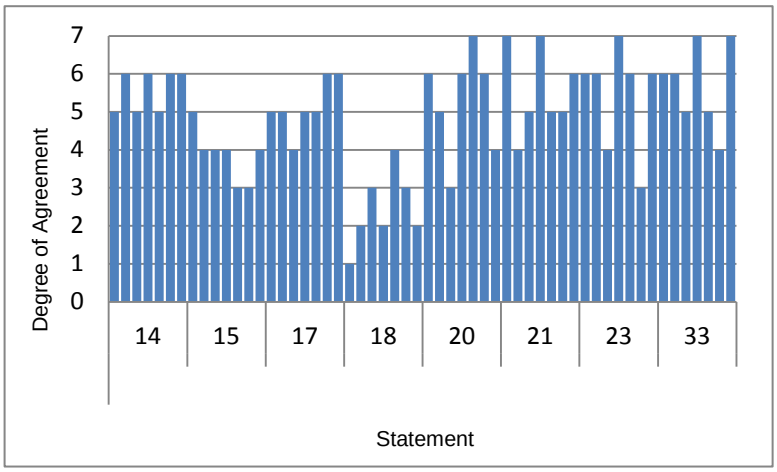


Figure 4.15 Statements reflected Problem Finding/ Human-Centeredness

Figure 4.15 presents participants' understandings about "problem finding" which was missed previously. Participants agreed or strongly agreed that finding a problem is embedded in design thinking process (see statement 14), other than designers, everybody can find design problems (see statement 20), and talking to people and asking people about their needs helps authentic problem finding (see statement 21).

Statement 21and 33 were about gaining empathy to define a problem; asking people about their needs, and putting students in real situations to understand the context. These statements took a fairly high level of agreement from participants.

The majority of participants (six out of seven) in different degrees agreed that collaboration helps define and find problems (see statement 17, and 23). But, the results from statement 18 are evidently different. All participants believed that design thinking fosters problem solving skills more than problem finding.

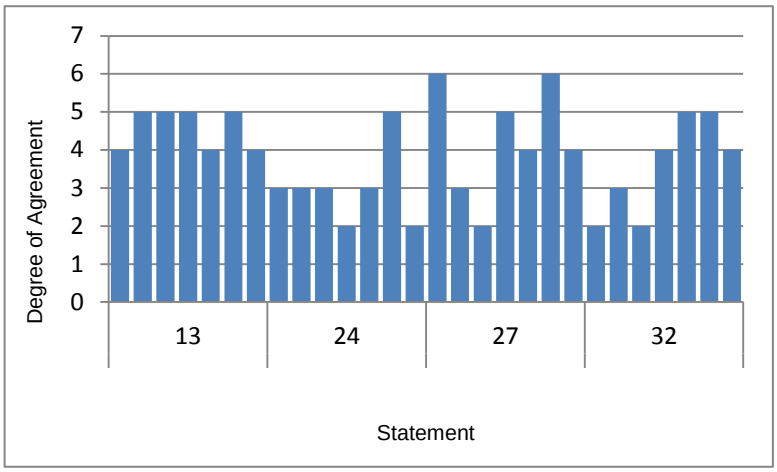


Figure 4.16 Statements reflected Refining/ Mindful of Process

Refining was another missed code in the previous survey. In the post-event survey, as Figure 4.16 shows, four out of seven participants agreed that existing artifacts are improved by design thinking (statement 13). But, they did not highly agree an open-ended, iterative circle in design thinking through which the prototype might be refined. Only one participant disagreed that design thinking leads to success (statement 24), three participants disagreed that design thinking is a closed circle process (statement 27), and two participants disagreed that mindfulness of prototype is more important than the process (statement 32).

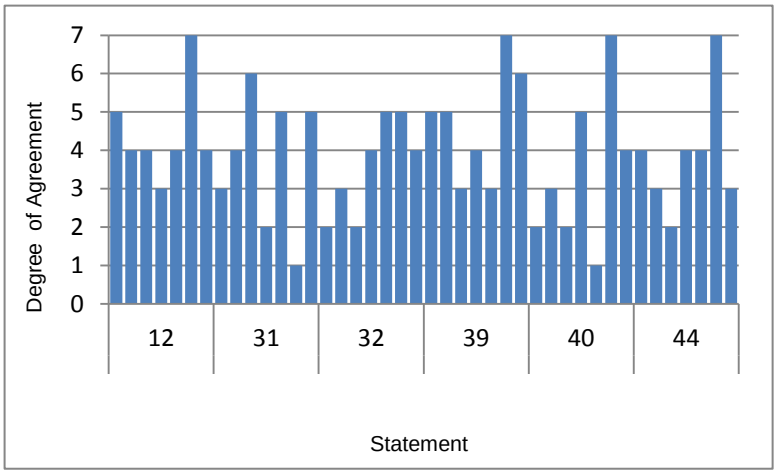


Figure 4.17 Statements reflected Making/ Action-Oriented

"Making" emerged as the dominant code in the pre-event surveys, when participants had not experienced the event. After experiencing the process six wrong statements were included the post-event survey to challenge teachers' understandings about making objects and its position in a design thinking process. As Figure 4.17 shows, three participants agreed

that only product-driven projects can be applied in a design thinking process, one was neutral, and three disagree with this statement (see statement 31).

Two participants agreed that being mindful of the process is more important rather than the product, two were neutral, and three were disagree and though product is more important (see statement 32).

Two out of seven teachers disagreed that specific materials are required to implement design thinking in the classroom (see statement 40), and only two out of seven participants disagreed that making beautiful artifacts is the aim of design thinking (see statement 12).

In terms of the specific physical space for applying design thinking, two participants agreed with statement 39, and thought specific physical spaces are required to conduct design thinking activities. In terms of using technology in design thinking, one person disagreed that technology is important to implementing design thinking in the classroom, three responded neutral, and three agreed that it is important (see statement 44).

Findings indicate that teachers perceived design thinking more as a product-driven approach, and their perceptions of applying design thinking in the classroom were more towards hands-on practices and making-oriented activities. Making was implied as creating a final product or model rather than a prototype, which may lead to failure, and needs refinement iteratively.

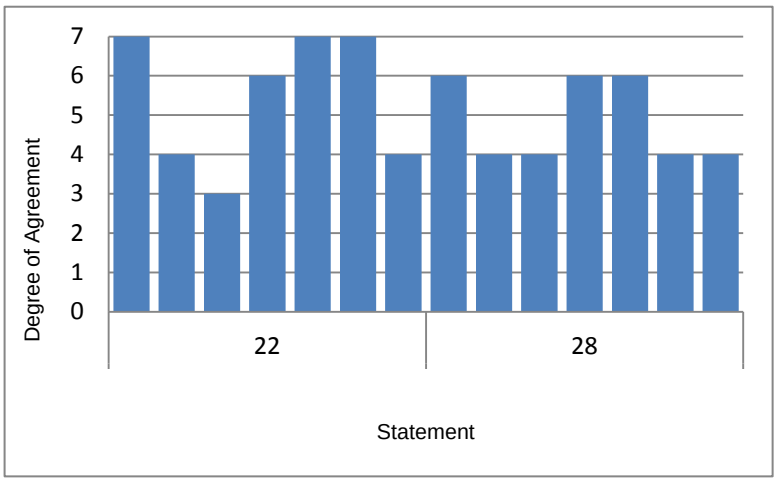


Figure 4.18 Statements reflected Problem Solving

Responses to the notion of "problem solving" in statement 22, shows that participants' understandings of the concept was fairly good because four out of seven participants thought a design problem does not have just one solution.

Participants # 1, 4, and 5, who believed in several possibilities to solve a problem, also thought if a design solution does not work, a designer changes the design solution not the design problem (statement 28). Other participants were unsure about this statement.

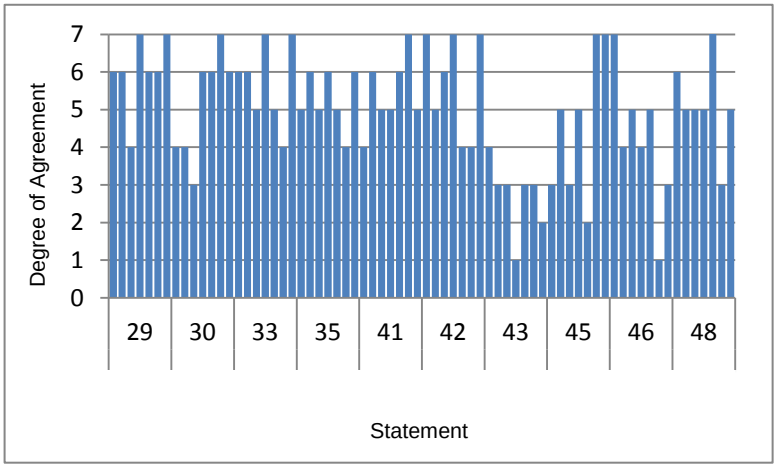


Figure 4.19 Statements reflected *Learning*

Findings from statements that reflected "learning" indicate that participants acquired a high level of understanding in terms of possibilities of implementing design thinking in the classroom (see statement 29, 30, 33, 41, 46, and 48), encouraging "risk taking" by using design thinking (see statement 35), and enhancing classroom's instruction (see statement 42).

Findings from statements 43 and 45 show participants did not have the same level of agreement that they showed in other statements. All participants agreed that it is easy to make a connection between design thinking and content learning (see statement 43), and three out of seven agreed that it can be used in all subject areas (see statement 45).

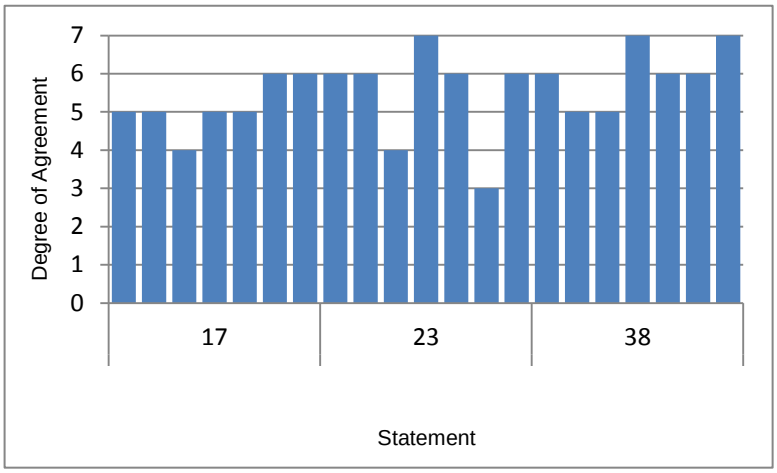


Figure 4.20 Statements reflected Collaboration

Figure 4.20 summarizes the responses to the statements that reflected "collaboration". Five out of seven participants, with various degree of agreement, thought collaboration helps define and solve a design problem (see statement 23). Six out of seven participants participant strongly disagreed that problem finding in design thinking always happens individually (see statement 17). Also in statement 38, five out of seven participants strongly agreed that design thinking and collaboration can be linked together.

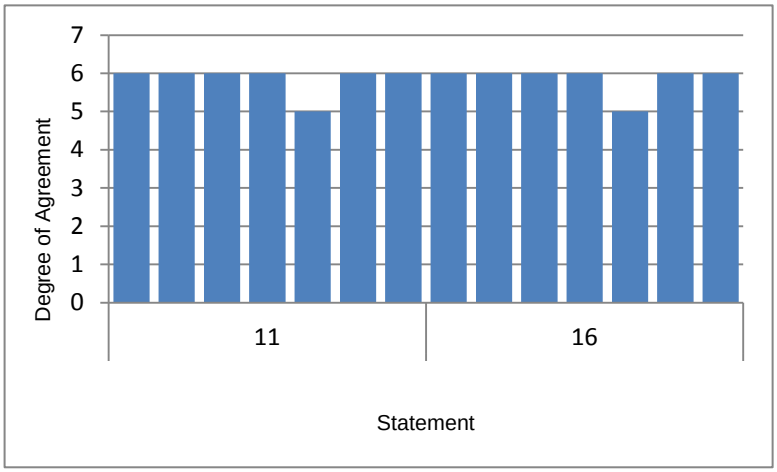


Figure 4.21 Statements reflected Creativity

Figure 4.21 shows that participants all strongly agree that design thinking fosters "creativity" and requires thinking creatively.

As participants made convincing statements about the influence of design thinking on developing creativity and collaborative work in the previous stage, I only included a few statements to examine if they still considered them after experiencing the event. Findings show that they strongly agree with the influence of design thinking on developing "creativity" and "collaboration", and encouraging "risk taking", and "problem solving".

Another group of statements designed to examine participants' ideas on considerations to apply design thinking and design skills (Statement 19, 26, 34, 36, 37, and 47). Figure 4.22 summarizes the findings from these statements. These statements were developed to further detail skills in section D of the survey, which is represented later.

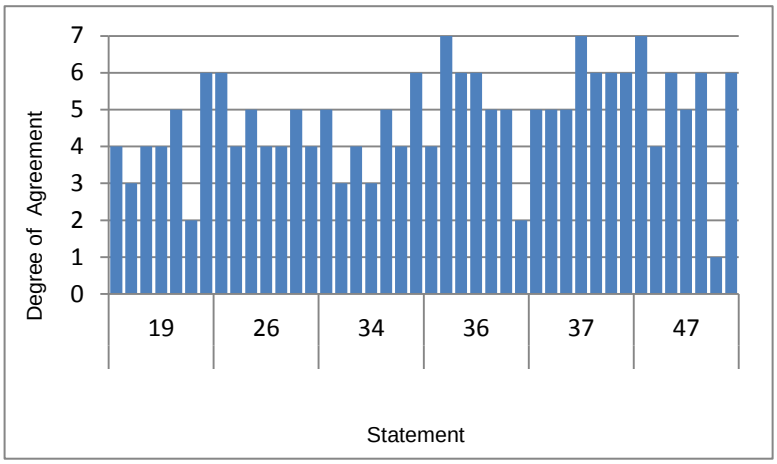


Figure 4.22 Statements reflected design skills

Two participants agreed that background knowledge is important in design thinking (statement 19), three thought design skills are needed to apply design thinking, and four agreed or strongly agreed that teachers should acquire those skills to apply design thinking (statements 26, and 47). Five out of seven participants agreed that visualization has the same value as written language in design thinking (statement 36). And, all of the participants did not think that lacking of such skills limited applying design thinking (statement 37).

Other than these questions in Section B and C, a separate section on the required design skills was created at the end of the post-event surveys. Statements in this section were designed drawing from Hoadley and Cox's (2009) divisions of design skills including problem finding skills, design techniques, and problem solving skills. They were distributed randomly in Section D. Figures 4.23 to 4.25 show the findings for each category.

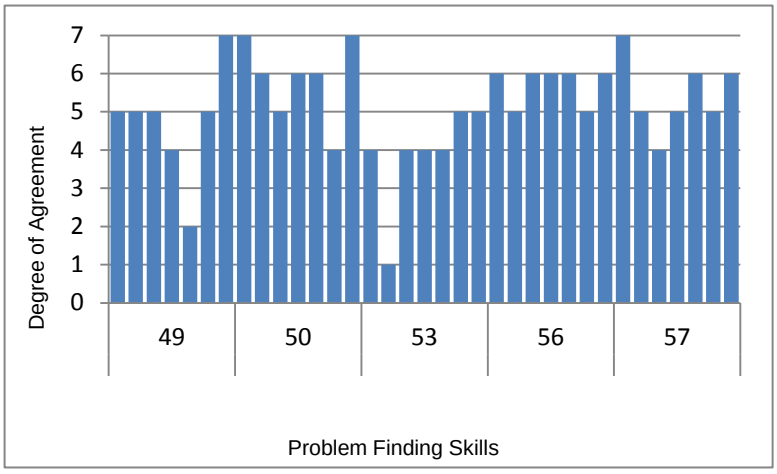


Figure 4.23 Skills and habits reflected problem finding skills

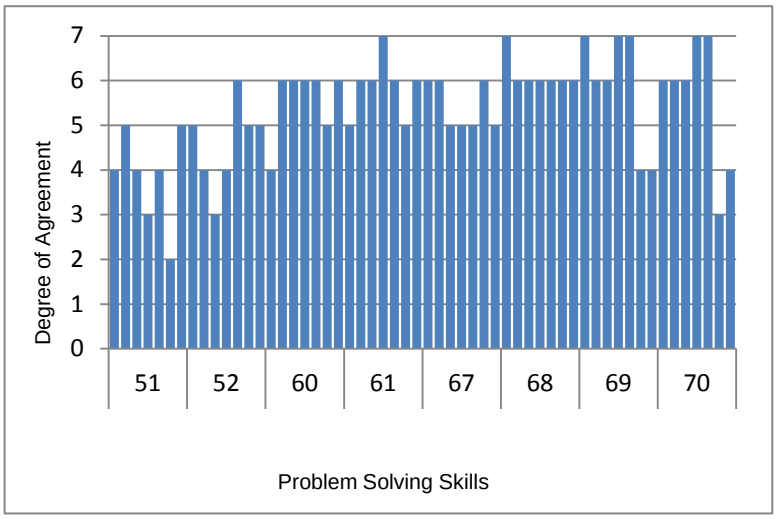


Figure 4.24 Skills and habits reflected problem solving skills

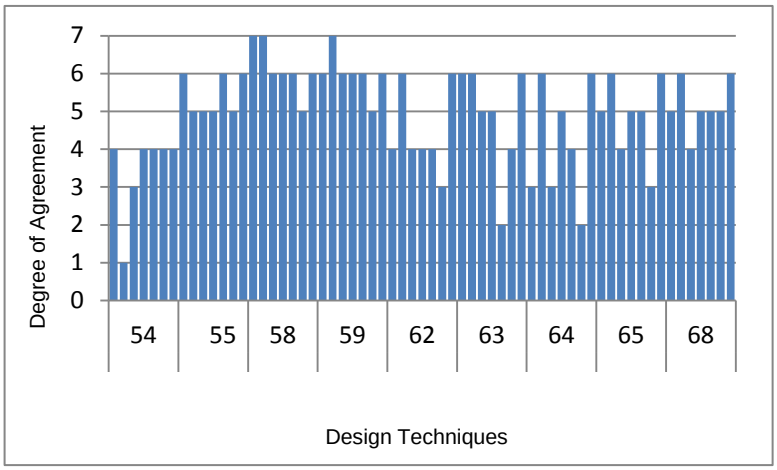


Figure 4.25 Skills and habits reflected design techniques

Figure 4.26 displays these three categories, and their importance according to participants' responses to Section D's statements. Comparing the results from three categories of skills in section D indicates that participants put more importance on problem solving skills. Problem finding skills were located in the second level of importance, and technical skills of design, including visual and construction techniques, were the least important types of skills in the participants' opinions.

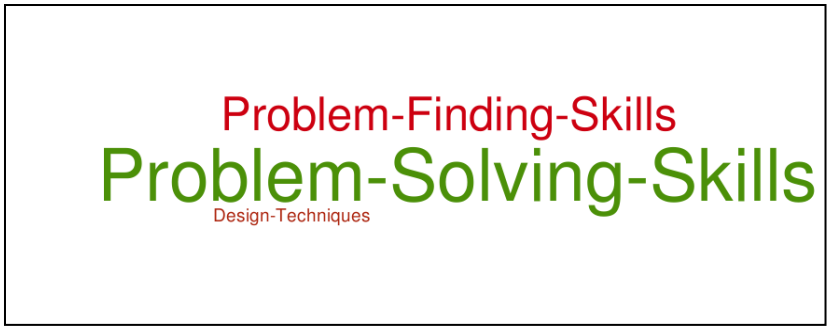


Figure 4.26 Level of importance of design skills in participants' opinions

4.4.4 Representation of Post-Event Surveys' Findings

In this phase, I used Word Clouds to present the findings and to highlight the main codes. These provide direction for detailed analysis and comparison of findings with the previous and following stages. The Word Cloud in Figure 4.27 presents the units of meaning from post-event surveys. Each word or phrase represents a code, which is a unit of meaning. The font size indicates the average quantity of content in participants' answers to post-event survey's statements.

