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Using Design Thinking in Mathematics for Middle School Students: A Multiple Case Study of Teacher Perspectives

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Using Design Thinking in Mathematics for Middle School Students: A Multiple Case Study of Teacher Perspectives

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Abstract

This multiple case study focused on the perception of teachers implementing a problem solving strategy called design thinking to help students master the Common Core Standards in Mathematics specifically in middle school classrooms. The analysis of the data provided evidence that teachers saw Design thinking as a strategy in which students were able to master math concepts. Participants participated in semi-structured interviews then provided digital portfolios as artifacts. The digital portfolios contained two lesson plans along with pre-lesson and post-lesson reflections. The artifacts and interview data were coded for main themes. The themes included critical thinking, failure, communication, collaboration, and real-world problems. These themes were compared with the definition of mastery to show that the majority of the teachers did perceive that using Design thinking did help students master mathematical standards.

Keywords: design thinking, Common Core, problem-solving

Dedication

I dedicate this accomplishment to my family who have been by my side throughout this journey. First, to my husband Sean who has been my cheerleader, sounding board, and love of my life who has sacrificed time as I took on this challenge and never complained about all the late nights. Next to my two daughters Kyla and Aubree who sacrificed time with their mom as they grew up. I hope that my dedication and love of learning provides you with strength when times get hard. I also hope that this journey you watched me go on serves to show you that with hard work you can accomplish anything. To my parents, you have been a rock for me in my life. You have always encouraged me and been a great example.

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Chapter 1: Introduction

Introduction to the Problem

From 2002 to 2010 the United States educational system was governed by the mandates of the No Child Left Behind Act (NCLB). This act had schools and teachers focusing more on standardized tests than the 21st century skills students need (Department of Education, 2016). As a response to NCLB, the Common Core State Standards (CCSS) were created and adopted by 46 states across the United States. The goal of CCSS was to provide common skills and content across the country. CCSS is not a curriculum, but provides educators with standardized indicators for student learning. The CCSS has a focus on four competitive skills needed for future jobs including creativity, communication, collaboration, and critical thinking (Common Core State Standards Initiative, 2015). The most current reaffirmation of the Elementary and Secondary Education Act is Every Child Succeeds Act. This act was established in 2015 by the Obama administration. This act aims at ensuring that all students receive access to an education that utilizes rigorous standards and are college and career ready (U.S. Department of Education, 2016).

Since the adoption of the No Child Left Behind Act of 2001, teachers have focused on students producing the correct answer on standards-based tests instead of focusing on developing critical thinking and problem-solving skills. Ultimately CCSS shifts student learning away from rote memorization, to analyzing problems, communication, problem solving, and applying new solutions. Many teachers struggle to find new instructional strategies to help students with the change (Mo, Kopke, Hawkins, Troia, & Olinghouse, 2014; Phillips & Wong, 2012) specifically in mathematics. With the amount of years that teachers focused on students choosing the right answer for standardized tests, work through worksheets looking only for one singular correct

answer, CCSS has now challenged mathematics teachers to shift learning to more open-ended, explanatory methods. Specifically looking at the standardized units of measure that most states are using, students are being asked to analyze, explain, and justify unique real-world problems. For teachers, this requires a shift in strategies. One potential solution is using the concept of design thinking (DT) as a problem-solving strategy. Design thinking is a process of using empathy, group ideation or brainstorming, prototyping, and testing to solve problems and create new products. Teachers have started to integrate DT into their classroom pedagogy. As more teachers and schools look for new problem-solving strategies, understanding the experience of the teachers using DT is important.