Figure 4.27 Word Cloud represents units of meaning in the post-event surveys

4.4.5 Discussion on the Post-Event Surveys' Findings

The analysis of post-event surveys suggested the following points:

1. Participants showed a high level of agreement to *Design as Connecting.*

They agreed that design thinking fosters creativity, problem solving, risk taking, and collaborative work.

2. Participants believed design thinking fosters problem solving more than problem finding.

They agreed that finding a problem was embedded in design thinking. They also thought that collaboration, gaining empathy through conversation, and observation in real situations helps finding authentic problems. They did not think that finding an authentic problem is as important as solving it in the process of designing.

3. Participants perceived design thinking more as a product-driven action rather than a process-driven or a prototype-driven work.

Although they agreed that design thinking improves products, they did not think that if the design ends up as a failure, the process should be iterated. In a process-driven approach, if the prototype doesn't meet the intended objectives in the testing stage, then the process should be iterated as many cycles as needed to meet those objectives.

4. Participants perceived design thinking as making-oriented activity.

Their understandings were towards hands-on practices and making models rather than rough prototyping which may end up with failure and require refinement and redesigning iteratively.

5. Participants still were not sure how to incorporate design thinking with curriculum.

They thought it should be possible to make a connection between design thinking and the curriculum. But, they were uncertain if it would be applicable in all subject areas.

6. Participants considered problem solving skills more than other skills in designing.

To discover participants' perceptions about the potential impact of design thinking on how teachers teach and design the learning environments, the required skills (problem solving, problem finding, and design techniques) for designing were considered in the statements of the post-event survey. Findings suggest that participants valued problem solving skills more than problem finding. Technical skills of design including visual and construction techniques were the least important kinds of skills in participants' opinions.

Four out of seven participants agreed that design skills were required to apply design thinking but, they did not think that lacking of those skills limited applying it. They also accepted the importance of visualization in applying design thinking. The only statement that just two participants agreed with it was the necessity of background knowledge to address a design problem.

In the following sections, findings from both surveys are compared. The comparison was conducted at two levels: first, an overall comparison is explained based on the findings mentioned from both surveys; and second, a cross-check of the data was conducted through a one by one comparison of pre- and post-event surveys for each participant who had completed both.

4.4.6 Overall Comparison of Pre- and Post-Event surveys

Based on findings from each survey, which are presented in Word Clouds in Figure 14, Figure 26, and Figure 27 and the description provided, Table 4.6 summarizes the comparison of findings from the pre- and post-event surveys.

Table 4.6

Comparison of findings from the pre- and post-event surveys

Pre-event Survey	Post-event Survey
Design as Exploring, experiencing design process through making objects, is highlighted	*Design as Connecting*, the powerful role of design thinking in developing creativity, collaboration, risk taking, and problem solving, is highlighted.
Some points of *Design as Connecting* were mentioned: creativity, collaboration, risk taking, ownership of learning, problem solving, student-centeredness	*Design as Connecting* is highlighted. Participants showed a high level agreement on impact of design thinking on problem solving, learning, creativity and collaboration.
Participants' definitions of design thinking included not all but, parts of the related definitions in the literature. Problem finding (human-centeredness) and refining (mindful of process) were the missing points in most of the quotes by participants.	Participants showed a high level of understanding and agreement on the potential possibilities and impacts of design thinking on problem solving, learning, fostering creativity and collaboration. Participants also showed a higher level of understanding on human-centeredness.
Making models within projects was the dominant code in definitions, and prior experiences of design thinking and its relation to learning settings	Participants perceived design thinking as a Making-oriented activity. Notion of making (action-oriented) and its position in a design thinking process had the lowest rate of understanding comparing with human-centeredness and mindful of process.
Problem finding was a missed point in design thinking definitions, its relationship to education, and also in similar experiences to design thinking that participants had before. (it was only found in one quote)	Participants agreed that finding a problem is embedded in design thinking. But, they did not think that finding an authentic problem is as important as solving it in the process of designing.

Refining was repeated in some of the definitions of design thinking. But, participants did not mention how they had used this notion in the actual experiences they had before.	Participants perceived design thinking as a product-driven action rather than a process-driven or prototype-driven consideration.
There was no example for *Design as Intersecting*, which is about the relationship between design thinking process and content knowledge of a specific subject.	Participant thought it should have been possible to make a connection between design thinking and curriculum. But, they were not sure whether it would be applicable in all subject areas.
Participants considered the potential impact of design thinking just on how students learn, not on how teachers teach. They put problem solving experience, leadership, basic standards, creativity, open-mindedness, and nothing as the required skills for applying design thinking.	Participants respectively put more importance on problem solving, problem finding, and technical skills as important considerations, and required skills in designing.

4.4.7 One by One Comparison of Pre- and Post-Event Surveys

Based on the findings from pre- and post-event surveys, the overall comparison of participants' understandings of design thinking was described in the previous section. In order to cross-check the findings, pre- and post-event survey for each participant who had completed both surveys were compared. Table 4.7, 4.8, and 4.9 summarize the one by one comparison.

The criteria for the one by one comparisons were the three categories that emerged in the previous stages: two goals of applying design thinking (*Design as Exploring*, and *Design as Connecting*) suggested by Carroll et al., (2010), the key components of design thinking (human-centeredness, action-oriented, and mindful of process) developed by Hasso Plattner Institute of Design at Stanford, 2007, and design considerations and skills (problem solving, problem finding, and design techniques) in Section D of the post-event survey. The quotes by each participant in the pre-event survey were examined, coded, and organized in the table under the related factor. For examining the post-event surveys, participant's responses to the related statements were averaged and labeled A, B, and C based on the level of agreement each achieved.

Table 4.7

One by one comparison of pre- and post-event surveys regarding three goals of applying design thinking

Participant	Pre-event Survey		Post-event Survey	
	Design as Exploring	**Design as Connecting**	**Design as Exploring**	**Design as Connecting**
Participant 1	Hands-on activity	-	B	A
Participant 2	Project-Based Learning	Success increases	B	A
Participant 3	Making and remaking to learn/ Develop products	-	B	A
Participant 4	Thinking trough solution	Student choice of a creative solution	B	A
Participant 5	Design & build instruments	-	B	A
Participant 6	Have students build models	-	B	A
Participant 7	Learning by making in a group	Collaboration	B	A

Table 4.8

One by one comparison of pre- and post-event surveys regarding key components of design thinking

Participant	Pre-event Survey			Post-event Survey		
	Human-Centeredness	**Mindful of Process**	**Action-Oriented**	**Human-Centeredness**	**Mindful of Process**	**Action-Oriented**
Participant 1	-	-	Hands-on activity	A	B	C
Participant 2	Student-centered	-	Project-Based Learning	A	B	C
Participant 3	-	Making and remaking	Making/ Develop products	A	B	C
Participant 4	Experience problems/listening to others	Problem solving process	-	A	B	C
Participant 5	-	Refinement the idea/ improvement/revision	Build instruments	A	B	C
Participant 6	-	-	Build models	C	B	A
Participant 7	-	-	Learning by making	A	B	C

Table 4.9

One by one comparison of pre- and post-event surveys regarding design considerations and skills

Participant	Pre-event Survey			Post-event Survey		
	Problem Solving Skills	Problem Finding Skills	Design Techniques	Problem Solving Skills	Problem Finding Skills	Design Techniques
Participant 1	-	-	-	A	B	C
Participant 2	-	-	-	A	B	C
Participant 3	Nothing	Nothing	Nothing	A	B	C
Participant 4	None	None	None	A	B	C
Participant 5	-	-	-	A	B	C
Participant 6	-	-	-	A	B	C
Participant 7	Creativity	Creativity	-	C	A	B

Findings from the one by one comparisons of pre- and post survey for each participant suggest the same points that the overall comparison did.

In the pre-event surveys, participants paid more attention to *Design as Exploring*; whereas, in the post-event survey their attention switched to *Design as Connecting* (see Table 4.7).

In the pre-event surveys, participants emphasized the importance of hands-on projects and "making" aspect of design thinking; whereas, compared to other factors, they did not show a high level of understanding on the position of prototyping instead of just making in a design process in the post-event surveys (except Participant #6). Instead, they demonstrated a high level of understanding and agreement to the details of human-centeredness in design thinking. This did not appear very frequently in their quotes from the previous surveys. Also, design as a process of refinement was mentioned in a few quotes previously (participants #3, 4, and 5). This perception as a key component of design thinking was not improved as well as the notion of human-centeredness in designing (see Table 4.8).

Participants who completed both survey did not mention any types of needed skills for designing in the pre-event survey. Only Participant #7 mentioned creativity as a required skill to apply design thinking in the classroom. In the post-event survey, when participants were asked to mention the importance of skills in the list, they agreed more with problem solving skills than problem finding and design techniques. The only exception was Participant # 7. He brought up creativity, which can be linked to both problem finding and problem solving skills. In the post-event survey, he put more importance on problem finding skills in designing, than design techniques, and finally problem solving skills (see Table 4.9).

Findings from this phase also were triangulated with participants' detailed descriptions in the interviews. In fact, interviews provided complementary data to gain as much insight as possible on teachers' understandings on design thinking after the Maker Day. Findings from the interviews are presented and discussed in the following sections.

4.5 Data from Interviews

In this section, data from semi-structured, in-depth interviews are presented and discussed. Participants of this phase and interview questions are explained first. Then, findings from the interviews are examined for two different purposes.

1. Data from the interviews was used to triangulate the surveys data and to gain as much insight as possible on teachers' understandings of design thinking after the Maker Day.
2. Data from the interviews was used to explore how participants envisioned implementing design thinking in their classroom with regard to their instructional strategies, and the restrictions they expected.

4.5.1 Participants in Interviews

The population of this phase included four voluntary secondary school teachers in School District #83, who attended the Maker Day Professional Development event and completed the pre- and post-event surveys. All the seven participants from the previous phase were given the opportunity to participate. The selection of the four teachers for this phase was based on their interest in being involved in the research. The volunteer teachers were introduced to me by the Professional Development Chairperson in School District # 83. The interviewees were all secondary school teachers and teach different subjects which included Languages, Science and Math, Science, and Music. To protect the identity of the

interviewees, they were assigned new names: A, B, C, and D. All participants' voices were considered, quoted, and discussed.

4.5.2 Interview Questions

Interviews consisted of a list of semi-structured open-ended questions (see Appendix H). Open-ended questions were developed with the intent to triangulate data from post-event surveys and to gain a deeper understanding of participants' perceptions of design thinking. Plus, I wanted to elicit discussion on how participants envision putting the new knowledge into practice. In the interview, participants were asked whether or not the Maker Day influenced their current teaching; if they imagined bringing design thinking in their classroom; and how they imagined integrate it into their classroom. They were also asked to describe the differences between the Maker Day Professional Development event and the similar event where they participated as a facilitator.

4.5.3 Representation of Findings from Interviews as Complementary Source of Data

In this section, findings from interviews, which are related to perceptions of the participants on design thinking and provide explanatory descriptions of their opinions about the concepts, are presented and discussed.

Analysis of the interviews was conducted through iterative cycles of coding and recording. Each transcript was read with attention to repeated stories and links between the narratives. Emerged codes from pre-event and post-event surveys guided the coding process, and then made room for the emergence of the new codes in the next iterations.

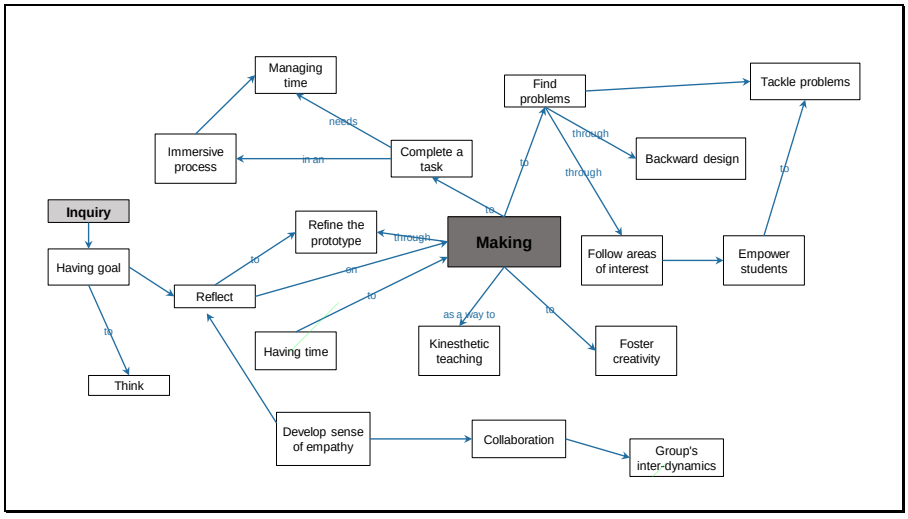


Figure 4.28 Findings from iterative cycles of coding in interviews as complementary data to the post-event surveys

Findings from iterative cycles of coding and recoding are presented in a Concept Map format in Figure 4.28, and discussed in the following parts:

1. Reasons for choosing design thinking as a making-oriented practice

Three participants perceived design thinking as making-oriented practices and only one participant was looking for more inquiry than making. They mentioned the positive influence of creating objects on students' learning, and they wanted to pick this aspect of Maker Day for different reasons which are described below.

- Making-oriented practices as a way to empower students

Participants A wanted to pick the "making" part of the Maker Day and encourage students to be more hands-on learners in order to stand school and enjoy learning. S/he believed this is a good way to empower them: "I think for them to walk away saying "I built this, I solved this, I did this" I think that would be revolutionary. They trust themselves and they believe in themselves more than actually now."

- Making-oriented practices as a way to foster creativity

According to Participant C, the Maker Day reinforced the idea that s/he had before; hands-on projects, in which students making things, fosters creative thinking.

- Making-oriented practices as a kinesthetic way of teaching

Participant B was trying to find and try a more kinesthetic way of teaching by hands-on practices; a way for teaching students who have difficulty with abstract thinking and students who are disinclined to read and learn from textual materials. S/he said:

> Drop rates for high schools improved significantly….[students] eventually finish it quite often as adults. I think there is something not right there…. I think something like this could really offer a way for a lot of kids because there is something in our education system that it is so dependent upon the text.

- Making-Oriented practices to find problems through backward design

Two participants suggested making an existing model first and through the making process, students understand, observe, learn, and explore the existing model in order to find

its problems. Participant A said students, typically boys in grade 9, are hands-on learners who need to build and see what it is, and then figure out the problems. S/he said:

> If I get them into the problem, they don't have any clue to talk about it…. They don't have the ability to conceptualize the theory to the end result. If they have end result first, like the prototype, and then work backwards to what the theory might be, that would be good…. I need those hands-on products, and then work backwards to the theory or take another hands-on product and make it better.

Participant B believed once you have the existing model, you can compare it with design criteria, and if it is not close enough to the design criteria, go back and modify it with the group. In his/her opinion, it is like writing essays. "You write them … and each time you re-read them, see does it express the ideas that I had? You can do the same type of process with an actual 3-dimensional product."

- Shortening the process to focus more on "making"

Participant C thought the design thinking step by step process doesn't work for the secondary school students. S/he wanted to shorten the process to focus more on "making". S/he declared" "I find my students very resistant to step by step procedures that they have to follow…. I would blend this step by step procedure with hands-on activities."

- Having a goal for thinking and enough time for making and remaking

Participant D, who was looking for inquiry more than making, brought up the necessity for a goal in order to make thinking happen first, and enough time for students to have hands-on time. S/he suggested having a goal is needed for secondary school students. "Teenagers specifically need to be given parameters about what things to think about not what to think." And s/he mentioned the importance of giving a proper amount of time for making and remaking: "There has to be some ways to allow student to play and figure things out and have a mistake and try to fix it….In a traditional classroom, there is not always that time allowed." This perception is more prototype-driven than making-driven, an iterative process through which the prototype is improved to achieve the goal. This perception aligns well with the nature of design. The iterative cycle of refinement has problem finding aspect

within itself. Because refinement needs finding an existing problem, trying to solve it, and make it better.

2. Design thinking is an immersive process to complete a task

Two participants acknowledged design thinking as a process, in which a task is completed in a certain amount of time. Participant B said: "[Students] learn that they should complete a task. There are tasks that they must do". And Participant A added:

> [In Maker Day], I saw different ways of solving a problem within a Pro D-day that was concrete and real…. It is not just thinking about the problem but it is an actual step by step manner to get it done.

3. Managing the time is important to finish a design task

Based on the Maker Day experience, Participant B believed that it is important how much time you are going to leave for each step, and to keep people on track and also to manage the time. S/he explained:

> When you see somebody confused [who] doesn't seem to be moving along to be able to give them a little cue and a little push. Otherwise, you will end up without enough time, and you end up just rushing it all at the end because you have to finish it today.

4. Reflection on the prototype is important

Participant B mentioned the importance of reflection upon the prototype they created. S/he thought that they missed this part in the Maker Day. "We finished and there was very little reflection on what we had done…. I think the post project analysis is absolutely essential and it would be a major part." S/he explained that they started with conceptualizing and a series of negotiations to come up with a group concept, and design criteria. Then the actual outcome was different from the group's initial concept.

5. Design thinking develops sense of empathy

Participant D found his/her students to be very focused on themselves and just those people who are around them. S/he said, "Empathy is not something that is really necessarily strong in the majority of students. So they may be very empathetic but it takes a minute for

them to realize that they have to look at it from the other person's point of view. It doesn't come naturally at that age for a lot of children." S/he believed the design thinking project that they did in the Maker Day was extremely beneficial for students to have those experiences and start thinking in a different way and maybe start thinking about people other than themselves.

6. Group's inter-dynamics is important in collaborative work

All participants in the interviews facilitated a similar Maker Day for students, and believed that design thinking fosters collaborative work. Participant B and D mentioned it is important to study the group's inter-dynamics in order to make a balance between the group's goals, and individual tasks. They shared their experiences about how the inter-dynamics of the group affected the performance of the group, and how changing the dynamics of the team improved the outcome of the group. Participant B said:

> One [student] for some reasons didn't show up and that changed the dynamics, and one of the kids didn't participate very much, and all the work have been done by two people. I think we lost a lot because of it….Every participant really brings something to this. Everybody has some skills, knowledge, ideas that are valuable to the group.

Participant D mentioned that one student didn't like the process because it was a completely different way of thinking. S/he said:

> I can understand not being willing. Once he had left, the dynamic of the group changed just enough to allow the students to really get on board and go full steam ahead. The student who didn't want to be engaged put the brakes on the whole group.

7. Allow students to follow areas of their own interests to find the problem.

In the interviews, two participants brought up descriptive ideas on problem finding which was missed previously.

Participant C believed the choice to decide what kinds of problems students want to tackle should be based on the area of their interest. S/he explained: "The choice is one of the

main things in making it [design thinking] successful. Choosing a topic that they [students] are interested is enough to follow it and do it."

Participant D expressed his/her perception of design thinking as a way to tackle the problems in future. S/he thought students need to be taught to better evaluate a problem from multiple sides, to see solutions, and to experience thinking in a different way to be prepared for the future life. In his/her words s/he said:

> The world that students are going to be graduating into and living into in the next twenty years is going to be so much different from the world they are in now; the world that I am in. The problems that they are going to be facing, we can see them coming, but we don't know the actual issues; we don't know what it is going to look like until it happens.

8. Design skills emerged: problem solving skills and design techniques

Three codes emerged from the interviews regarding the required skills for applying design thinking: the ability to motivate students (Participant C); Prior knowledge to facilitate the process (Participant B); skills to use the tools and technology (Participant D). In fact, according to Hoadley and Cox (2009), Participant C and B discussed problem solving skills as the required important skills to apply design thinking. By problem solving skills Participant C meant, "The skills that teachers generally have, which is the ability to motivate the students and to link the process with something that students are interested in pursuing". Participant B thought prior knowledge for the facilitator is really important. S/he said, "Because you have to be comfortable enough to be able to control the process and anxiety of participant. What matters and what doesn't?"

Participant D thought skills to use the tools and the technology aspect is important. S/he thought being able to use them effectively would be helpful. But, s/he believed "It is not just based on tools"…. Anybody who has lived a life can figure out problems to use and solutions. People can deal with those things. I think anybody can do this."

9. Connecting design thinking concepts and content learning is important.

Participants mentioned through design thinking and making a prototype, students need to learn the content knowledge of the specific subject. This is what Carroll et al. (2010) call it *Design as intersecting*.

Participant A said that s/he did not know how to take the Maker Day concepts and link them to the grade 9 learning outcomes. S/he mentioned, "I am sure it is reasonable but, I have not been able to do that yet."

Participant B also believed that design thinking should be linked to the specific subject area. S/he expressed his/her opinion on importance of linking design thinking process to the content knowledge as:

> When you build something, you have to have not just the idea of constructing an object but, some theoretical principles that you are trying to teach them through construction. Next time when you are talking about the theoretical concept, they remember that they experienced it in a construction project and they won't forget it. The mental sequence is established in their minds from having done the project.

Participant C thought that in some subject areas like Music does not really work. S/he mentioned: "What we do in Music is we learn how to play the instruments and play a song. So, it doesn't apply to Music process". But, s/he believed that in "the less traditional courses, which tend to be more project-based, more hands-on and more student-directed" design thinking can be used and can be linked to the content knowledge.

Participant D discussed that design thinking does support an integration of the content. S/he believed:

> It is not just the content but it asks them to do something with it…So often, education is spoon feeding; here is the information and just take it in. They are not asked to do anything with the information that they are given.

S/he suggested students need to internalize the knowledge though learning it in such a process, instead of knowing something for two weeks before the test and then forgetting it.

4.5.4 Discussion on Findings from Interviews as Complementary Source of Data

Findings from the interviews provided the study with more detailed and explanatory descriptions of participants' understandings about design thinking after the Maker Day. The following points are incorporated to the post-event surveys' findings.

1. Making-oriented activities within projects are the most dominant part of participants' perceptions on design thinking. They provided some reasons to explain why this part intrigued them: to empower students, to foster creativity, and to find a way of kinesthetic teaching and learning. Although still the focus of three participants was on the "making" part but, they provide arguments on why they chose the "making" part.
2. Problem finding, which was a missed point before, was suggested by participants through conducting backward design and allowing students to follow their area of interests to find a problem. Also design thinking was perceived as a way to prepare students to tackle the unknown in the future.
3. Importance of reflection upon the prototype was mentioned by a participant. S/he thought this part was missed in the Maker Day and they did not get a chance to reflect on the prototype they made.
4. Participants brought up specific considerations of applying design thinking for the secondary school students: shortening the thinking process because teenagers are resistant to step by step process; developing sense of empathy through design thinking because they are very focused on themselves at this age and design thinking can be beneficial to start thinking about people; and, having a goal to give parameters about what things to think about not what to think.
5. Participants mentioned some careful thought on importance of design thinking to complete a task; importance of the facilitator's role in managing the time to be able to complete the task; and importance of group inter-dynamics to make a balance between the goal and individuals' tasks in design thinking.
6. Participants felt the need to acquire and improve problem solving and technical skills of designing. Problem finding skills were not mentioned as required skills for designing.

Findings from pre- and post event surveys plus the complementary data from interviews explore and compare participants' understandings of design thinking before, and after experiencing it. This part includes a semi- summative evaluation to conclude whether the Maker Day met the predetermined specifications. It also ties to the first research question, which is "What are the secondary teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event?" Concluding the results from this section provides recommendations for improvement of content in the next Maker Days.

Findings from the interviews in the next section, which explore whether participants envision bringing the new knowledge to their classroom, include a formative evaluation on the Maker Day. This part ties to the second research question, which is "How might the participant teachers envision implementing design thinking concepts into their classroom?"

The results of semi-summative and formative evaluation generate design principles and guidelines to optimize the design of Maker Day for more improvement for the next cycle of design.

4.5.5 Representation of Interviews' Findings on How Participants Envision Putting the Knowledge into Practice

The open-ended questions also were used to explore whether or not participants envisioned bringing design thinking to their classroom. Participants of this phase, other than attending the Maker Day Professional Development event, facilitated the same process they had experienced in the Maker Day for secondary school students in a learning workshop developed by School District #83. So, in the interviews they were asked to describe the differences between the two events they had experienced.

All interviewees liked the Maker Day and found it beneficial. For example Participant D mentioned, "I never heard one negative comment the entire time around the pedagogies being expressed."

Participants of this phase were asked to describe if they had applied design thinking concepts in their classroom before the Maker Day; if they had applied design thinking after the event and, if they envisioned applying it in their classroom later. Table 4.10 summarizes the answers to these questions.

Table 4.10

Participants' use of design thinking before the Maker Day, currently, and in the future

Participant	Before the Maker Day	After the Maker Day	In the Future
Participant A	No	No	Yes
Participant B	Building models	No	Yes
Participant C	Hands-on projects	No	Yes
Participant D	Open-ended/not solution-based	10-20% of the time	Yes

Participant A, who had not applied design thinking before the Maker Day, mentioned, "Currently I am still in the interesting stage, and not developing or planning stage. I look forward to providing my students with background of Maker Day, and linking it to Science or Math".

Participant B said that as a similar experience to the Maker Day, s/he had asked students to build 3-dimensional models, and they needed to meet a list of criteria through making the model. S/he said that it was just by chance that s/he had been doing this, rather than by design. It had been something in his/her consciousness and after the Maker Day s/he was just learning about it. S/he explained:

> I was unaware of design thinking process in terms of specific teaching methodology…. However, after my experience, I am trying to thinking about that…. I think something like this could really offer a way for a lot of kids because there is something in our education system that it is so dependent upon the text.

Participant C had used hands-on projects before and s/he thought design thinking "doesn't really apply" in the subject s/he was teaching but, s/he envisioned using it in other circumstances. In "some of the less traditional courses, that we are offering at our school, which tend to be more project-based, more hands-on".

Participant D said that s/he had done aspects of design thinking process before the event. S/he used to do something similar but, it was a little bit more open ended and wasn't quite solution-based that you must get to a certain point. Regarding using the concepts after the Maker Day, s/he said: "[I used them] probably not as much as I should be. I am using about 10-20% of the time, and I still have the things more open ended in the classroom". S/he

designed a cross-curriculum course with his/her colleagues collaboratively in their school. S/he described: “In the upcoming year, we actually are implementing a six week block of time for a group of students to actually do nothing but design thinking. They should take it as a course.” When I asked to explain more about this course, Participant D added,

> So, it is Science, Social Studies, Math, and English, all four combined, and it is going to be taught by a shop teacher. It is going to include all of the aspects of Maker Day that we talked about. But it is going to be extended over six weeks. We hope by the end of it students will be fluent enough in the process, and they can actually come up with something patentable.

In addition, s/he hoped to be able to do it to other classes as well. S/he was figuring out “the when, and the where, and the how”.

All participants envisioned bringing some of the aspects of the Maker Day into their classroom. They shared their ideas on how they wanted to do so, and described the strategies they imagine to use in order to apply the concepts in their classrooms. Figure 4.29 illustrates the key points captured from participants’ ideas about which aspect of the event they wanted to bring to their classroom, and how. The key points emerged from the iterations of coding and recoding of the interviews’ transcriptions.

Participant A, who teaches Science and Math in secondary school, was “excited” to examine more about the Maker Day with regard to Science and Math. S/he was not quite sure how to link the Maker Day procedure to grade 9 learning outcome. S/he liked the idea of Maker Day in which students give solutions to a problem in a certain block of time. But, s/he said to do so the problem should be chunked into smaller sections for students to be able to make that solution. What s/he imagined as a future possibility was starting with a model of an existing object through which they may find a problem and then, working backwards to the theory, or taking another hands-on product and making it better. S/he added “I would need physical, tangible, real-world. This is the pump, this is the equipment, [and] this is the tool I made, how to make it better, or how to make it cheaper, or how to make it with less materials instead of just the theory.”

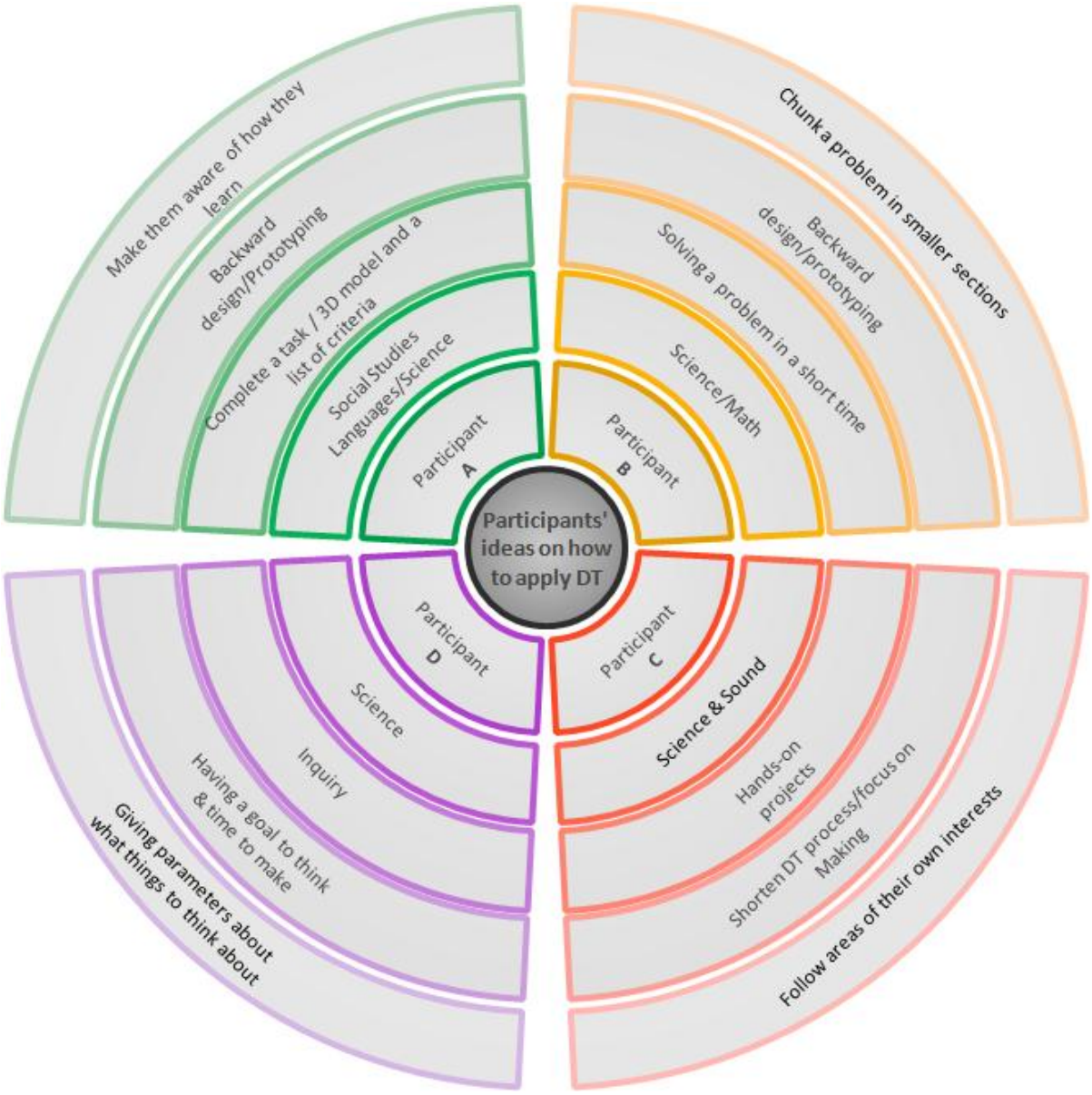


Figure 4.29 Participants' ideas on bringing some aspects of the Maker Day

Participant B teaches Languages, and Social Studies. S/he pointed that s/he was relatively new to this whole idea. However, after experiencing design thinking process, once as a participant in the Maker Day and once as a facilitator, s/he believed in a design thinking process, students learn that they should complete a task. S/he wanted to bring the *Making* part into his/her classroom; creating a three-dimensional model and comparing the model with the design criteria that the students are given was the suggestion s/he made. S/he brought up an example of building dioramas in a Social Studies project:

> They do a three dimensional model, and they have a list of criteria that they must meet. For example, if there are doing the construction of a rail road in the 19th century in Canada, they would have to show a person of Chinese origin as a labor of rail road to get the anchor of that idea that a large number of the people were Chinese labors to come over, and build the rail road, or they would have to show a trestle made of tooth picks on a particularly mountain slope to give them the idea that it was difficult to cross the Rocky mountains.

Participant B also emphasized on importance of having a goal and criteria, and comparing the prototype with the design criteria to see if it meets the criteria. Like Participant A, S/he suggested backward design as a possibility to apply design thinking. S/he explained: "…build the prototype first. Then, once you have the prototype, you can compare it with design criteria, [then], go back and rehash it with the group". Participant B believed the best strategy to apply design thinking is to make students aware of how they will learn, or how they will meet their learning outcomes; letting them know what it is that you want them to learn through this process at the beginning. S/he explained "Otherwise, I am sure they enjoy it but, they have to gain something out of it".

Participant C envisioned taking the "making" part of the Maker Day as well. S/he explained: "I would definitely shorten the process and focus more on the making part…. I find my students very resistant to step by step procedures that they have to follow. They mostly really want to do it in their own way so. I would blend this step by step procedure with hands-on activities". As a best strategy to apply design thinking, s/he suggested to allow students follow areas of their own interests, which is opposed to saying "You are going to build something related to X". S/he meant students should have the choice to decide what kind of problems they want to tackle, and what kind of solutions they want to build. He clarified "The choice is one of the main things in making [design thinking] successful. Choosing a topic that hopefully they are interested in enough to follow it, and do it".

Participant D was the only person who wanted to focus more on inquiry than on making. As a best strategy to apply design thinking concepts, s/he suggested having a goal, parameters, and enough time. S/he believed "Teenagers specifically need to be given

parameters about what things to think about not what to think". Also, s/he mentioned the importance of giving a proper amount of time for making and remaking in order to allow students to play, have mistakes and try to fix it. S/he also shared his/her opinion on the connection of design thinking and the content learning, and declared:

> So often, education is spoon feeding; Here is the information and just take it in. [students] are not asked to do anything with the information that they are given. Design thinking does support an integration of the content. It is not just the content but it asks them to do something with it. So, they have to internalize their knowledge. It is not just something know for two weeks before the test and then they forget.

As mentioned earlier, all four interviewees were involved as facilitators in a learning workshop similar to the Maker Day conducted for students. Participants in the interviews shared their experiences about the differences between the Professional Development event and the learning workshop for students.

According to Participant D, reactions from students who attended the similar event to Maker Day were extremely positive. There were almost 60 students, and only 3 left. They were all engaged in the activity. Participant D said: "When you think about it, they had the opportunity to leave, and have lunch, and a lot of them got their lunch ate it as fast as they could to get back in there and work. They were still talking about it in June".

Participants B and D mentioned that the Maker Day Professional development event that they participated in was more fun. They felt that there was a lot of satisfaction of making something. But, as a facilitator in the second event they tended to take on a lot of anxiety of the outcome and achieving something. Participant B said: "[In the second one] there was a sense of time frame of organizations, and being somehow responsible for what is being produced". Participant D said that s/he did not want to be the person directing their thinking to a specific path. S/he clarified:

> Teachers are very used to leading kids down a specific path to get to the end goal well. In Maker Day, the end goal was going to look different for everyone. So, what I

had in my brain was not necessarily what was going to be the end goal for students; trying not to influence that was difficult.

In contrast, Participants A and C mentioned that they were more comfortable in the second event working with the students. Because they experienced the process once, and trusted the procedure that it did work. Participant A shared his/her experience on both events and explained:

> As a participant, and being a teacher, I had bunch of reason skills and ability to adapt but, as a grade 9 students, they had no idea what it means and so, I had to empathize with my students to make a connection that yes! This procedure works that you would be even proud of…. Now, as a facilitator, I see the merits of this thinking process.

Participant C thought the same way as participant A thought. S/he believed that the teachers got into it more easily than the students did. S/he added: "The students really wanted to get into the building part as quickly as possible. They were not patient enough in the design thinking process. The first part should be modified. It should be short".

In general students liked the event so much. Participant D said: "Students positive feedback was a big suggestion to me that this is the way things should be moving".

The interviewees also were asked to describe restrictions and obstacles of using design thinking in their subject area.

Participants A and C brought up the restrictions of interconnecting design thinking and their subject area. Taking the higher level of thinking concepts and applying it to the grade 9 level was a restriction to Participant A. He said: "I am sure it is reasonable but, I have not been able to do that yet". Participant C said that design thinking is not applicable in Music. S/he said: "What we do in Music, is we learn how to play the instruments and play a song. So it doesn't apply to Music process". But, he said that he will teach other subjects that it does apply. He believed design thinking can be applied "in some of the less traditional courses which tend to be more project-based, more hands-on and more student-directed".

Participants B and D pointed that time would be a serious restriction to apply design thinking in the classroom. In Participant B's opinion the time a teacher needs to be more creative and design learning activities was the biggest problem. S/he clarified

> This maker day is a perfect example. I, as a teacher am getting sort of inclined about it. But I don't have the time to spend time learning about this. It is not an easy process trying to integrate a new idea into your practice…. It is such a long process to put things in place, and they have to be reinforced so many times so that, people don't backslide, or forget, or fall away from things.

From Participant D's point of view, the timetable was a restriction; the efficient time s/he needed for applying design thinking including the process of describing a problem, generating ideas, and prototyping in the classroom was a restriction. S/he explained:

> If it takes me twenty minutes to discuss an idea or concept, and go through the stuff and then they get to play or work or start doing it. Then, I have to clean it up and get going. They only have an hour and fifteen minutes. So if you take twenty minutes out at the beginning and another ten minutes out at the end, they don't have an actual hands-on time.

To him/her, the danger aspect of using the tools might be an obstacle. S/he hesitated to allow students to play with tools like drills. Accessibility to the tools was another issue s/he brought up explaining: "If I only have one tool and 25 students that is an issue".

4.5.6 Discussion on Interviews' Findings: How Participants Envision Putting the Knowledge into Practice

Analysis of the interviews indicated the following points:

1. Research participants found the experience of Maker Day beneficial and effective. Although not all of them found an effective way to link design thinking to their subject area, they had the concept in the back of their minds and wanted to move forward with them.
2. Participants had already felt the need for change in the education system, and thought design thinking can support internalizing the information, and integrating the content

knowledge with something meaningful. Also, as secondary school teachers working with teenagers, they suggested design thinking can encourage different kinds of learners to stand and enjoy school. They were trying out where, when, and how to apply it in their classroom.

3. Findings show participants were not passive recipients of design thinking as a new pedagogical tool. They facilitated a similar Maker Day for students and went through the same process that they, themselves had experienced it in the Professional Development event. Experiencing design thinking with students gave them more insight about how it might work with students.

4. They envisioned modifying and customizing the d.School's design thinking process to better meet their students' needs in secondary level. Making the design thinking process shorter, making it extended, focus more on inquiry, and using backward design starting from building an existing model and refining it were the ideas that the participants imagined them as future possibilities to apply design thinking in their classroom.

5. Three out of four participants envisioned bringing "making" part of the Maker day to their classrooms. They thought Maker Day reinforced ideas they had before; conducting hands-on creative projects in which students making objects.

6. Participants expressed two different feelings they had working with students and facilitating the design thinking process: Anxiety of the outcome and achieving something, and feeling more comfortable and trusting the process.