Background, Context, and History

The nature of problem solving is highly subjective, especially given the two competing educational paradigms: No Child Left Behind (NCLB) and Common Core State Standards (CCSS). NCLB focuses on quantitative outcomes, whereas CCSS expects a more subjective focus on problem solving, which is inherently subjective and qualitative. It was reasonable to investigate the problem of this study via a multiple case study (Brannen, 2005; Creswell, 2013), to understand how the lived experience of students using design thinking (DT) impacts the problem. For this study, a combination of qualitative investigative data collection techniques was used, consisting of interviews and digital portfolio reviews from middle school teachers grades 6-8 from two middle schools in Southern California that both currently use design thinking (DT) as part of their core instructional strategies. The interviews consisted of open-ended questions that focused on the experience of teachers in the integration of design thinking (DT) into their core content, lessons learned, successes, failures, and challenges. Each interview was recorded and the answers were coded for overall shared experiences. All teachers were asked by the

researcher to compile a digital portfolio that included teacher reflections, and lesson plans. The target population were teachers who serve Grades 6–8.

Conceptual Framework

The conceptual framework or research paradigm for this study is comprised of three major elements including theoretical framework, practical framework, and the secondary practical framework. For this study, the combination of problem-centered design and real-world practice help the study fall under the umbrella of pragmatism (Creswell & Plano Clark, 2010). Pragmatism was combined with two different practical theories to form the conceptual framework. The first practical theory was design thinking (DT). DT is a real-world problem-solving cycle. The application has shown success in the business sector in providing real world solutions with a focus on the user (Kelley & Kelley, 2013). The application has shown limited success in education for students needing to utilize the 4 Cs of the Common Core State Standards (CCSS) which are creativity, communication, creativity, and critical thinking. This study will utilize DT as the classroom strategy being integrated into middle school math classrooms.

Another element of the conceptual framework for this study is the Common Core State Standards (CCSS) in mathematics for middle school students. Many states shifted to CCSS which has caused many teachers to struggle in classroom instruction. The standards were used as a practical theory in this study for teachers to integrate DT as a problem-solving strategy into the CCSS math standards. From the starting point of pragmatism, design thinking (DT), and the Common Core State Standards (CCSS) the approach of multiple case study, qualitative approach was used. Through the triangulation of interview data, teacher lesson plans, and pre/post lesson reflection, the study showed that the perceptions of teachers using DT in the classroom does help students master the concepts in CCSS mathematics.

Statement of the Problem

Currently a conflict in American education exists between a focus on helping students succeed on standardized tests via the No Child Left Behind (NCLB) paradigm, and a focus on helping students succeed in higher level thinking skills via the Common Core State Standards (CCSS) paradigm. As a result of this conflict, many teachers struggle to find appropriate instructional strategies to help students with the change (Phillips & Wong, 2012; Mo, Kopke, Hawkins, Troia, & Olinghouse, 2014; (Smith, Wilhelm, & Fredricksen, 2013). The shift and struggle to meet the new demands and standards of CCSS, particularly in the subject area of mathematics, has left a void in strategy teachers have been taught to use. To compound the problem, many educators using a CCSS-based curriculum lack a cohesive strategy to increase students' problem-solving skills. There is a need for new strategies that help teachers utilize a common problem-solving language and process students can follow no matter the content for successful implementation of the four Cs of CCSS: creativity, collaboration, communication, and critical thinking.

Purpose of the Study

The purpose of the study is to provide evidence regarding the impact of DT on meeting CCSS goal for problem-solving and the 4 Cs of creativity, communication, critical thinking, and collaboration specifically in mathematics. This study is important because the Common Core State Standards (CCSS) ask students to use higher order thinking skills, which are needed for college and careers. This study will allow teachers, administrators, schools, and even districts to understand the successes, challenges, changes, and overall experience of utilizing the design thinking Process in their own students' learning to comply with CCSS.

Research Question

- How do teachers perceive the impact of design thinking strategies on a student's ability to meet middle school Common Core State Standards (CCSS) in mathematics?

This question is important because understanding the successes, failures, struggles, and overall experience of design thinking will allow interested teachers to understand what they are attempting before actually making the change (Kwek, 2011).