7. The probable restrictions they imagined, or they encountered to apply design thinking were: finding time in a busy life of a teacher to design learning activities based on design thinking; restrictions in the timetable in the classroom to give sufficient time to students to create, experiment, fail, and recreate; and finding a linkage to integrate design thinking mindset to the content knowledge of the specific subject and learning outcome of the students.

8. Students' positive feedback was a big suggestion that this could be a way to move forward and make the change in 21st century's teaching and learning take place.

9. Findings also indicate the importance of support from the School District and school leadership to promote and adopt design thinking to transform curriculum and instruction. Maker Day impressed decision makers in the School District. After the Professional Development event, the School District funded and developed a similar workshop for the

students. This event developed by School District # 83 in partnership with UBC's Innovative Learning Centre (ILC) one month after the Professional Development event. It was the first Maker Day with students in B.C and over 60 students from five different schools came together to engage in design thinking and prototyping activity. Teachers from the Maker Day facilitated the workshop and experienced the process from another angle. Also, having the experience of the Maker Day, teachers from one school developed a shared vision, and collaboratively designed a cross-curriculum course on design thinking for the next semester. The aim of bringing design thinking to schools is not adding another course to the curriculum but rather, designing such courses fosters environments that are conducive for design thinking.

4.6 Concluding Remarks for Chapter 4

Chapter 4 outlined and discussed the findings of the research. In this study, within the framework of Design-Based Research, secondary school teachers, who participated in the Maker Day Professional Development event were surveyed and interviewed in order to collect their perceptions of design thinking prior to, and after experiencing the event and examine their visions on implementing it as a future possibility.

Findings from the pre- and post-event surveys were compared in two levels: an overall comparison of teachers' understandings before and after the event, and one by one comparisons of the pre- and post-event survey from each teacher who completed both to cross-check the data. Findings from the interviews were used as a complementary source of data to the post event surveys in order to better identify the teachers' perceptions of design thinking after experiencing the Maker Day.

Findings from the pre- and post event surveys plus the complementary data from the interviews explore and compare participants' understandings of design thinking before, and after experiencing it. This part includes a semi- summative evaluation to conclude whether the Maker Day met the predetermined specifications about design thinking. It also ties to the first research question, which is "What are the secondary teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event?" Concluding the results from this section provides recommendations for improvement of content in the next Maker Days, but still needs more evidence from the formative evaluation (McKenney, 2001).

Formative evaluation is conducted based on findings from the interviews in the next stage of the study.

Findings from the interviews in the next section, which explore whether participants envision bringing the new knowledge to their classroom, include a formative evaluation on the Maker Day and concluding the results from this part generates design principles for more efficiency and improvement for the next cycle of design. This part ties to the second research question which is "How might the participant teachers envision implementing design thinking concepts in their classroom?"

The results of semi-summative and formative evaluation generate design principles and guidelines to optimize the design of Maker Day in future cycles of design. In the next chapter, Chapter 5, based on the findings and discussion mentioned in this chapter and evidence from the literature and theoretical framework of the study, recommendations for improvement of content, and format of the Maker Day in the next design cycles will be offered.

Chapter 5: Conclusion

5.1 Summary of the Study

Design thinking, as a human-centered approach considers empathy and supports constructionist learning. In education, design thinking can encourage students and educators to identify real-world problems and offer solutions through prototyping. By using this approach, teachers can design learning environments and broader sets of 21st century's required skills can be cultivated in students.

Maker Days were designed to support educators in making changes to their teaching practices as they are increasingly being asked to do so. Maker Days aimed at informing the educators of the potential values of design thinking and making by actively experiencing the process of design thinking and prototyping and encouraging them to bring the concepts to their classroom.

Secondary school teachers who participated in the Maker Day Professional Development event were surveyed before and after the event. They were also interviewed after experiencing the design thinking process in order to examine their perceptions about design thinking prior to, and after experiencing it, and to explore their insights about implementing it as a future possibility in their teaching practices.

Findings from the pre- and post-event surveys were compared. The comparison was conducted in two levels. First, based on findings from both surveys, an overall comparison took place; second, a cross-checking of the data conducted through one by one comparison of pre- and post-event surveys for each participant who had completed both.

Findings from this phase were triangulated with participants' detailed descriptions in the interviews. In fact, interviews provided complementary data to gain as much insight as possible on teachers' understandings of design thinking after the Maker Day.

Comparing participants' understandings of design thinking before and after the event includes a semi- summative evaluation to examine whether the Maker Day met the predetermined specifications about introducing design thinking. This part ties to the first research question, which is "What are the secondary teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event?" Discussing the findings from this section provides recommendations for improvement of the next Maker Days but,

still needs more evidence from the formative evaluation (McKenney, 2001). Formative evaluation conducted according to the findings arose from the interviews.

Four interviews were conducted to explore the second research question which is, "How might the participant teachers envision implementing design thinking concepts in their classroom?" Findings from the interviews include a formative evaluation of the Maker Day. Examining the findings from this phase and the semi-summative evaluation from the previous phase generates design principles and recommendations for more improvement for the next cycles of design in the Maker Days research.

5.2 Summary and Discussion of Findings

In this section all findings collected from the surveys and interviews are summarized and discussed according to the related literature and theoretical framework of the study. The results are arranged and presented into two main categories that relate to the research questions.

5.2.1 Participants' Understandings of Design Thinking Before and After the Event

Findings from the pre-event surveys suggested that the concept of design thinking was not new to the majority of participants before experiencing it in the Maker Day. They brought up not all but parts of design thinking definitions and some aspects of its integration to learning settings.

In the pre-event surveys, ten out of thirteen participants mentioned the powerful role of design practices in developing creativity, collaboration, risk taking, ownership of learning, problem solving, and student-centeredness. These all align to *Design as Connecting*, one of the goals of applying design thinking in the classroom suggested by Carroll et al. (2010). In the post-event surveys, *Design as Connecting* was highlighted too. Participants showed a high level of agreement about the impact of design thinking on problem solving, learning, creativity and collaboration.

Experiencing a design process through making objects was highlighted by participants before they went through the actual process of design thinking. This aspect of designing and its integration to learning aligns with *Design as Exploring*, a goal of applying design thinking in learning settings (Carroll et al., 2010). *Design as Exploring* highlights the ways that students engage in collaborative design activities and prototype-driven projects, and experience the design process. Participants of the pre-event surveys assumed design

thinking is making artifacts through Project-Based Learning. They expressed their similar experiences they had before; different hands-on projects they did in their classroom were perceived as design thinking practices.

Design as Exploring should give an opportunity for inquiry and exploration rather than immediately reaching a solution. In the pre-event surveys only one participant brought up the importance of problem finding before making in a design thinking process. Making two- or three-dimensional models is a part of a design thinking process not the objective. Creating prototypes is located almost at the end of the process. After identifying the problem through inquiry, observation, developing a point of view, and addressing needs through empathy, different ideas are suggested and the prototype is made as the generated solution to the identified problem.

In the post-event surveys, six out of seven participants perceived design thinking as a making-oriented activity. Their understandings were towards hands-on practices and making models rather than rough prototyping, which may end up in failure and need refinement and redesigning. Notion of action-oriented and the position of making in a design thinking process had the lowest rate of understanding compared to human-centeredness and mindful of process in the post-event surveys. Also, in the interviews three out of four participants focused on making-oriented activities and doing projects. Participant C wanted to shorten the thinking process to focus more on making. Participants provided some reasons to explain why the making part intrigued them: to empower students, to foster creativity, and to find a way of kinesthetic teaching and learning. Only Participant D envisioned focusing more on inquiry with a goal in mind and then, doing hands-on activities to achieve the goal. Guiding the students to use an inquiry orientation with a goal in their mind considers the learning objectives, and using the materials purposefully. This approach aligns with what Wiggins and McTighe (2006) suggest for bringing the maker approach to schools.

Before experiencing the design thinking process in the Maker day, participants (except one) did not mention anything about problem finding in a design process. In the post-event surveys they expressed agreement about the fact that finding a problem is embedded in design thinking. But, they did not think that finding an authentic problem is as important as solving it in the process of designing. In the interviews where participants explained their ideas descriptively, they suggested problem finding as a part of the process they were

imagining for implementing design thinking in their classroom. They suggested problem finding through conducting backward design (Participants A, and B), and allowing students to follow their area of interests to find a problem (Participant C). Also design thinking was perceived as a way to prepare students to tackle the unknown in the future (Participant D).

By backward design Participants A, and B meant a similar process that designers/engineers go through in a reverse engineering process. Reverse engineering is taking apart an object to see how it works in order to find its problems and improve it. In fact, the two participants suggested extracting knowledge by making an existing object, and finding its problems through making it, disassembling it, and trying to refine it and improve it.

Participant C's idea of allowing students to follow their area of interests to find a problem aligns to Bruner's (1960) constructivist approach that suggests educators should encourage students to discover principles by themselves based on their own interests, and examine how they process information effectively. By doing so, meta-cognitive skills and thoughtfulness are improved in learners. Meta-cognitive skills involve thinking about thinking, and purposely making changes in the way of thinking (Tan et al., 2003).

Participant D mentioned that design thinking can be used as a way to prepare students to tackle the unknown problems in the future. This idea supports the aim of 21st century's education which tries to cultivate broader sets of required skills in students and integrate them with the curriculum in order to cope with the challenges they encounter in their lives. Students should be capable of finding complex problems that exist in real environments and offering solutions to such complex and open-ended problems collaboratively and creatively.

Although problem solving has been addressed as a required skill in the 21st century, fostering problem finding skills can empower students to become 21st century's thinkers. Prior to offering any solutions to a problem through making objects, one needs to explore why one would make something and what is worth making. Finding a problem is an authentic way to approach making. Applying design thinking, inquiry and brainstorming prior to making an object makes the process purposeful and also makes the object as the specific solution to the identified problem. Also, conducting a Human-Centered Design process prior to making focuses on the value of empathy and finding user's needs instead of offering the immediate solution(s).

As Owen's (2007) states finders are as creative as makers. Finders exercise their creativity through discovery and sensitive observation to understand and to find problems that are not well solved; and makers prove their creativity through invention by constructing tangible products. 21st century needs creative thinkers and problem finders with sensitive observations to find specific human needs as well as creative makers with construction skills to offer solutions through making specific objects.

The notions of refining and being mindful of process, as the key components of a design thinking process, (Hasso Plattner Institute of Design at Stanford, 2007) were missed in participants' quotes in the pre- and post-event surveys. Refining was repeated in some of their definitions of design thinking. But, they did not mention how they had used this notion in the actual situations of learning. In the post-event surveys, participants perceived design thinking as a product-driven action rather than a process-driven or prototype-driven consideration. In the interviews, Participant B mentioned the importance of reflection upon the prototype they created. S/he thought that they missed this part in the Maker Day.

Before the event, there was no example for integrating design thinking with the content knowledge of a specific subject that participants are teaching. After the event, participants thought it should have been possible to make a connection between design thinking and curriculum. But, they were not sure whether design thinking would be applicable in all subject areas. Carroll et al. (2010) mentioned the integrating of design thinking and academic content as a goal of applying design thinking in learning settings and called it *Design as Intersecting*.

Before and after the event, participants considered the potential impact of design thinking just on how students learn, not on how teachers design learning activities. In the pre-event surveys they mentioned problem solving experience, leadership, basic standards, creativity, open-mindedness, and nothing as the required skills for applying design thinking. In the post-event survey, when participants were asked about the importance of required skills and specific considerations to designing (problem solving, problem finding, and design techniques), except Participant # 7, all of them placed problem solving skills over problem finding. Technical skills of design including visual and construction techniques were the least important kinds of skills in participants' opinions. In the interviews, none of the participants

mentioned the problem finding skills which are related to setting of values and refinement in designing (Hoadley and Cox, 2009).

In the following section, based on the findings mentioned, a semi-summative evaluation of the Maker Day is described.

5.2.2 Semi-Summative Evaluation of the Maker Day

Semi- summative evaluation of the Maker Day looks at the impact of the event on secondary school participant teachers, and explores whether the Maker Day met the predetermined aims about introducing design thinking. This section ties to the first research question, which is "What are the secondary teachers' perceptions of design thinking prior to, and after the Maker Day Professional Development event?" and aligns with Level 2 of Guskey's (2000) model of Professional Development evaluation, which is Participants' Learning.

The following subsections explain the influence of the Maker Day on participant's understandings about design thinking and identify teachers' needs for future Maker Days.

5.2.2.1 Maker Day Reinforced Some Values of Experiential Types of Learning

Several forms of experiential learning such as Project-Based Learning, Problem-Based Learning, and Inquiry-Based Learning are currently being used in educational settings. These types of learning are grounded in constructivism and reclaim Dewey's experiential approach. Research participants were secondary school teachers with 5 to 30 years of teaching experiences. They experienced experiential projects and inquiry through hands-on activities and making artifacts. They were aware of some aspects of experiential types of learning and its influence on fostering meta-cognitive competencies. Before the event, participants mentioned the powerful role of design practices in developing creativity, collaboration, risk taking, ownership of learning, problem solving, and student-centeredness. Also, after the event, they mentioned that the Maker Day reminded them of the importance of these aspects in the secondary level. The participants believed this type of learning could encourage different kinds of teenager learners in secondary school to stay in school and enjoy learning.

Participants also pointed out that by having a goal and parameters, the design thinking process was beneficial for completing a task in a certain amount of time. The continuity of experiences in a meaningful process recalls Dewey's (1938) idea of the importance of

continuity of experiences in experiential learning. Dewey's principle of continuity indicates that knowledge is continuously derived from the learner's experiences, and learning happens in a meaningful process by continuity of experiences (Dewey, 1938). Participants also referred to the importance of the facilitator's role in managing time to ensure the task is completed. They had already experienced facilitation of learning in their teaching practices, and were familiar with dynamic student-centered practices where students can work independently or collaboratively. The Maker Day experience reminded the participants of the importance of their role as facilitators of the learning process rather than merely distributors of information.

5.2.2.2 Maker Day Introduced Human-Centeredness as a New Approach

Findings from the comparisons of participants' understandings before and after the Maker Day suggest that the event opened the participants' eyes to perceive design thinking as a human-centered process.

Participants had not talked about human-centeredness before the event. But, when they were asked about some details of it after the event they showed a high level of agreement to the statements describing design thinking as a human-centered approach to design. Also, in the interviews, participants brought up specific considerations of applying design thinking for the secondary level students. A participant envisioned shortening the thinking process because s/he thought teenagers are resistant to step by step processes; another participant believed students can develop sense of empathy through design thinking because they are very focused on themselves at this age and design thinking can be beneficial to start thinking about people.

5.2.2.3 Maker Day Improved Participants' Perceptions about Problem Finding

Findings from the comparisons of participants' understandings before and after the Maker Day suggest that before the event they perceived design thinking as a problem solving process. Problem finding, which is a key element in a human-centered approach to design, was a missing point before they experienced the process. After the event, participants agreed that finding a problem is embedded in a design thinking process. But, they did not think that finding an authentic problem is as important as solving it in the process of designing. In the descriptive explanations in the interviews, all participants brought up their ideas about problem finding through conducting backward design (Participants A, and B), and allowing

students to follow their area of interests to find a problem (Participant C). Also, design thinking was perceived as a way to prepare students to tackle the unknown, and to find and solve problems in the future (Participant D).

5.2.2.4 Missing Key Elements in Participants' Perceptions about Design Thinking

Findings from the comparisons of participants' understandings before and after the Maker Day suggest that some key elements of a design thinking process and notions which were considered in the Maker Day design intentionally were missing or misunderstood. They included:

- Notion of prototype instead of product

Research participants perceived design thinking as a product-driven and making-driven activity before and after the event. Making-oriented activities were the most dominant part of participants' perceptions about design thinking. Learning by designing implies more than simply engaging students in the production of products. Instead, it entails cultivating 21st century learning competencies and linking them to the specific subject through sensitive observation, exploration, and gaining empathy to find problems specific to human needs, ideation and offering possible solutions to those problems, and finally, making a concrete object to be tested. This approach makes the connection between inquiry, problem finding, problem solving, and prototyping.

Design thinking is a prototype-driven process. But, a prototype may not be the final product of design thinking process. It is a rough and preliminary model of the design process which is made as the generated solution to the identified problem, and needs to be refined iteratively. Testing the prototype is a part of an iterative process of designing that provides feedback. The purpose of testing is to learn what works and what doesn't, and then iterate. This means going back to the prototype and modifying it based on feedback.

Moreover, a prototype can be a sketch or a two- or three- dimensional model made out of diverse materials. According to constructionist approach to learning, to design and make something meaningful, one needs tools. But, rather than concrete tools, the act of building may occur by using words, diagrams, and sounds. Papert (1991) suggests constructionist learning happens where "the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe" (p.1).

- Mindful of process (making and refinement)

The notion of being mindful of the process, as a key component of a design, was missing before the event. After the event, participants perceived design thinking more as a product-driven action rather than a process-driven or a prototype-driven consideration. Although they agreed that design thinking improves products, they did not think that if the design ends up in failure, the process should be iterated. One participant in the interviews mentioned that they missed this part in the Maker Day because they did not compare the object they made with the design criteria and the idea that had been developed. They also did not test the prototype to refine it according to the user's needs.

5.2.3 Participants' Visions about Implementing Design Thinking in Learning Settings

This section ties to the second research question, which is "How might the participant teachers envision implementing design thinking concepts into their classroom?" and aligns with Level 4 of Guskey's (2000) model of Professional Development evaluation, which is Exploring Participants' Use of New Knowledge and Skills.

Findings from the four interviews suggest that although not all of the research participants found an effective way to link design thinking to their subject area, they had the concept in their minds and they were interested to move forward with it. After the Maker Day, they took what they had learned two steps forward by facilitating a learning workshop for secondary level students and designing a cross-curriculum course to apply design thinking in a school in School District # 83.

Research participants facilitated a similar Maker Day for students and went through the same process that they had experienced in the Professional Development event. They thought that students were all engaged in the process. Students had the choice to leave but, among over fifty students just three left. The event was held in March, 2014; according to one teacher's quote, "[S]tudents were still talking about it in June". Experiencing design thinking with students gave the teachers more insight about how it might work with students. They expressed two different feelings they had when they facilitated a design thinking process for the students: anxiety of the outcome and achieving something, and also feeling more comfortable and trusting the process.

Also, having the experience of the Maker Day, one of the participants and his/her colleagues, who teach different subjects, developed a shared vision and collaboratively

designed a cross-curriculum course on design thinking for the next semester. The aim of bringing design thinking to schools is not adding another course to the curriculum but rather, designing such courses takes the Maker Day a step forward and fosters environments that are conducive for design thinking.

All the participants in the interviews found the experience of the Maker Day beneficial and effective. They imagined bringing not all, but some aspects design thinking concepts to their classroom. They were trying out where, when, and how to apply design thinking in their classroom.

Three out of four participants envisioned conducting hands-on creative projects in which students would make objects and one participant wanted to focus more on inquiry by giving the students a goal and design parameters. Participants, who wanted to do hands-on projects, envisioned modifying and customizing the d.School's design thinking process to better meet their students' needs in the secondary level. Their ideas of the process modification included making the design thinking process shorter and using backward design starting from building an existing model and then, refining it based on design criteria.

Also, participants discussed the probable restrictions they imagined, or they encountered when they apply design thinking in their classroom. These restrictions included finding time in a busy life of a teacher to design learning activities based on design thinking; restrictions in the timetable in the classroom to give sufficient time to students to create, experiment, fail, and recreate; and finding a linkage to integrate design thinking mindset to the content knowledge of the specific subject and learning outcome of the students.

5.2.4 Formative Evaluation of the Maker Day

Drawing from a Design-Based Research approach, this study is a micro-cycle of research of a Maker Day with a formative evaluation intended to improve and refine the event in the future cycles of design. Plomp (2007) believes "formative evaluation is the most prominent research activity in Design-Based research" (p.15). The results of the formative evaluation with the results from the semi-summative evaluation mentioned before generated contextual design principles to optimize the design of the Maker Day in the future cycles of design to better meet the teachers' needs.

One of the aims of the Maker Day was to introduce teachers to design thinking and making as an innovative pedagogical approach to 21st century's teaching and learning,

encourage the participants to experience the concepts directly in the events, and start bringing them into their classroom.

Findings suggest that the Maker Day met its predetermined holistic aims about introducing design thinking; secondary school teachers were introduced to the concept by directly experiencing a design thinking process; they took their learning two steps forward. First, they developed a workshop for secondary level students and experienced the same process of the Maker Day as a facilitator. Second, having the experience of the Maker Day, teachers from one school in the region developed a shared vision, and collaboratively designed a cross-curriculum course to apply design thinking in their school. In addition, the four teachers who participated in the research interviews found the Maker Day beneficial and effective. Although they had not found an effective way to link design thinking to the subject area they taught, they were trying to move forward with design thinking using their rough ideas.

Also, the Maker Day influenced decision makers in the School District level as well as the school level. They found it beneficial and wanted to develop it to re-conceptualize teaching and learning in the 21st century. After the Professional Development event, the School District funded and developed the similar event for the students in a school in partnership with UBCO's Innovative Learning Centre (ILC). This event was held one month after the Maker Day. The principal of the school and the Professional Chairperson were the persons who supported and tried to make this event happen. They also collaborated with the teachers in the school to develop the design thinking cross-curriculum course. From the leadership level, the principal supported and encouraged the teachers and shared his ideas.

The Maker Day also influenced the number of students who attended the event and experienced the design thinking and prototyping process. According to a teacher, students' positive feedback was a big suggestion telling them this could be a way to move forward and make the change in 21st century's teaching and learning take place.

As mentioned before, findings from a semi-summative evaluation suggested the Maker Day influenced participants' understandings of design thinking by reinforcing the values of experiential learning, introducing human-centeredness, and improving participants' perceptions of problem finding.

Despite all the positive feedback from the teacher participants, the School District, and the students who were involved in the design thinking process and also the influence of the Maker Day on perceptions of the participants about some aspects of design thinking, there are significant points that need to be addressed and considered in designing future Maker Days. Specific needs of the participants regarding the key elements of design thinking, which seemed to be missed or misunderstood, were identified in this study. Iteration and refinement as key elements of a design thinking process seemed to be missed; moreover, design thinking perceived more as a making-oriented action rather than challenge-oriented process. Participants of the Maker Day were interested to bring some concepts of design thinking to their classroom; they had some rough ideas to try it but, they were still unsure whether they can integrate the process to the content learning and learning outcomes of the students.

Drawing from Hoadley and Cox's (2009) designing requires a careful balance between problem finding skills, design techniques, and problem solving skills. Problem finding corresponds to the setting of values; whereas, techniques refer to the knowledge-in-practice of how to accomplish things including visual and construction skills. Problem solving skills corresponds to the notion of the concepts in order to solve problems. Teachers as novice or expert designers need to acquire and improve specific needed skills for designing and facilitation of a design process. Schon (1983) claims design in a reflective practice. Referring to this theory, teachers can acquire the needed skills for designing, constructing more knowledge by experiencing it in the classroom, and then reflecting upon it. They can gain a better understanding of their own new roles and improve their knowledge by starting to design 21st century's practices and reflecting upon them to develop the better. According to reflective practice theory, teachers know more than they can put into words. They become more aware of their tacit skills by starting to design the practices; Schon (1983) called this implicit knowledge as knowing in action. Teachers also learn from theirexperiences and improve their skills by reflection on their existing experiences; this is called reflection in action in Schon's (1983) theory. Acknowledging the teachers who have already experienced designing the learning practices, teachers who feel the need for changing their practices through design thinking need to be aware of the needed skills for designing and start experiencing it.

This research project will be sent to the Superintendent of Schools in the School District #83. Also, the findings will be sent to participants of the Maker Day, who were surveyed and interviewed. This may make the word spread and more conversations happen between participant teachers and their colleagues, the principals and the policy makers across the region. So that, a shared knowledge may be constructed about effective ways to design the learning environments using design thinking and cultivate broader sets of needed skills for the 21st century's teaching and learning.

5.3 Design Principles (Lessons Learned)

Plomp (2007) believes the outputs of Design-Based Research could be categorized into three groups: interventions (program, product, and process), design principles, and professional development of the participants involved in the research. Design principle is a term that Van den Akker (1999), Reeves (2006), and Wademan (2005) use when they refer to the theoretical outputs of Design-Based Research.

The findings from the semi-summative and formative evaluation in this study generated design principles to optimize the content and organization of the events in the future. Design principles generated from this study are not suitable for generalization. They should be applied and tested in more cycles of design and in more contexts.

The semi-summative along with the formative evaluation of the Maker Day suggested that the following points need to be investigated more and considered in the subsequent Maker Days.

- Prototyping and being mindful of the iterative process in design thinking need to be considered in the next events. Design thinking does not emphasize the product but the iterative process to construct knowledge upon prior knowledge. It is not about making artifacts but designing objects that meet specific humans' needs. In the Maker Day participants spent more time creating a three-dimensional model that represented their solution to the identified problem. Each group shared their idea with other groups but, they did not get a chance to get feedback, go back to the design problem and the specific criteria, and refine the solution based on what worked and what could have been improved. This step is situated in step 9 in d.School's design thinking template and seemed to be missed or less discussed (see Appendix J).

- Participants of the Maker Day were provided with a large variety of materials and tools for prototyping. Participants perceived design thinking more as a making-oriented action rather than problem-oriented process through making prototypes. Besides, the Maker Day took place in a shop class at a secondary school, which was equipped with a variety of power tools. So, research participants mentioned one of the restrictions of applying design thinking in the classroom as a lack of materials, skills to use them, and a fear of using the tools.
- The notion of problem finding and its importance prior to prototyping needs to be more emphasized. Maker Day was designed to fully engage all participants in design thinking and creative problem finding. Findings suggested that the design thinking process was disruptive prior to prototyping in order to focus on the value of problem finding through gaining empathy. After the event, participants appeared to consider the notion of problem finding and gaining empathy to the students' in secondary level. But, they still prioritize problem solving over problem finding when they were talking about the possible ways they envisioned applying design thinking in the classroom.
- As a human-centered approach, design thinking is a useful strategy to tackle the unknown in how students learn and how teachers design 21st century's learning environments. Findings suggested participants of the Maker Day perceived design thinking more as a methodology to teach students how to use it as a problem solving process. Teachers need to be more aware that this approach could be used to address challenges in the classroom too.
- Uncertainties and concerns about how to integrate design thinking to specific subject area were identified in participants' ideas about applying design thinking in learning settings. This challenge needs further experimental research to find out the appropriate connections between design thinking and content learning in different subject areas.

In the following sections a few recommendations for improvement of the content and organization of the events in the future are offered.

5.4 Recommendations for Content Improvement of the Maker Day

In this section, based on the learned lessons, a few recommendations for improving the content of the Maker Day are offered.

- At the opening section of the Maker Day, where teachers are introduced to design thinking, participants should be highly encouraged to think empathically about problems and focus on human-centeredness of design thinking rather than creating a product.
- Design thinking can start small. Maker Day can be developed in a simple physical space with few materials, simple, low-tech hand tools in order to absorb the attentions of the participants more to the process of problem finding including understanding the design challenge, or design scenario, creative observations, and gaining empathy.
- Empathy maps can be added to the design thinking process for empathetic thinking, finding the specific problem of the user, and defining the problem. Empathy maps are used by designers to synthesize the observations and draw out unexpected insights. They are used to identify the needs as well as to identify the insights.
- Three recommendations are offered to help participants become aware of creating a prototype and the necessity to refine it based on feedback.

First, tracing paper; it is a simple tool that the designers use to record the process of their design. Using tracing papers can be helpful to help participants with being mindful of the process of creating an idea, and to make them aware that they can use tracing paper over tracing paper to develop a rough idea and refine their plan. Using tracing papers for refining an idea and keep the process of the refinement is more effective than using an eraser and end up with a final version of the solution in a design process. It exposes the process of thinking and the process of constructing knowledge upon the prior knowledge,\ and makes thinking visible.

Second, rough prototyping with simple materials; it can be helpful to create a preliminary model with simple materials just to present the idea, and to save more time for getting feedback to the design criteria as well as user's needs to refine it. The process of prototyping in the Maker Day could be divided into two or three steps. In each step the prototype can be presented, tested and feedback can be provided by the other participant for refinement. Participants can learn that it is better to fail early and often as they create prototypes. This is the purpose of prototyping in a design thinking process.

Third, digital prototyping; educators can be introduced to digital prototyping. Digital prototyping is an alternative that actual designers use in industry to design, iterate, optimize, validate, and visualize their products throughout the product development process. In order to use the possibilities of technology, digital prototyping can be applied in teaching and learning settings as well. Instead of building multiple physical prototypes and then testing them to see if they work, a digital prototype reduces the number of physical prototypes needed to validate the design. Digital prototyping could be an appropriate response to what Zhao (2009) assumes by digital or technology literacy for the virtual world.

- Facilitators need to be more aware of the notion of rapid prototyping and refinement based on feedback and the design criteria. They should continually remind the group members to be mindful of the process. Facilitator's appropriate interventions by asking questions and challenging participants' assumptions would be helpful to remind them of the aim of prototyping.

5.5 Recommendations for Organization Improvement of the Maker Day

In this section, based on the learned lessons, a few recommendations for modifying or altering the organization of the Maker Days are offered.

- Developing Maker Days for teachers of specific subject areas

The research participants were unsure how to integrate design thinking concepts to their specific subject area. They were also concerned about students' outcomes in the content learning. This challenge can be identified and discussed through a design thinking process within a Maker Day. Educational researchers, teachers of specific subject areas, and students could identify, define, and offer possible solutions to this problem collaboratively using a design thinking process.

- Inviting actual designers to the Maker Day

Actual designers from the community can be invited to the Maker Day events in order to introduce problem finding, and need finding through gaining empathy. In such situations design studio techniques for applying design thinking can be introduced by the designers.

- Developing Maker Days in collaboration with designers in the community

In order to add some realism to the concept, the event can be held in possible realistic situations where designers use strategies of problem finding and problem solving. Maker Day

can be developed in collaboration with designers, companies, architects, or city planners to engage teachers, and students in real design projects as co-designers.

5.6 Limitations of the Study

This study was conducted within the framework of a Design-Based Research approach in a specific context, and with a small number of participants. Findings from this study reflects perceptions of participants of a Maker Day Professional Development about design thinking and the possible strategies they envision bringing design thinking to their classroom.

The output of this study is the contextual design principles to be considered in the next cycles of design and inquiry in Maker Days research. The design principles generated in this study are not suitable for generalization. If after a number of iterations the realized outcomes are close enough to the intended outcomes, then, design principles appear to be effective as a local theory (Plump, 2007). Drawing from DBR approach, findings can be examined and adapted to other contexts for their own purposes; generalization of the findings increases when they are tested and validated in more cycles of design in more contexts. Design principles generated from this study can be examined and tested in the same context for local conditions. Also, it can be used as "working hypothesis" (Cronbach, 1975, p 125) in other contexts, rather than conclusion.

5.7 Implications for More Research

Design thinking has started to receive a lot of attention by researchers and practitioners as an innovative instructional strategy to support constructivist teaching and learning but, still there have been restrictions and challenges in implementing it in real situations which needs more research, design, and experimental studies. The following research questions arose from this study and can be investigated by researchers and educators in the future.

- What are the strengths and shortcomings of designing cross-curriculum courses to apply design thinking?
- What are the most effective ways to integrate design thinking process, and specific subject areas?
- How does design thinking function as a strategy to address the challenges in the school or in the classroom?

- What are the best practices to engage secondary level students in empathetic thinking within a design thinking process?
- How can teachers evaluate what students are learning about the design thinking process and specific content learning?
- What strategies can be applied to encourage students to follow their area of interests to find a real problem?
- What strategies can be applied to implement design thinking using backward design or reverse engineering?
- How can teachers customize the d.School's design thinking process to be applicable in the classroom's learning practices?

5.8 Concluding Remarks

Design thinking is a mindset for the teachers who are seeking an alternative to what they are currently doing. It is a choice for those teachers who are willing to change their roles towards designers of learning environments, and to help students act as change agents in the world of 21st century.

As Donald Schon's (1996) suggests, design is not teachable rather, it is learnable. Design thinking is something that has to be developed gradually. It cannot be perceived deeply only by attending a Professional Development event rather, it is something that needs to be practiced. Maker Day was an awareness session rather than training session for acquiring design thinking skills.

Research participants felt the need for change. They chose to attend the Maker Day intentionally to experience design thinking as a new instructional strategy. Also, they were not passive recipients of the concepts. They had been familiar with this concept less than one year before experiencing it directly in the Maker Day, and after the Maker Day, they envisioned bringing it to their classroom. They took their learning two steps forward to action by facilitating the same process for the students and by collaboratively designing a cross-curriculum course in one school in the region.

What teachers need in the next steps is to be more empowered by subsequent Professional Development events that meet their needs. They need to personalize design thinking, to internalize it, and to apply it to address the challenges in the classroom, to integrate them to the subject area they teach, and to teach students how to use it as a problem

finding and problem solving process. Design thinking is a flexible methodology and does not need to be offered as a pre-packaged instruction.

Change requires gaining empathy through the processes of connecting, thinking and doing. Essentially, teachers need to practice self-empathy; trying to understand why one thinks the way s/he does; and how to change that way of thinking. In addition, it needs gaining empathy for learners and their needs in order to identify the problem and design learning practices that better meet their needs. Then, teachers need to take the action to design and implement appropriate practices to better meet the students' needs, to integrate to 21st century's competencies, and to connect to the content learning.

Changing the instructions and adopting design thinking as an alternative need support from the School District and school leadership, willingness of teachers for change and investment of extra time for designing the practices as well as extra effort for implementing it. In addition, adopting design thinking requires students' positive feedback and engagement; it requires active involvement of students as co-designers of learning and makers of meaning.

Increasing the use of design thinking in classrooms would be a positive change however, change cannot be imposed. Teachers need to make a sustainable change in teaching and learning environments; this change is intentional, deep, and complex. Teachers can become the designers of learning and architects of their classroom. They just need to start if they have not already done so.

One of the research participants used a beautiful metaphor to express the idea of accepting a new thought.

> We have to plant the seed of the new in the old. So, when the plant of the new grows, it comes to flower in the soil of the old. Therefore, it won't end up being exactly what was conceived. The foliage falls from the new tree and becomes the soil of the old. Eventually, it will become new but it is going to take time.

References

Ackermann, E. (2001). Piaget's constructivism, Papert's constructionism: What's the difference. *Future of learning group publication*, *5*(3), 438.

Alberta Education (2011). Framework for Student Learning: Competencies for Engaged Thinkers and Ethical Citizens with an Entrepreneurial Spirit. Edmonton, Alberta, Canada.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences, 13*(1), 1-14.

Barrows, H. & Tamblyn, R. *Problem-Based Learning: An Approach to Medical Education.* New York: Springer, 1980.

Bowler, L., & Large, A. (2008). Design-based research for LIS. *Library & Information Science Research, 30,* 39-46.

Boyer, E. L., Mitgang, L. D. (1996). Building community: A new future for architectural education and practice. Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.

Brandt, C. B., Cennamo, K., Douglas, S., Vernon, M., McGrath, M., & Reimer, Y. (2011). A theoretical framework for the studio as a learning environment. *International Journal of Technology and Design Education*, *23*(2), 329–348. doi:10.1007/s10798-011-9181-5

British Columbia (BC) Ministry of Education (2010a). *Personalized learning in BC: Interactive discussion guide.* Victoria, BC. Retrieved from http://personalizedlearningbc.ca

British Columbia (BC) Ministry of Education (2010b). *Primary program: A framework for teaching.* (M. Chapman, Lead Researcher). Victoria, BC. Retrieved from http://www.bced.gov.bc.ca/primary_program/

Brown, A., & Campione, J. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289–325). Mahwah, NJ: Lawrence Erlbaum Associates.

Brown, A. L. (1992). Design experiments: theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, *2*(2), 141-178.

Bruner, J. (1960). The Process of Education. Cambridge, MA: Harvard University Press

Carroll, M. (2014). Learning from What Doesn't Work: The Power of Embracing a Prototyping Mindset. Stanford REDlab. *Retrieved from stanford. edu/group/redlab/cgi-bin/publications_resources. Php*

Carroll, M. P. (2014). Shoot For The Moon! The Mentors and the Middle Schoolers Explore the Intersection of Design Thinking and STEM. *Journal of Pre-College Engineering Education Research*, *4*(1), 14-30.

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein, M. (2010). Destination, Imagination and the Fires Within: Design Thinking in a Middle School Classroom. *International Journal of Art & Design Education*, *29*(1), 37–53. doi:10.1111/j.1476-8070.2010.01632.x

Carroll, M. (2004) *Cartwheels on the Keyboard: Computer-Based Literacy Instruction in an Elementary Classroom.* Newark, DE: International Reading Association

C*arter, D., Crichto*n, S. & Naghshbandi, S. *(Submitted* 2014*). Use of Design Thinking as a* Disruptive E*lement in Professional Development for K-9 Educators. The International Journal of Design Education*

Cennamo, K., Brandt, C., Scott, B., Douglas, S., McGrath, M., Reimer, Y., & Vernon, M. (2011). Managing the Complexity of Design Problems through Studio-based Learning. *Interdisciplinary Journal of Problem-Based Learning*, *5*(2), 12–36. doi:10.7771/1541-5015.1253

Clandinin, D. J., & Connelly, F. M. (1992). Teacher as curriculum maker. In Jackson, P. (Ed.), Handbook of research on curriculum. New York: Macmillan, pp. 363–401.

Cobb, P., Confrey, J., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational researcher*, *32*(1), 9-13.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences, 13*(1), 15–42.

Collins, A. (1992). Toward a design science of education. New York: Center for Technology in Education.

Confrey, J.; Bell, K.; Carrejo, D. (2001): Systemic crossfire: What implementation research reveals about urban reform in mathematics. - University of Texas at Austin, www.syrce.org.

Cox, C. D., Harrison, S., & Hoadley, C. (2009). Applying the "studio model" to learning technology design. In C. DiGano, S. Goldman, M. Chorost (Eds.), *Educating learning technology designers* (pp. 145-164). New York, NY: Routledge.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative Research* (4th ed.). Upper Saddle River, NJ: Pearson Education.

Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage Publications.

Crichton, S. & Carter, D. (Accepted 2014). Taking Making Into the Schools: An Immersive Professional Development Approach. In M. Niess & H. Gillow-Wiles (Eds.). Handbook of Research on Teacher Education in the Digital Age. IGI Global.

Cronbach, L.J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist, 30* (2), 116-27.

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process.* Thousand Oaks, CA: Sage.

Crowther, P. (2013). Understanding the signature pedagogy of the design studio and the opportunities for its technological enhancement. *Journal of Learning Design, 6*(3), 18-28.

Design-Based Research Collective. (2003). *Design-based research:* An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.

Design Thinking in the Classroom (2009). The Bully and the Bystander Design Challenge. Retrieved from http://web.stanford.edu/group/redlab/cgi-bin/publications_resources.php

Dewey, J. (1938). *Experience and Education.* New York: Touchstone.

Dewey, J., (1931). Ausweg aus dem pa¨dagogischen Wirrwarr. Inglis Vorlseung 1931. In: Petersen P(ed) (1935) Der Projekt-Plan. Grundlegung und Praxis von, John Dewey und William Heard Kilpatrick, Weimar, pp 85–101

Dewey, J. (1916). Democracy and Education: An Introduction to the Philosophy of Education. MacMillan Company, New York.

diSessa, A. (1991). Local sciences: Viewing the design of human-computer systems as cognitive science. In J. M. Carroll (Ed.), *Designing interaction: Psychology at the human-computer interface* (pp. 162–202). New York: Cambridge University Press.