Rationale, Relevance, and Significance of the Study

The objectives of this study are to provide a holistic overview of the phenomenon of integrating DT into core content instruction for student success with the Common Core State Standards (CCSS) in meeting both problem-solving and the 4 Cs of CCSS of creativity, communication, critical thinking, and collaboration. By presenting the entire experience of the phenomenon more schools and teachers will have the insight to make an informed decision to follow in the same path or to make changes to their current pedagogy.

With education continually trying to meet the needs of the global society, new strategies are looked at to implement in classrooms. Studies and research are needed into strategies that both have quantitative and qualitative results. These studies allow for decision making from administration as well as from teachers as to the strategies and learning methods worth trying. This study does just that, shows the persective of teachers that are using the design thinking (DT) strategy and can be relevant to schools looking for a change. Education's goal is for students to master concepts while businesses and employers are looking for problem solvers, this study combines asked teachers to look at both mastery and problem solving success in students which makes it relevant to those looking to expand currentl student learning and future success.

As standards and expectations for student learning change from No Child Left Behind standards to Common Core curriculum, students are being asked to critically think and problem solve. These new standards have caused many schools and teachers to look for problem-solving strategies. Design thinking (DT) is one emergent strategy that might be used by education leaders. DT gives students a common vocabulary, process, and meaning to solving problems. Current research on DT in the classroom has not focused on a fully encompassing view of what a teacher utilizing the strategy experiences. From this research educators and administrators will be able to avoid some of the failures that teachers have had as well as fully understand how the strategy will be able to change the learning of their students.

Definitions of Terms

Common Core State Standards (CCSS): is a term used to describe expectations for student learning. (Common Core State Standards Initiative, 2016)

Design Thinking (DT): is a process of steps that includes empathy, ideation, prototyping and reflection that allows students to solve problems focused on the needs of others and finding innovative solutions (Kelley & Kelley, 2013; Hasso Plattner School of Design, 2012; Purdy, 2014)

Assumptions

For this study, the researcher assumed that all teachers in this research study group understand the elements of design thinking (DT) in the same way. This assumption comes from cohesive training between the schools and teachers throughout the fundamental building and planning of the schools. This study also assumed that the research target group of teachers are integrating DT to the meet the needs of the students within their individual classrooms. This

assumption comes from research into philosophies of the schools. Lastly this study assumed that all teachers participating in the study have had some level of training in problem solving and DT.

Limitations

Any study that focuses solely on the perspectives of individuals through a case will have limitations. The lack of generalizing a study to larger groups is one major limitation of a case study based qualitative study. The researcher understands limitations of this study include transferability as not all teachers or schools have the resources and training in design thinking (DT) as the teachers in the study. Another limitation is the transferability to grades kindergarten through third grade (Brown, 2009; Goldman, Kabayadondo, Royalty, Carroll, & Ruth, 2013).

Delimitations

Starting with the problem it is easy to define the delimitations. The choice of looking at the problem-solving/critical thinking side of learning for students. The study also only looked at the perceptions of the teachers using design thinking in their classroom and did not look at student, parent, or administration's perception of the success. This study was delimited to public middle school teachers using the Common Core State Standards. This study did not include all common core subject areas as well as all grade levels. The study also did not look at private schools in this study. The last delimitations of the study included the choice to complete a qualitative study and exclude the use of quantitative data all together. This choice meant that statistical data like standardized test scores and student work to prove mastery. The choice was made to allow other teachers to see how perceptions can help to change and move education just as much as quantitative data.

Summary

Understanding the perceptions that DT teachers experience could become valuable to other educators looking to undertake a similar journey in their own classrooms; however, there is a lack of studies evaluating the experience. In order to capture the essence of the experience, interviews and artifacts will be combined, coded, and analyzed to provide an overview of the experience of being a DT teacher. Understanding learning theories, history of DT, as well as current research will provide a thorough perspective of why this study is valuable.

Chapter 2: Literature Review

Introduction

The Common Core State Standards (CCSS), adopted by 45 states, calls for radical changes to the way curriculum and instruction are presented in K–12 classrooms. The changes in the transition to CCSS for teachers and students focus on its four Cs: communication, collaboration, creativity, and critical thinking (P21, 2015). The CCSS has shifted the emphasis from content knowledge to a more skills-based approach to leaning (Common Core State Standards Initiative, 2015). With the changes in the standards and approaches in education, the need to help teachers innovate how they teach and how students learn has become a major focus for many administrators (Mo, Kopke, Hawkins, Troia, & Olinghouse, 2014; Phillips & Wong, 2012; Smith, Wilhelm, & Fredricksen, 2013)

One instructional approach to help students learn the skills of the four Cs is design thinking. Design thinking (DT) has been used in business and industry for many years as a process to bring different viewpoints together to solve complex problems (Kelley & Kelley, 2013). Education leaders are beginning to see the benefits of using this process (Brown, 2009; Campos, 2011) to help students develop real-world problem-solving skills in collaboration, communication, and critical thinking (Common Core State Standards Initiative, 2015). In order to integrate design thinking into their instructional practices, K–12 teachers need specific professional development training.

The development of the problem statement for this study was influenced by the lack of research on design thinking (DT) integration into core content classes, professional development (PD) strategies in DT, and effective PD in educational change. The problem addressed in this study is Educators using Common Core Standards (CCSS) curriculum do not have the necessary

strategies to instruct students on how to use problem-solving strategies specifically in mathematics.

There is a great deal of research on the concept of design thinking (DT) used in business to solve problems and to innovate or create new products (Brown, 2009; Kelley & Kelley, 2013; Kimball, 2011; Martin, 2010); however research on the effective use of DT in education is lacking. Moreover, there is no current research showing the persepctive of teachers for implementing DT as a problem-solving strategy in education. This chapter will examine the fundamental ways all people learn, what the process of design thinking involves, and the professional development-training teachers need in order to effectively implement design thinking methods.

Conceptual Framework

The conceptual framework for this study consists of three major research frameworks: theoretical framework, practical framework, and the secondary practical framework. The theoretical framework in this study is pragmatism. Pragmatism is attributed to thinkers like Charles Sanders Pierce (1839-1914), William James (1842-1910), and John Dewey (1859-1952). When a researcher uses the theory of pragmatism, they are really focusing on knowledge coming from action, consequences, or even situations. Pragmatism does not focus on a single philosophy and provides the researcher with the freedom of choice. For this study, the combination of problem-centered design and real-world practice combined to have the study fall under the umbrella of pragmatism (Creswell & Plano Clark, 2010).

Pragmatism was combined with two different practical theories to form the conceptual framework. The first practical theory will be design thinking (DT) and the second was the Common Core State Standards (CCSS). DT is a real-world problem solving cycle. DT has roots

in Kolb's Experimental Learning Theory. Kolb's theory focuses on learning in four stages including concrete experience or doing, reflective observation, abstract conceptualization or thinking, and active experimentation or planning (Learning Theories, 2016). DT has demonstrated success in the business sector in providing real world solutions with a focus on the user (Kelley & Kelley, 2013). The application has shown limited success in education for students needing to utilize the 4 Cs of the Common Core State Standards (CCSS) which are creativity, communication, creativity, and critical thinking (Common Core State Standards Initiative, 2015). This study will utilize DT as the classroom strategy being integrated into middle school math classrooms.

The second practical theory of the conceptual framework for this study is the Common Core State Standards (CCSS) in mathematics for middle school students. Many states shifted to CCSS which has caused many teachers to struggle in classroom instruction. In a study conducted with six focus groups from California it was found that teachers lack the training and strategies to properly meet the CCSS expectations for students (Frizzell & Dunderdale, 2015). The standards will be used as a practical theory in this study for teachers to integrate DT as a problem-solving strategy into the CCSS math standards.

The multiple case study was selected as part of the framework in an attempt to capture the essence and experience teachers experience in utilizing and integrating DT in their core content instruction. Although other research methods such as Constructivist, Case Study, and Narrative Research could all be used, those theories were not selected due to their limitations in types of data (Creswell, 2013).