Dougherty, D. (n.d.). The maker mindset. Retrieved from http://llk.media.mit.edu/courses/readings/maker-mindset.pdf

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 94*, 103–120.

Edelson, D. C. (2002). Design research: What we learn when we engage in design. *Journal of the Learning Sciences, 11*(1), 105–121.

Edwards, C., Gandini, L. & Forman, G. (eds.) (1998). The hundred languages of children: the Reggio Emilia approach – advanced reflections. 2nd Edition. Greenwich, CT: Ablex Publishing.

Eisner, Elliot W. (1998) *The kind of schools we need: personal essays,* Portsmouth, NH: Heinemann.

Fricke, G. (1999). Successful approaches in dealing with differently precise design problems. *Design Studies, 20*, 417–429. doi:10.1016/S0142-694X(99)00018-6

Gardner H (2007). Five minds for the future. McGraw-Hill Professional, New York

Gay, L. R., Mills, G., & Airasian, P. (2012). *Educational research: Competencies for analysis and applications* (10th ed.). New York, NY: Prentice Hall.

Goldman, S., Kabayadondo, Z., Royalty, A., Carroll, M. P., & Roth, B. (2014). Student Teams in Search of Design Thinking. In *Design Thinking Research* (pp. 11-34). Springer International Publishing.

Gravemeijer, K. & Cobb, P. (2006). Design research from a learning design perspective. In: Van den Akker, J., Gravemeijer, K, McKenney, S. & Nieveen, N. (Eds). (2006). *Educational design research.* London: Routledge, 17-51.

Greeno, J. G., Collins, A., & Resnick, L. (1996). Cognition and learning. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 15–46). New York: Macmillan.

Guskey, T. R. (2000). *Evaluating professional development.* Thousand Oaks, CA: Corwin Press.

Hardiman, M. (2010). The Creative-artistic Brain. In Souza, D. (Ed.), *Mind, Brain, and Education: Neuroscience Implications for the Classroom*. Bloomington, IN: Solution Tree.

Hasso Plattner Institute of Design at Stanford. (2007). Design Thinking Process. Palo Alto, CA: Stanford University.Retrieved from https://dschool.stanford.edu/groups/k12/wiki/17cff/

Hatch, M. (2014). The Maker Movement Manifesto: Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers. NY: McGraw-Hill.

Hawley, W.D. & Valli. L. (1999). The essentials of effective professional development: A new consensus. In L. Darling-Hammond &r G. Sykes (Eds,), *Teaching as the learning profession: Handbook for policy and practice* (pp. 127-150). San Francisco: Jossey-Bass.

Herrington, J., McKenney, S., Reeves, T., & Oliver, R. (2007). *DBR and doctoral students: Guidelines for preparing a dissertation proposal.* Paper presented at the Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007, Chesapeake, VA: AACE.

Hoadley, C., & Cox, C. (2009). What is design knowledge and how do we teach it. Educating learning technology designers: Guiding and inspiring creators of innovative educational tools, 19-35.

Hoadley, C. (2003*). Design-Based Research: An* Emerging Paradigm for Educational Inquiry. Educational Researcher, 32(1), 5-8.

Huitt, W. (2009). Constructivism. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved from http://www.edpsycinteractive.org/topics/cognition/construct.html

Juuti, K., & Lavonen, J. (2006). *Design-based research in* science education: One step towards methodology. *NorDiNa, 4*, 54-68.O'Donnell, A. M. (2004). A commentary on design research. *Educational Psychologist, 39*(4), 255- 260.

Kafai,Y. B. (1995). *Minds in play: Computer game design as a context for children's learning*. Mahwah, NJ: Lawrence Erlbaum.

Kalantzis, M., & Cope, B. (2011). The Teacher-as-Designer: Pedagogy in the New Media Age. *ΠΑΙΔΑΓΩΓΙΚΗ–θεωρία & πράξη*, (4).

Kelley, T., & Kelley, D. (2013). *Creative confidence: Unleashing the creative potential within us all*. Random House LLC.

Kolb, D.A. (1984). Experiential Learning : Experience As The source of Learning and Development. Englewood Cliffs. NJ: Prentice Hall Inc.

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., ... & Ryan, M. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting learning by design (tm) into practice. *The journal of the learning sciences*, *12*(4), 495-547.

Koro-Ljungberg, M., Yendol-Hoppey, D., Smith, J. J., & Hayes, S. B. (2009). (E)pistemological awareness, instantiation of methods, and uninformed methodological ambiguity in qualitative research projects. *Educational Researcher, 38*(9), 687-699. doi:10.3102/0013189X09351980

Kress, G. (2003). *Literacy in the New Media age*. New York: Routledge.

Kuhn, S. (1998). The software design studio: An exploration. *IEEE Software, 15*(2), 65-71.

Kwek, S. H. (2011). Innovation in the classroom: Design thinking for 21st century learning. *Retrieved from stanford. edu/group/redlab/cgi-bin/publications_resources. php*.

Lai, G., Calandra, B., & Ma, Y. (2009). Leveraging the potential of *design-based research to improve reflective thinking in an educational assessment system. International Journal of Technology in Teaching and Learning*, *5*(2), 119-137.

Liu, Y-T. (1996). Is designing one search or two? A model of design thinking involving symbolism and connectionism. Design Studies, 17, 435–449. doi:10.1016/S0142-694X(96)00018-X

Longview Foundation. (2008). *Teacher preparation for the global age*. The Imperative for Change. Retrieved from https://www.google.com/url?q=http://www.longviewfdn.org/files/44.pdf&sa=U&ei=NmaOU_TPO8yKqgaLnYCoDA&ved=0CAoQFjAF&client=internal-uds-cse&usg=AFQjCNGicJDPZH-ft7BZGaDaIT1CLfkqzg

Ma, Y., & Harmon, S. W. (2009). A case study of design-based research for creating a vision prototype of a technology-based innovative learning environment. *Journal of Interactive Learning Research, 20*(1), 75-93.

Martinez, S. & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom.* Torrance, CA: Constructing Modern Knowledge Press.

Mathews, J. M. (2010). Using a Studio-Based Pedagogy to Engage Students in the Design of Mobile-Based Media. *English Teaching: Practice and Critique*, *9*(1), 87-102.

McKenney, S. (2001). Computer-based support for science education materials developers in Africa: exploring potentials. Doctoral dissertation. Enschede: University of Twente.

McNaught, C., & Lam, P. (2010). Using Wordle as a Supplementary Research Tool. *Qualitative Report*, *15*(3), 630-643.

Mears, C. L. (2012). In-depth interviews. In Coe, R., Waring, M., Arthur, J., & Hedges, L. V. (Eds.). (2012). *Research Methods and Methodologies in Education*. Thousand Oaks, California, CA: Sage Publications.

Moss, P. A., Phillips, D. C., Erickson, F. D., Floden, R. E., Lather, P. A., & Schneider, B. L. (2009). Learning from our differences: A dialogue across perspectives on quality in education research. *Educational Researcher, 38*(7), 501-517. doi:10.3102/0013189X09348351

Nagai, Y., & Noguchi, H. (2003). An experimental study on the design thinking process started from difficult keywords: Modeling the thinking process of creative design. *Journal of Engineering Design, 14*, 429–437. doi:10.1080/09544820310001606911

New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review*, *66*(1), 60–92.

Nieveen,N. (2007). Formative Evaluation in Educational Design Research. In Plomp,T & Nieveen,N. (Eds.), An Introduction in Educational Design (pp. 37-52). Research. Proceedings of the seminar conducted at the East China Normal University, Shanghai (PR China). Netherlands institute for curriculum development

Noweski, C., Scheer, A., Buttner, N., Thienen, J. Von, Erdmann, J., & Meinel, C. (2012). Towards a Paradigm Shift in Education Practice: Developing Twenty-First Century Skills with Design Thinking. Design Thinking Research. (H. Plattner, C. Meinel, & L. Leifer, Eds.), 71–94. doi:10.1007/978-3-642-31991-4

Owen, C. (2007). Design thinking: Notes on its nature and use. Design Research Quarterly, 2, 16–27.

Papert, S., & Harel, I. (1991). Situating constructionism. *Constructionism*, *36*, 1-11.

Papert, S. (1990). *Introduction: Constructionist Learning.* Idit Harel (ed.). Cambridge, MA: MIT Media Laboratory.

Papert, S. (1990). *A critique of technocentrism in thinking about the school of the future*. Epistemology and Learning Group, MIT Media Laboratory.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books.

Piaget, J. (1973). *To understand is to invent*: *The future of education* (G.A. Roberts, Trans.): Penguin Books.

Piaget, J. (1926). *The language and thought of the child*. London: Routledge & Kegan

Pink, D. H. (2005). A Whole New Mind: Why right-brainers will rule the future. New York: Riverhead.

Plomp, T. (2007). Educational design research: An introduction. *An introduction to educational design research*, 9.

Presterud, T. (2013). MAKERS- The New Industrial Revolution. Retrieved from http://orangemakers.com/makers-new-industrial-revolution/

Quintana, C., Krajcik, J., & Soloway, E. (2000). Exploring a Structured Definition for Learner Centered Design. In B. Fishman & S. O'Connor-Divelbiss (Eds.), *Fourth International Conference of the Learning Sciences* (pp. 256-263). Mahwah, NJ: Erlbaum.

Rauth, I., Koppen, E., Jobst, B., & Meinel, C. (2010). Design thinking: an educational model towards creative confidence. In *Proceedings of the 1st international conference on design creativity*.

Razzouk, R., & Shute, V. (2012). What Is Design Thinking and Why Is It Important? *Review of Educational Research*, *82*(3), 330–348. doi:10.3102/0034654312457429

Reeves, T. C. (2006). Design research from a technology perspective. In J. V. d. Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), Educational design research (pp. 52-66). UK: Routledge.

Richey, R. C., Klein, J. D., & Nelson, W. A. (2003). Development research: Studies of instructional design and development. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (2nd ed., pp. 1099–1130). Mahwah, NJ: Lawrence Erlbaum Associates.

Rittel, H.W. J. (1972). On the Planning Crisis: Systems Analysis of the First and Second Generation. Bedriftsokonomen, 8, 390-396.

Sanders, E. B. N. (2002). From user-centered to participatory design approaches. *Design and the social sciences: Making connections*, 1-8.

Sari, E. and Herrington, J. (2013). *Using Design-based research to investigate the design and development of an online community of practice for teacher professional development.* In: EdMedia 2013 World Conference on Educational Media and Technology , 24 - 27 June 2013, Victoria, BC, Canada.

Scheer, A., Noweski, C., & Meinel, C. (2012). Transforming constructivist learning into action: Design thinking in education. *Design and Technology Education: an International Journal*, *17*(3).

Schön, D. (1983). The reflective practitioner: How professionals think in action. New York, NY: Basic Books.

Schwab, J. (1960) Inquiry, the Science Teacher, and the Educator. *The School Review 1960*. Chicago: The University of Chicago Press.

Shavelson, R. J., Phillips, D. C., Towne, L., & Feuer, M. J. (2003). On the science of education design studies. *Educational Researcher, 32*(1), 25–28.

Shulman, L. S. (2005). Signature pedagogies in the professions. *Daedalus, 134*(3), 52-59.

Siok, S., Lim, H., Lim-ratnam, C., & Atencio, M. (2007). Understanding the Processes Behind Student Designing : Cases from Singapore

Srivastava, P., & Hopwood, N. (2009). A practical iterative framework for qualitative data analysis. *International Journal of Qualitative Methods*, *8*(1), 76-84.

Stake, R.E. (2005). *Quantative case studies.* In N.K. Denzin & Y.S. Lincoln (eds.), *The Sage handbook of qualitative research* (*3rd ed.)* (pp. 443-466). Thousand Oaks, CA: Sage.

Stanford University (2009). *Introduction to Design Thinking. Facilitator's Guide.* Retrieved from https://dschool.stanford.edu/sandbox/groups/dresources/wiki/welcome/attachments/f8e24/d.school%27s%20Facilitator%27s%20Guide%20to%20Leading%20Re.d%20the%20G.G.%20Exp.pdf?sessionID=2e4eabcb9b0ebc30c0309e7b2e68740b16890784

Sullivan, L. E. (2009). *Constructivist Learning Theory*.The SAGE Glossary of the Social and Behavioral Sciences. Thousand Oaks: SAGE Publications, Inc.

Tan, O. S., Parsons, R. D., Hinson, S. L. & Sardo-Brown, D. (2003). *Educational psychology a practitioner-researcher approach*. Australia: Thomson.

The Design-Based Research Collective. (2014). Design-Based Research : An Emerging Paradigm for Educational Inquiry. *32*(1), 5–8.

van den Akker, J. (2007). Curriculum Design Research. In Plomp,T & Nieveen,N. (Eds.), An Introduction in Educational Design (pp. 37-52). Research. Proceedings of the seminar conducted at the East China Normal University, Shanghai (PR China). Netherlands institute for curriculum development

van den Akker, J. (1999). Principles and methods of development research. In J. van den Akker, N. Nieveen, R. M. Branch, K. L. Gustafson & T. Plomp (Eds.), Design methodology and developmental research in education and training (pp. 1–14). The Netherlands: Kluwer Academic Publishers.

Vygotsky, L.S. (1962). Thought and Language. Cambridge, MA: MIT Press. (Original work published in 1934).

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard university press.

Wademan, M. (2005). *Utilizing Development Research to Guide People Capability Maturity Model Adoption Considerations.* Unpublished doctoral dissertation, Syracuse University (New York, USA).

Wagner T (2010) The global achievement gap: why even our best schools don't teach the new survival skills our children need–and what we can do about it. Basic Books, New York.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology: Enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5-23.

Wiggins, G. P., & McTighe, J. (2006). *Understanding by design*. Ascd.

Yin, R. K. (2003). Case study research, design and methods, 3rd ed. Newbury Park: Sage Publications.

Zhao, Y. (2009). *Catching Up or Leading the Way.* Alexandria, VA: ASCD.

Appendices

Appendix A: Approval for Conducting Research in School District #83

The Board of Education of School District #83
(North Okanagan-Shuswap)
P.O. Box 129 ~ 220 Shuswap St. N.E. ~ Salmon Arm, B.C. V1E 4N2
Phone: (250) 832-2157 Fax: (250) 832-9428

May 12, 2014

Serveh Naghshbandi
Graduate Student, Faculty of Education
University of British Columbia – Okanagan campus
Kelowna, BC V1V 1V7

Dear Ms. Naghshbandi:

RE: Secondary Teachers' Conceptions and Implementations of Design Thinking in North Okanagan Schools

Further to your request to conduct a research survey within the North Okanagan-Shuswap School District: investigating the impact of Maker Day at [redacted] teachers' understandings of design thinking within their classroom teaching and learning practices. I hereby grant permission for you to proceed with your research as outlined in your proposal.

Thank you for your conditional Ethics Approval, I look forward to receiving a copy of the final approval upon issue.

I wish you success in your project. Please contact my office if any further information is required. Upon completion of your research, I would appreciate receiving a copy of the results which could be shared with district staff and trustees.

Sincerely,

Glenn Borthistle,
Superintendent of Schools

/idb

Appendix B: Behavioral Research Ethics Board Certificate of Approval

The University of British Columbia Okanagan
Research Services
Behavioural Research Ethics Board
3333 University Way
Kelowna, BC V1V 1V7 Phone: 250-807-8832
Fax: 250-807-8438

CERTIFICATE OF APPROVAL - MINIMAL RISK

PRINCIPAL INVESTIGATOR:	INSTITUTION / DEPARTMENT:	UBC BREB NUMBER:
Sharon L. Mccoubrey	UBC/UBCO Education, Faculty of	H14-00624

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

Institution	Site

CO-INVESTIGATOR(S):
Serveh Naghshbandi

SPONSORING AGENCIES:
N/A

PROJECT TITLE:
Secondary Teachers' Conceptions and Implementations of Design Thinking in North Okanagan Schools

CERTIFICATE EXPIRY DATE: **May 8, 2015**

DOCUMENTS INCLUDED IN THIS APPROVAL: | DATE APPROVED: May 8, 2014

Document Name	Version	Date
Protocol:		
Research Proposal	N/A	April 15, 2014
Consent Forms:		
Teacher Consent Form for Pre-event survey	1	April 30, 2014
Teacher Consent Form for Interview	1	April 30, 2014
Teacher Consent Form for Post-event survey	2	April 30, 2014
Questionnaire, Questionnaire Cover Letter, Tests:		
Post-event Survey	2	April 30, 2014
Interview	N/A	April 2, 2014
Other Documents:		
Permission to Conduct Research Study	1	April 30, 2014
Letter of Approval SD 83	1	May 27, 2014

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

This study has been approved either by the full Behavioural REB of the UBC Okanagan or by an

Appendix C: Tri-Council Policy Statement (TCPS 2: CORE) Certificate

PANEL ON RESEARCH ETHICS

Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

serveh naghshbandi

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Date of Issue: **7 February, 2013**

Appendix D: Pre-Event Survey Questions

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Education
Okanagan Campus

Teachers' Pre-event Survey

Name of Study:

Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach

Gender: Female □ Male □

Age: _____years

How long have you been teaching? _____years

What grade are you teaching? _____

What is your teaching subject(s)? _____

What is your degree major?

Art □ Career/Health □ Dance □ Drama □ French □ Language Arts □ Math □ Music □ Physical Education □ Science □ Social Studies □

Others (Please specify _____)

What level of education have you achieved?

Bachelor □ Master's student □ Master's □ PhD student □ PhD □

Had you heard about the term 'Design Thinking' before attending the Maker Day?

Yes □ No □

How long have you been familiar with design thinking concept?

Where did you hear or read about design thinking?

Books □ Online resources □ Conference □ Workshops □

Colleagues □ Others (Please specify_____)

How do you define design thinking?

What is the connection between design thinking and education in your opinion?

Have you ever applied design thinking in your classroom? Yes □ No □

How would you apply design thinking?

What is the most important aspect of your experience applying design thinking?

What kind of skills do you assume you need to apply design thinking in your classroom?

Have you attended any training sessions or workshops on design thinking? Where? When?

Why did you choose “Maker Day” as a professional development activity?

Appendix E: Teacher Consent Form for Using Data from the Pre-event Survey

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Education
Okanagan Campus

Faculty of Education, Okanagan Campus
University of British Columbia
3333 University Way
Kelowna BC Canada
Tel. 250.807.8084 Fax:250.807.8084
www.ubc/okanagan/education

Teacher Consent Form for Using Data from the Pre-event Surveys

"Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach"

Principal Investigator:
Dr. Sharon McCoubrey, PhD
Associate Professor
Faculty of Education
University of British Columbia Okanagan
Phone: 250-807-8109
Sharon.mccoubrey@ubc.ca

Co-Investigator:
Serveh Naghshbandi, BA, MA
Graduate Student
Faculty of Education
University of British Columbia
Phone: 250-864-0918
naghshbandiserveh@gmail.com

This research is part of a thesis in partial fulfillment of a Master of Arts in Education in the Faculty of Education at the University of British Columbia, Okanagan campus. Findings of this research will be published in a thesis, which is a public document. The identity of the school, location, and participants will be confidential as assigned numeric or pseudonyms will be used.

Purpose of the Research Study

Increasingly, teachers are being asked to radically change their professional practices to integrate 21st century teaching and learning. It has been also evidenced in British Columbia Plan that educators are being invited to become designers of the learning environments rather than implementers of the curriculum. Maker Day was developed by the Innovative Learning Centre (ILC) as an immersive, Professional Development event. The aim of the event was to disrupt current classroom practices and introduce teachers to design thinking and the Maker Movement. We are doing this study to understand the impact of

Maker Day and design thinking processes on your understanding of design thinking. We will examine teachers' understanding of design thinking prior to and after the Professional Development event and will examine the ways that the participant teachers might integrate the concepts of design thinking and making into their classroom teaching and learning practice.