The following arguments or warrants serve to support the claim and to provide a base for the study:

1. Common Core State Standards call for students to increase the skills of communication, creativity, collaboration, and critical thinking to a level that middle school students currently do not have.
2. Design thinking has been successfully used in multiple business applications and higher education to help solve complex problems.
3. Design thinking can build a common language and process for students to use in all core content areas.
4. Teachers and administrators have not been trained in critical thinking and problem solving strategies.

The conceptual cycle was developed from five main elements including the conceptual framework, methods, problem statement, validity, and research question. Figure 2 shows the conceptual cycle used in this study. The methods for this study consisted of an analysis of the perceptions of teachers who are currently integrating design thinking (DT) in their math instruction. The analysis was conducted through semi-structured interviews with the teachers. The main focus and binding element of each interview will be the teacher's perception of the success or lack of success that DT has on student's meeting the needs of Common Core State Standards (CCSS). Open-ended questions focused on the success of the DT integration in their classroom, what works, what doesn't work, what changes could be made. Teachers will also be asked to submit artifacts to be analyzed such as lesson plans and reflections.

As an educator and mother, the skills and content that children are learning in schools is of the upmost importance to me. Schools have been stuck in an industrial age learning model in which rote memorization and a teach to the test mindset or where the results of the test were the entire focus of student learning more than mastery of skills was prevalent (Lichtman, 2014;

Wagner, 2012). Dewey (Lichtman, 2014) stated, "If we teach today as we taught yesterday, we rob our children of tomorrow" (p. 25). Although John Dewey was speaking of the 19th century, the quote is still relevant today. Educators have called for change in instructional methods as well as for relief from outdated standards. In answer to the national call for change in educational standards, the Common Core State Standards (CCSS) were developed. Many states in the United States have adopted CCSS and are now in the all-important transition to incorporating skill based learning systems. Based on personal experience, teachers are struggling with their students as they transition from a rigorous standard based system to a skill based system of learning and problem solving.

Some schools have taken on challenge of CCSS in innovative ways, including the integration of design thinking (DT). With DT becoming a new strategy the question of its validity in student achievement comes to many administrators and teachers mind. This research brings into question the validity of DT as a strategy and tool that teachers and schools can use to develop the skills students need to be successful with CCSS. Based on current research in DT, this study will investigate the best way teachers and administrators can develop the DT concepts into core curriculum, as well as its effect on students' achievement (Campos, 2011; Kelley & Kelley, 2013; Liu, Hsieh, Cho, & Schallert, 2006). The current research shows promise in student's use of DT and with proper training on integration into core content, students achievement should show an improvement.

Current research demonstrates that children and adults learn through hands-on experiences that combine past experience and reflection (Brown, 2009; Dewey, 1938; Hilgard & Bower, 1975; Wirth, 1966). Expanding on the research and philosophies of Progressive learning theories is where the concept of DT came from and has come to the forefront of business by the

firm IDEO (Kelley & Kelley, 2013). IDEO used the concept of DT to help innovate and transform businesses. David Kelley, founder of IDEO, then went on to develop a school-based program using DT at Stanford University called the d.School (Kelley & Kelley, 2013). The objective of the school was to bring students from all different majors and areas of study together to learn to think through complex problems and begin to think of innovative new ideas. K–12 educators have started to explore the concept of using DT in their schools, but there is a lack of research data on its effect on student achievement. While the current K–12 education research on DT shows promise, more research is needed in this area to support its use by school district administrators.

With design thinking (DT) moving forward in schools (Brown, 2009; Campos, 2011; Kelley & Kelley, 2013), there is a need for an understanding from the perspective of teachers who are currently integrating DT into core content areas. Currently there are studies that isolate research to a single school and overall experience, but there is a lack of research on the experience of a teacher integrating DT into their core content instruction.