You are being invited to take part in this research study because the population of this study will be secondary teachers in School District #83 who attended Maker Day as a Professional Development event. We are inviting you to help us examine your understanding of design thinking prior to and after experiencing it in Maker Day and the ways you might envision to apply it in your classroom.

The Research Study Procedures

This research includes three sequential phases and the participants of each phase are as follows:

The population of the first phase includes ١٨ secondary teachers in School District #83 who attended the Maker Day event at Eagle River Secondary School, Sicamous, BC on February 8, 2014. You have already been asked to fill out the pre-event survey and to describe your perceptions of design thinking prior to experiencing the professional development event. This form is seeking your consent to use the pre-event surveys that you filled out on February 8, 2014.

The population of the second phase includes the same 18 teachers as in the first phase who attended Maker Day on February 8, 2014. You will be asked to fill out the post-event survey and describe your understanding of design thinking after experiencing Maker Day. Please review this Summary of Research and Consent form and return it to the Professional Development Chairperson within one week.

The population of the third phase will be four selected teachers, who were part of the Maker Day on February 8, 2014. The four selected teachers of the Phase Three will be interviewed and asked to describe how they envision implementing design thinking in their teaching practices. Among the interested teachers I will select a variety of teachers from different disciplines. Then, I will ask the professional development chair for the four selected teachers' contact information. I will then contact the four teachers and set up a convenient interview time. The interview will take about 45 minutes.

I will send the interview transcripts to the teachers to be confirmed and may ask them for clarification if needed.

The study will take place between April 30 and May 30, 2014.

Study Result

The results of this study will be reported in a graduate thesis and may also be published in journal articles and books. A summary report of the study will be made available to you by email.

Potential Risks and Benefits

There are no potential risks for the teachers. We do not think there is anything in this study that could harm teachers or be bad for them. Participants will not be rewarded for participation; participation needs to be completely voluntary. No special treatment or special consideration will result from participation in the study. At the end of the study, the findings will be made available to the participants.

The study will examine secondary teachers' conceptions of design thinking and their approaches to implement it in the classroom if they envision doing so. Considering BC's Education Plan to transform education and make changes to better meet the needs of all learners across the province, the value of design thinking in learning and the infrequency of experiential design thinking research conducted in education, this study will provide some insight into design thinking implementation as a teaching practice for secondary teachers.

Confidentiality

The participants' identities will be kept strictly confidential, as well as the school name and location. Your name will not appear on the surveys, so there is no way to identify the teachers who filled out each survey.

In the questionnaire part of the surveys, some demographic information about you may be collected for statistical purposes, such as age, gender, number of years teaching, and educational background. All information will be kept strictly confidential. You are free to not answer any question that you are not comfortable answering and you are free to withdraw from the study at any time without any negative consequence.

To ensure protection of your privacy, you will be assigned a random numeric code and will not be identified. In the published thesis, the schools and teachers will not be identified.

Security of Data

All documents related to the study will be kept in a locked filing cabinet at the school, and after the study is complete, they will be kept in a locked filing cabinet in Dr. McCoubrey's office at UBC-O for a period of five years following publication. When those five years are past, all documents will be destroyed. All documents will be identified by code numbers. All electronic records will be destroyed as well. Teachers will not be identified by name in any report of completed study.

Withdrawal from the Study

Your participation in this study is voluntary and you may refuse to participate or withdraw from the study at any time without giving a reason and without any negative impact on your situation and with no negative consequences. At any point during the study, if you want to withdraw from the study, you are free to do so. You will ask the Professional Development Chairperson that you want to withdraw and I will exclude your data. I will find your data according to the demographic questions you answered. Any data collected about a withdrawing participant will not be included in the study and will be destroyed.

Contact for Concerns about the Rights of Research Subjects

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. If long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

Teacher Consent: Researcher's Copy

Your participation in this study is entirely voluntary and you may refuse to participate. You are free to withdraw from the study at any time without giving a reason and without any negative impact on your situation and any negative consequences. Once you have returned the consent form, a copy will be made and returned to you for your records. Your signature indicates your consent to participate in the first phase of this study and use the pre-event surveys you have already filled out in this study.

Consent

I, _____ , have read the summary for the research "Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach" conducted by Serveh Naghshbandi, in the Faculty of Education at The University of British Columbia. I understand what the research project entails and I have been provided with an opportunity to ask questions about the research.

Yes, I **consent** to participate in this study.

_____

Teacher Signature Date

_____

Teacher Name Printed

Appendix F: Post-Event Survey Questions

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Education
Okanagan Campus

Teachers' Post-event Survey

Name of Study:

Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach

A. Demographic Information

Gender: Female □ Male Age: _____years

How long have you been teaching? _____Years

What grade are you teaching? _____

What is your teaching subject(s)? _____

What is your degree major?

Art □ Career/Health □ Dance □ Drama □ French □ Language Arts □ Math □ Music □ Physical Education □ Science □ Social Studies □

Others (Please specify _____

What level of education have you achieved?

Bachelor □ Master's student □ PhD student □ PhD □

.Had you heard about the term 'Design Thinking' before attending the Maker Day?

Yes □ No □

How long have you been familiar with design thinking concept?

.Where did you hear or read about design thinking?

Books □ Online resources □ Conference □ Workshops □

Colleagues □ Others (Please specify_____)

B.**Please circle the most appropriate number of each statement that closely represents your response.**

	Statement	Strongly Disagree			Neutral			Strongly Agree
		1	2	3	4	5	6	7
11	Design thinking is a creative process							
12	Making beautiful artifacts is the aim of design thinking							
13	Design thinking is about improving existing artifacts							
14	Finding a problem is embedded in design thinking process							
15	Design problems are easy to find							
16	Design thinking needs a certain amount of creativity							
17	Problem finding in design thinking happens individually							
18	Design thinking fosters problem solving skills more than problem finding							
19	Background knowledge is necessary to address a design problem							
20	Design problems can be found just by designers							
21	Asking people about their needs helps the authentic problem finding							
22	Every design problem has a specific solution							
23	Collaboration helps to define and solve a design problem							
24	Design thinking process leads to success							
25	Design thinking and problem-solving are used in limited cases							
26	Specific skills are needed in design thinking process							
27	Design thinking is a closed circle process							
28	If the design solution leads to failure, designer changes the design problem							

C. Please circle the most appropriate number of each statement that closely represents your responses.

Statement		Strongly Disagree			Neutral			Strongly Agree
		1	2	3	4	5	6	7
29	Design Thinking can be implemented in the classroom							
30	Applying design thinking at schools means adding a design course to the curriculum							
31	Only Prototype-driven projects can be applied as design thinking practices							
32	Mindfulness of the prototype is more important than the process							
33	Putting students in real-world situation is helpful to understand design thinking							
34	Specific vocabulary is needed to apply design thinking in the classroom							
35	Design thinking can improve risk taking in the classroom							
36	Visualization skills have the same value as written language to convey the idea in design thinking							
37	Because of visual and technical skills required for design thinking, it is not possible to implement it in regular teaching practices							
38	Design thinking and collaboration can be linked together easily							
39	Specific physical spaces are required to conduct design thinking activities							
40	Specific materials are required to implement design thinking in the classroom							
41	Design thinking skills should be taught separately from content learning							

Statement		Strongly Disagree			Neutral			Strongly Agree
		1	2	3	4	5	6	7
42	Design thinking can enhance the classroom instruction							
43	It is easy to make a relationship between design thinking and content learning							
44	Technological restrictions influence applying design thinking in the classroom							
45	It is not possible to use design thinking in all subject areas							
46	It is critical to assess what students are learning about design thinking							
47	Teachers need to acquire design skills to implement it in their teaching practices							
48	Teachers need to facilitate the students' learning process in design thinking process							

D.Based on your teaching experience, to what extent are the following skills and habits important in design thinking? Please circle the most appropriate number that closely represents your response.

	Skills	Strongly Disagree			Neutral			Strongly Agree
		1	2	3	4	5	6	7
49	Awareness of environment							
50	Caring about human's needs							
51	Conversation with experts							
52	Background knowledge about the design problem							
53	Awareness of cultural and social context							
54	Bias toward action							
55	Observation							
56	Conversation							
57	Gaining empathy							
58	Collaboration							
59	Brainstorming							
60	Open-mindedness/ no prejudice							
61	Ability to consider other possibilities							
62	Sketching Skills							
63	Modeling/ Prototyping Skills							
64	Storytelling							
65	Mind mapping							
66	Experience mapping							
67	Facilitation the learning process							
68	Reflection							
69	Testing and giving feedback							
70	Considering the feedback							

Appendix G: Teacher Consent Form for Post-event Survey

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Education
Okanagan Campus

Faculty of Education, Okanagan Campus
University of British Columbia
3333 University Way
Kelowna BC Canada
Tel. 250.807.8084 Fax:250.807.8084
www.ubc/okanagan/education

Teacher Consent Form for Post-event Surveys

"Identifying Secondary School Teachers' Understandings and Implementation of Design Thinking within a Design-Based Research Approach"

Principal Investigator:
Dr. Sharon McCoubrey, PhD
Associate Professor
Faculty of Education
University of British Columbia Okanagan
Phone: 250-807-8109
Sharon.mccoubrey@ubc.ca

Co-Investigator:
Serveh Naghshbandi, BA, MA
Graduate Student
Faculty of Education
University of British Columbia
Phone: 250-864-0918
naghshbandiserveh@gmail.com

This research is part of a thesis in partial fulfillment of a Master of Arts in Education in the Faculty of Education at the University of British Columbia, Okanagan campus. Findings of this research will be published in a thesis, which is a public document. The identity of the school, location, and participants will be confidential as assigned numeric or pseudonyms will be used.

Purpose of the Research Study

Increasingly, teachers are being asked to radically change their professional practices to integrate 21st century teaching and learning. It has been also evidenced in British Columbia Plan that educators are being invited to become designers of the learning environments rather than implementers of the curriculum. Maker Day was developed by the Innovative Learning Centre (ILC) as an immersive, Professional Development event. The aim of the event was to disrupt current classroom practices and introduce teachers to design

thinking and the Maker Movement. We are doing this study to understand the impact of Maker Day and design thinking processes on your understanding of design thinking. We will examine teachers' understanding of design thinking prior to and after the Professional Development event and will examine the ways that the participant teachers might integrate the concepts of design thinking and making into their classroom teaching and learning practice.

You are being invited to take part in this research study because the population of this study will be secondary teachers in School District #83 who attended Maker Day as a Professional Development event. We are inviting you to help us examine your understanding of design thinking prior to and after experiencing it in Maker Day and the ways you might envision to apply it in your classroom.

The Research Study Procedures

This research includes three sequential phases and the participants of each phase are as follows:

The population of the first phase includes ١٨ secondary teachers in School District #83 who attended the Maker Day event at Eagle River Secondary School, Sicamous, BC on February 8, 2014. You have already been asked to fill out the pre-event survey and to describe your perceptions of design thinking prior to experiencing the professional development event.

The population of the second phase includes the same 18 teachers as in the first phase who attended Maker Day on February 8, 2014. You will be asked to fill out the post-event survey and describe your understanding of design thinking after experiencing Maker Day. Please review this Summary of Research and Consent form and return it to the Professional Development Chairperson within one week. This form is seeking your consent to participate in the second phase of this study.

The population of the third phase will be four selected teachers, who were part of the Maker Day on February 8, 2014. The four selected teachers of the Phase Three will be interviewed and asked to describe how they envision implementing design thinking in their teaching practices. Among the interested teachers I will select a variety of teachers from different disciplines. Then, I will ask the professional development chair for the four selected

teachers' contact information. I will then contact the four teachers and set up a convenient interview time. The interview will take about 45 minutes.

I will send the interview transcripts to the teachers to be confirmed and may ask them for clarification if needed.

The study will take place between April 30 and May 30, 2014.

Study Result

The results of this study will be reported in a graduate thesis and may also be published in journal articles and books. A summary report of the study will be made available to you by email.

Potential Risks and Benefits

There are no potential risks for the teachers. We do not think there is anything in this study that could harm teachers or be bad for them. Participants will not be rewarded for participation; participation needs to be completely voluntary. No special treatment or special consideration will result from participation in the study. At the end of the study, the findings will be made available to the participants.

The study will examine secondary teachers' conceptions of design thinking and their approaches to implement it in the classroom if they envision doing so. Considering BC's Education Plan to transform education and make changes to better meet the needs of all learners across the province, the value of design thinking in learning and the infrequency of experiential design thinking research conducted in education, this study will provide some insight into design thinking implementation as a teaching practice for secondary teachers.

Confidentiality

The participants' identities will be kept strictly confidential, as well as the school name and location. Your name will not appear on the surveys, so there is no way to identify the teachers who filled out each survey.

In the questionnaire part of the surveys, some demographic information about you may be collected for statistical purposes, such as age, gender, number of years teaching, and educational background. All information will be kept strictly confidential. You are free to not answer any question that you are not comfortable answering and you are free to withdraw from the study at any time without any negative consequence.

To ensure protection of your privacy, you will be assigned a random numeric code and will not be identified. In the published thesis, the schools and teachers will not be identified.

Security of Data

All documents related to the study will be kept in a locked filing cabinet at the school, and after the study is complete, they will be kept in a locked filing cabinet in Dr. McCoubrey's office at UBC-O for a period of five years following publication. When those five years are past, all documents will be destroyed. All documents will be identified by code numbers. All electronic records will be destroyed as well. Teachers will not be identified by name in any report of completed study.

Withdrawal from the Study

Your participation in this study is voluntary and you may refuse to participate or withdraw from the study at any time without giving a reason and without any negative impact on your situation and with no negative consequences. At any point during the study, if you want to withdraw from the study, you are free to do so. You will ask the Professional Development Chairperson that you want to withdraw and I will exclude your data. I will find your data according to the demographic questions you answered. Any data collected about a withdrawing participant will not be included in the study and will be destroyed.

Contact for Concerns about the Rights of Research Subjects

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. If long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

Teacher Consent: Researcher's Copy

Your participation in this study is entirely voluntary and you may refuse to participate. You are free to withdraw from the study at any time without giving a reason and without any negative impact on your situation and any negative consequences. Once you have returned the consent form, a copy will be made and returned to you for your records. Your signature indicates your consent to participate in the second phase of this study.

Consent

I, _____ , have read the summary for the research "Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach" conducted by Serveh Naghshbandi, in the Faculty of Education at The University of British Columbia. I understand what the research project entails and I have been provided with an opportunity to ask questions about the research.

Yes, I **consent** to participate in this study.

_____

Teacher Signature Date

_____

Teacher Name Printed

Teacher Consent: Teacher's Copy

Your participation in this study is entirely voluntary and you may refuse to participate. You are free to withdraw from the study at any time without giving a reason and without any negative impact on your situation and any negative consequences. Once you have returned the consent form, a copy will be made and returned to you for your records. Your signature indicates your consent to participate in the second phase of this study.

Consent

I, _____ , have read the summary for the research "Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach" conducted by Serveh Naghshbandi, in the Faculty of Education at The University of British Columbia. I understand what the research project entails and I have been provided with an opportunity to ask questions about the research.

Yes, I **consent** to participate in this study.

_____

Teacher Signature Date

_____

Teacher Name Printed

Appendix H: Interview Questions

Interview Questions

Name of Study:
Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach

Did you apply design thinking concepts in your teaching practices prior to the Maker Day? Please explain and provide examples.

To what extent are you currently using design thinking process in your classroom with students? Please explain and provide examples.

Do you envision bringing the concepts you learned in Maker Day to your classroom? Please explain and provide examples.

Has the experience of Maker Day affected your teaching and learning practices in the classroom? How?

Based on your experience in secondary level, in your opinion what are the best strategies and approaches to implement design thinking in teaching practices?

Describe, if any, obstacles and restrictions on using design thinking in your subject area?

Appendix I: Teacher Consent Form for Interview

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Education
Okanagan Campus

Faculty of Education, Okanagan Campus
University of British Columbia
3333 University Way
Kelowna BC Canada
Tel. 250.807.8084 Fax:250.807.8084
www.ubc/okanagan/education

Teacher Consent Form for the Interview

"Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based research Approach"

Principal Investigator:
Dr. Sharon McCoubrey, PhD
Associate Professor
Faculty of Education
University of British Columbia Okanagan
Phone: 250-807-8109
Sharon.mccoubrey@ubc.ca

Co-Investigator:
Serveh Naghshbandi, BA, MA
Graduate Student
Faculty of Education
University of British Columbia
Phone: 250-864-0918
naghshbandiserveh@gmail.com

This research is part of a thesis in partial fulfillment of a Master of Arts in Education in the Faculty of Education at the University of British Columbia, Okanagan campus. Findings of this research will be published in a thesis, which is a public document. The identity of the school, location, and participants will be confidential as assigned numeric or pseudonyms will be used.

Purpose of the Research Study

Increasingly, teachers are being asked to radically change their professional practices to integrate 21st century teaching and learning. It has been also evidenced in British Columbia Plan that educators are being invited to become designers of the learning environments rather than implementers of the curriculum. Maker Day was developed by the Innovative Learning Centre (ILC) as an immersive, Professional Development event. The aim of the event was to disrupt current classroom practices and introduce teachers to design thinking and the Maker Movement. We are doing this study to understand the impact of

Maker Day and design thinking processes on your understanding of design thinking. We will examine teachers' understanding of design thinking prior to and after the Professional Development event and will examine the ways that the participant teachers might integrate the concepts of design thinking and making into their classroom teaching and learning practice.

You are being invited to take part in this research study because the population of this study will be secondary teachers in School District #83 who attended Maker Day as a Professional Development event. We are inviting you to help us examine your understanding of design thinking prior to and after experiencing it in Maker Day and the ways you might envision to apply it in your classroom.

The Research Study Procedures

This research includes three sequential phases and the participants of each phase are as follows:

The population of the first phase includes ١٨ secondary teachers in School District #83 who attended the Maker Day event at Eagle River Secondary School, Sicamous, BC on February 8, 2014. You have already been asked to fill out the pre-event survey and to describe your perceptions of design thinking prior to experiencing the professional development event. This form is seeking your consent to use the pre-event surveys that you filled out on February 8, 2014.

The population of the second phase includes the same 18 teachers as in the first phase who attended Maker Day on February 8, 2014. You will be asked to fill out the post-event survey and describe your understanding of design thinking after experiencing Maker Day. Please review this Summary of Research and Consent form and return it to the Professional Development Chairperson within one week.

The population of the third phase will be four selected teachers, who were part of the Maker Day on February 8, 2014. The four selected teachers of the Phase Three will be interviewed and asked to describe if they envision implementing design thinking in their teaching practices. Among the interested teachers I will select a variety of teachers from different disciplines. Then, I will ask the professional development chair for the four selected teachers' contact information. I will then contact the four teachers and set up a convenient interview time. The interview will take about 45 minutes.

I will send the interview transcripts to the teachers to be confirmed and may ask them for clarification if needed.

The study will take place between April 30 and May 30, 2014.

Study Result

The results of this study will be reported in a graduate thesis and may also be published in journal articles and books. A summary report of the study will be made available to you by email.

Confidentiality

The researcher will know your identity, but will use a pseudonym at all times when working with the data and when publishing or reporting the research findings. At no time will your name be used.

The only other person connected to this research who will know your identity is the Professional Development Chairperson who will provide the researcher with your contact details. So, I can reach you to conduct the interview.

Potential Risks and Benefits

There is minimal risk for the participants. Given the Professional Development Chairperson knows the teachers' identities, it is not possible to guarantee absolute anonymity. Participants will not be rewarded for participation; participation needs to be completely voluntary. No special treatment or special consideration will result from participation in the study. At the end of the study, the findings will be made available to the participants.

The benefit to the participants of this study is that it enables them to consider design thinking and its approaches to implement it in the classroom. Considering BC's Education Plan to transform education and make changes to better meet the needs of all learners across the province, the value of design thinking in learning and the infrequency of experiential design thinking research conducted in education, this study will provide some insight into design thinking implementation as a teaching practice for secondary teachers.

Security of Data

All documents related to the study will be kept in a locked filing cabinet at the school, and after the study is complete, they will be kept in a locked filing cabinet in Dr. McCoubrey's office at UBC-O for a period of five years following publication. When those five years are past, all documents will be destroyed. All documents will be identified by code numbers. All electronic records will be destroyed as well. Teachers will not be identified by name in any report of completed study.

Withdrawal from the Study

Your participation in this study is voluntary and you may refuse to participate or withdraw from the study at any time without giving a reason and without any negative impact on your situation and with no negative consequences. At any point during the study, if you want to withdraw from the study, you are free to do so. Any data collected about a withdrawing participant will not be included in the study and will be destroyed.

Contact for Concerns about the Rights of Research Subjects

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832

. If long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

Teacher Consent: Researcher's Copy

Your participation in this study is entirely voluntary and you may refuse to participate. You are free to withdraw from the study at any time without giving a reason and without any negative impact on your situation and any negative consequences. Once you have returned the consent form, a copy will be made and returned to you for your records. Your signature indicates your consent to participate in the third phase of this study.

Consent

I, _____ , have read the summary for the research "Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach" conducted by Serveh Naghshbandi, in the Faculty of Education at The University of British Columbia. I understand what the research project entails and I have been provided with an opportunity to ask questions about the research.

Yes, I **consent** to participate in this study.

_____

Teacher Signature Date

_____

Teacher Name Printed

Teacher Consent: Teacher's Copy

Your participation in this study is entirely voluntary and you may refuse to participate. You are free to withdraw from the study at any time without giving a reason and without any negative impact on your situation and any negative consequences. Once you have returned the consent form, a copy will be made and returned to you for your records. Your signature indicates your consent to participate in the third phase of this study.

Consent

I, _____ , have read the summary for the research "Identifying Secondary School Teachers' Understandings and Implementations of Design Thinking within a Design-Based Research Approach" conducted by Serveh Naghshbandi, in the Faculty of Education at The University of British Columbia. I understand what the research project entails and I have been provided with an opportunity to ask questions about the research.

Yes, I **consent** to participate in this study.

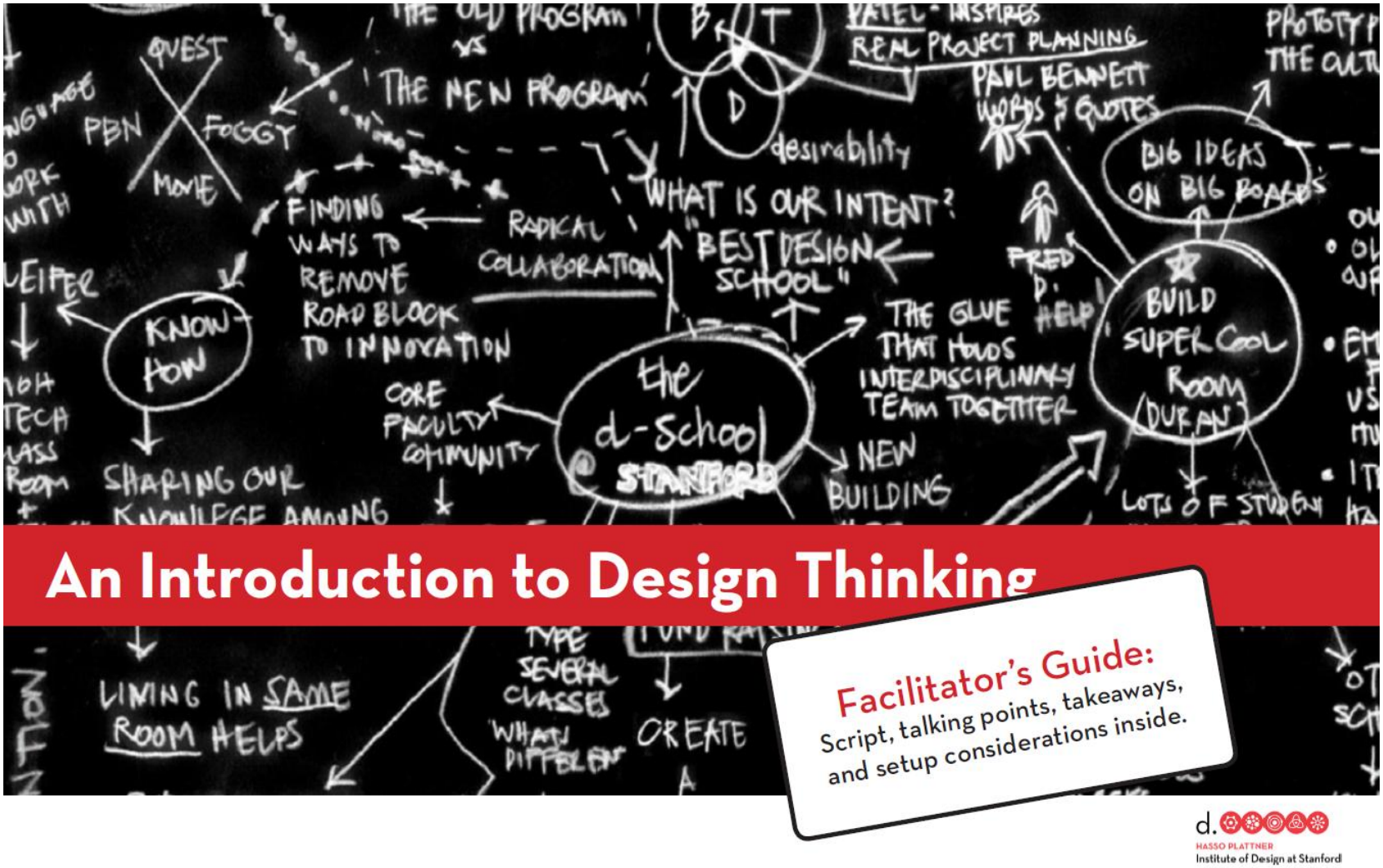
_____

Teacher Signature Date

_____

Teacher Name Printed

Appendix J: An Introduction to Design Thinking, d.Scool, The Hasso Plattner Institute of Design, Stanford University



Redesign the Gift-Giving Experience

A little background on the project

The project you're holding in your hands is an iteration on the d.school's iconic "Wallet Project." The Wallet Project is an immersive activity meant to give participants a full cycle through the design thinking process in as short a time as possible. The project itself gives facilitators the opportunity to touch on the fundamental values of the d.school—human-centered design, a bias towards action, and a culture of iteration and rapid prototyping—without attempting to communicate all of the methods and activities that the term "design thinking" encompasses.

Why did we choose a wallet as the subject for the introductory design challenge?

* everyone has experience with a wallet, or another way to carry cash, cards, and ID
* the wallet and its contents have the potential to evoke a range of meaning and the larger context of a person's life
* wallet as a starting point enables a wide range of potential innovation outcomes (we've seen objects, experiences, services, systems, and spaces!)
* having a physical artifact in-hand allows for immediate recall of experiences (participants can gain empathy for one another in the room)

The original wallet project was created as an introduction to design thinking for the d.school's inaugural Boot Camp class in the Winter of 2006. It has since been contributed to, modified, stretched, and evolved by many d.school collaborators. As an evolution of the wallet project, this project asks participants to redesign the gift-giving experience in order to amplify the likelihood of experiential prototypes and testing.

Why project-based, team-facilitated learning?

Having created learning experiences for students of all cultures, ages, disciplines, and industries, we have found that engaging in projects provides a much richer learning experience than listening to a "talking head" does. As such, our bias is to provide limited scaffolding to allow participants to **do**, and then to facilitate a reflection that invites the participants themselves to extract the meaningful learning opportunities from the experience. We teach in teams at the d.school because we have found that this approach tends to create a conversation in the classroom, as opposed to the one-way communication that often transpires in more lecture-driven formats. We relish the diversity of perspectives that emerge when faculty from diverse backgrounds instruct, and even disagree in front of, a class. This approach to learning also happens to highlight a couple of our core values: having a bias towards action, "show, don't tell," and radical collaboration.

How to set up and kickoff the project

Set up the room so that participants are standing (this is an ideal, not a requirement), with access to a horizontal space for note taking.

Space should be configured to allow for participants to pair up near one another easily.

Cocktail style—small, standing height—tables are nice to have.

Play upbeat music during all steps while participants work,
and turn it down to give instruction.

Make sure you have supplies on hand for prototyping (we recommend paper, pens, popsicle sticks, pipe cleaners, scissors, duct tape, and the like).
Print the participant worksheet ("The Gift-Giving Project.pdf") in color on single-sided 11x17 paper.
Print the facilitator's guide ("GG Facilitators Guide.pdf") in color on double-sided 11x17 paper.
Display a widely-visible timer that lets participants know how much time they have left during each step.
Find a fun way to announce "Time's up!" (we use a gong at the d.school).

Be assertive about keeping the timing tight.

Have a TEAM of coaches who are familiar with the project share the responsibility for facilitating the learning experience.

The kick-off:

"Instead of just telling you about design thinking,
we want to immediately have you jump right in and experience it for yourself.
We are going to do a design project for about the next hour.
Ready? Let's go!"

Start by gaining empathy.

EMPATHIZE

How to facilitate these steps

1—Interview your Partner

"This is going to feel rushed; that's okay. Roll up your sleeves and get ready to lean into the project."
Have participants partner up in pairs.
It helps to refer to "Partner A" and "Partner B" to simplify your language in these interactive steps.

"Your challenge is to redesign
the gift-giving experience . . . for your partner."

"The most important part of designing for someone is to gain empathy for that person."

"One way to do this is to have a good conversation."
Be clear about the logistics of the interviews:
"Partner A will have three minutes to interview Partner B, and then we will tell you when to switch."

"As a starting point, ask your partner to tell you about the last time they gave a gift."

"To whom did they give it? Why was it meaningful? How did they come up with the idea for the gift?"
"What was difficult about finding and giving this gift?"
Tell them to take note of things they find interesting or surprising.

"Let's begin!"

2—Dig deeper

After the first set of interviews, tell them to follow up on things that intrigued them during the first interview.

"Try to dig for stories, feelings, and emotion."
"Ask 'WHY?' often"

You might pause and give them a short time (forty-five seconds) to plan their second interview.
Remind them you will let them know when three minutes are up.
..."Time to switch! Again, make note of any unexpected discoveries along the way, capture quotes!"

Your mission: **Redesign the gift-giving experience ...for your partner. Start by gaining empathy.**

1 Interview

6min (2 sessions x 3 minutes each)

Notes from your first interview

Switch roles & repeat Interview

2 Dig deeper

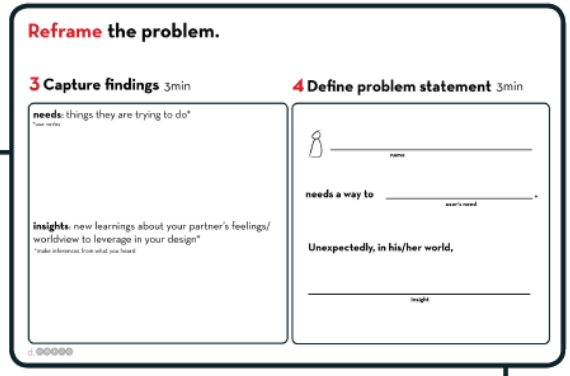
6min (2 sessions x 3 minutes each)

Notes from your second interview

Switch roles & repeat Interview

d.

Reframe the problem.



How to facilitate these steps

DEFINE

3—Capture findings

Tell them to *individually* take three minutes to collect their thoughts and reflect on what they've learned about their partner.

"Try to synthesize your learning into a few 'needs' that you have discovered, and a few 'insights' that you find interesting."

"'Needs" should be verbs."

"For example maybe your partner *needs* to feel like they have a personal knowledge of the recipient's preferences."

"Insights" are discoveries that you might be able to leverage when creating solutions."

"For example, you might have discovered the insight that your partner views handmade gifts as more meaningful and personal."

4—Define the problem statement

Now tell them to select the most compelling need and most interesting insight to articulate a problem statement.

"This is the statement that you're going to address with your design, so make sure it's juicy and actionable!"

"It should feel like a problem worth tackling!"

"Bonus points if you can describe your partner with adjectives and nouns more descriptive than their name alone."

Reframe the problem.

3 Capture findings 3min

needs: things they are trying to do*
*use verbs

insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard

4 Define problem statement 3min

_____
name

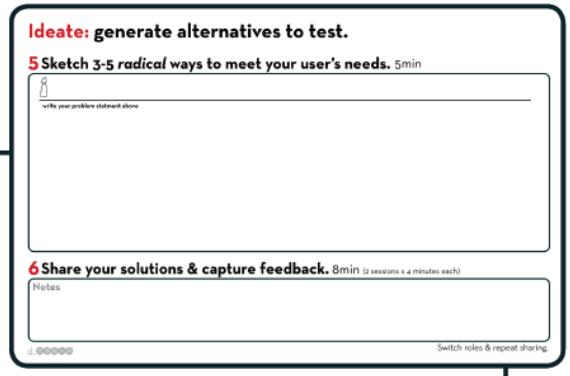
needs a way to _____ .
user's need

Unexpectedly, in his/her world,

_____
insight

d.

Ideate: generate alternatives to test.



How to facilitate these steps

IDEATE

5—Sketch to Ideate

Have them rewrite their problem statement at the top of the page.

Remind them they are now creating solutions to the new challenge they've identified.

They will have 5 minutes to sketch as many ideas as possible.

"GO FOR VOLUME!"

"This is time for idea generation, not evaluation—you can evaluate your ideas later."

You can even suggest a friendly competition to come up with the most ideas --
"See if you can come up with at least 7 ideas!"

"Remember to be VISUAL—use words just when necessary to call out details."

... "One minute left! Try to sketch at least 2 more wildly different ways to address your problem statement!"

TEST

6—Share solutions and capture feedback

"Now it's time to share your sketches with your partner!"
"Partner A, share your sketches with Partner B first, and then we will tell you to switch after four minutes."
Tell them to note likes/dislikes and builds on the idea, but also listen for new insights.

"This is not just about testing your ideas."

"This is another opportunity to learn more about your partner's feelings and worldview."

"Fight the urge to explain and defend your ideas—see what they make of them!"

"Spend the time listening to your partners reactions and questions."

Tell them to switch after four minutes.

Ideate: generate alternatives to test.

5 Sketch 3-5 *radical* ways to meet your user's needs. 5min

write your problem statement above

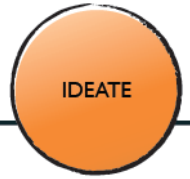
6 Share your solutions & capture feedback. 8min (2 sessions x 4 minutes each)

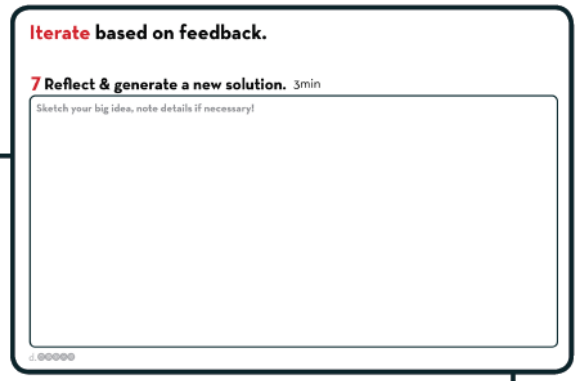
Notes

d.

Switch roles & repeat sharing.

Iterate based on feedback.





How to facilitate this step

7—Reflect & generate a new solution

They've had a chance to share their sketches with their partners and collect feedback.

"Now, take a moment to consider what you have learned both about your partner, ***and*** about the solutions you generated."

"From this new understanding of your partner and his or her needs, sketch a new idea."

Tell them this solution may be a variation on an idea from before or something completely new.
They are still addressing a problem statement that *they* articulated, but you might point out that their previous problem statement may need to change to incorporate the new insights and needs they discovered.

"Try to provide as much detail and color around your idea as possible."

"How might this solution fit into the context of your partner's life?"

"When and how might they handle or encounter your solution?"

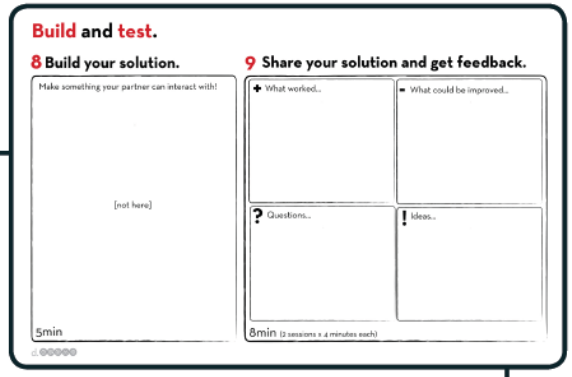
While participants are working, grab the prototyping materials if you have not already.

Iterate based on feedback.

7 Reflect & generate a new solution. 3min

Sketch your big idea, note details if necessary!

Build and test.



How to facilitate these steps

PROTOTYPE

8—Build!

Tell participants to use the idea they just sketched as a blueprint for a tangible manifestation of their solution.

"Create a physical prototype of your solution."

Explain that they should not simply make a scale model of their idea to explain the idea.
They should create an experience that their partner can react to.
They could decide to test just one aspect of the overall solution.

"MAKE something that your partner can engage and interact with."

"If your solution is a service or a system,
create a scenario that allows your partner to experience this innovation."

"Use whatever materials are available to you—including space!"
Provide some urgency and excitement in your voice—you want to get them building immediately.
"Be scrappy and quick—you only have five minutes!!"

TEST

9—Share your solution and get feedback

Explain that they will have four minutes each to share and collect feedback, and then they will switch so the other partner can share.

"Now you're going to have the opportunity to share your prototype with your partner."

Validation of the prototype is not the point—it should be an artifact that facilitates a new, targeted conversation.

"When you test, LET GO of your prototype, physically and emotionally."

"Your prototype is NOT PRECIOUS, but the feedback and new insights it draws out are!"

"Don't defend your prototype; instead, watch how your partner uses and misuses it."

Tell them to jot down things their partner liked and didn't like about the idea, as well as questions that emerged and new ideas that came up.

Build and test.

8 Build your solution.

Make something your partner can interact with!

[not here]

5min

9 Share your solution and get feedback.

✚ What worked...

▬ What could be improved...

? Questions...

! Ideas...

8min (2 sessions x 4 minutes each)

d.

Reflection and takeaways.

How to facilitate this step

10—Group gather and debrief

This step is important! A well facilitated reflection has the power to turn this exercise from simply a fun activity to a meaningful experience that could impact the way participants approach innovation in the future. Quickly pull together a few tables that everyone can gather around.

Tell everybody grab their prototypes and set them on the table in the middle of the room.

"We're going to huddle around and see what innovations you've created for your partners!"

"Who had a partner who created something that you really like?"

"Who sees something they are curious to learn more about?"

Ask for the person who created the prototype and engage them in the conversation.

"How did talking to your partner inform your design?"

"How did testing and getting feedback impact your final design?"

"What was the most challenging part of the process for you?"

The key to leading this conversation is to relate the activity to the big takeaways you want to illustrate.

Some of core values of design thinking that would be great to draw out include:

Human-centered design: Empathy for the person or people you are designing for, and feedback from users, is fundamental to good design.

Experimentation and prototyping: Prototyping is not simply a way to validate your idea; it is an integral part of your innovation process. We build to think and learn.

A bias towards action: Design thinking is a misnomer; it is more about doing that thinking. Bias toward doing and making over thinking and meeting.

Show don't tell: Creating experiences, using illustrative visuals, and telling good stories communicate your vision in an impactful and meaningful way.

Power of iteration: The reason we go through this exercise at a frantic pace is that we want people to experience a full design cycle. A person's fluency with design thinking is a function of cycles, so we challenege participants to go through as many cycles as possible—interview twice, sketch twice, and test with your partner twice. Additionally, iterating solutions many times within a project is key to successful outcomes.