Review of the Research Literature and Methodological Literature

History of mathematics education in the United States. Knowing and understanding how, why, and what students received mathematical education helps to establish the foundation for this study. Due to the shift that has occurred in the expectations on learning math for students through the adoption of the Common Core State Standards (CCSS) drove the foundation but the need for the study. Mathematics has a long history of viewpoints from prominent people in both pedagogy and content. A complete understanding of these viewpoints and how they have shaped the current structure of the mathematical standards we have today.

The root of mathematics education can be traced back to ancient Greek philosophers such as Plato, Euclid, and Pythagoras as well as Jean Jacques Rousseau and John Dewey (Klein, 2003). Their concepts of progressive learning dominated the landscape of learning throughout the almost the entire 19th century and the early part of the 20th century. Shortly after Dewey and Rousseau, William Heard Kirkpatrick emerged onto the educational landscape (Klein, 2003; Saracho & Spodek, 2009). He was regarded as the nation's "most influential introducer of progressive ideas into American schools of education" (Klein, 2003, p. 2) as he introduced what became the standardized text in the education of teachers. One of the main concepts that Kirkpatrick stressed was that any subject including mathematics should be taught in practical and applicable ways. Many Americans believed the study of mathematics was needed to provide mental discipline more than practical applications (Klein, 2003).

In 1920, a special council was formed to help in the development and oversight of education. The council is called the National Council of Teachers of Mathematics (NCTM). The focus of the group is on mathematics and help to provide a platform in which reforms, adjustments, curriculum decisions come from teachers of mathematics and not from any other source. In the 1930's a movement arose in education called the Activity Movement. This movement stated that education needs to be driven by the needs and interests of the students and professionals not by academic subjects (Klein, 2003). The activity movement spread from middle school education to elementary school through the integration of content and subjects. The high schools were reluctant to integrate subjects because of the training that teachers, specifically the single subject aspect of high school learning. However, in the 1940s educational philosophy shifted once again from the focus on the integrated approach to learning to a focus on daily living skills. The skills that were focused on were health, home making skills, and so on.

Besides teaching basic mathematical skills needed to shop and maintain household bills, math as we know it today was not taught. The belief at that time was the professions that needed more math skills would teach it themselves to their employees. There was an overall decline in the percentage of high school students who were enrolled in algebra, geometry or trigonometry from 1909 to 1953.

At the beginning of the 1950s the inception of new math occurred. New math looked and felt more in line with what we see as math education today. The new math era lasted through the beginning of the 1960s. One of the changes that new math brought about was the use of mathematicians in the creation of curriculum. The new math also brought about the inclusion on explanations for mathematical procedures that were being taught in the classroom. Froom 1954 to 1955 there was a slight increase in the percentage of high school students who took on the challenge of being enrolled into all three mathematical disciplines, with trigonometry have the highest percentage enrolled since 1909.

With the launch of Sputnik by the U.S.S.R. in 1957, mathematics started to gain the attention of the nation. Congress responded to Sputnik by passing an educational act to increase the number of students majoring in mathematics and science across the nation. During the 1950's this race to space push caused new committees on mathematics to be formed along with an abundance of textbooks. Some textbooks were written by organizations and councils while others were written by teachers themselves. The biggest contribution that the new math era brought was the addition of calculus courses for high school students. One of the biggest pitfalls was the loss of focus and attention on the basic foundational skills of mathematics.

As with all changes in educational focuses and philosophies, the new math era came to an end in to 1970's. The pendulum of mathematical focus once again moved from a focus on

explanations of the math to back to the basics in all subjects. While the pendulum was shifting to a back to basics approach a small subgroup of proponents of progressive education started to gain a voice in the country. The small group of proponents gave way to another new movement in educational learning that greatly influenced mathematical learning called Open Education or free schools. In the concept of Open Education, students were free to choose day by day what they wanted to learn and how they would learn it. What Open Education caused was a striation in the children from low income households who lacked the resources to help them be successful.

The 1980s called once again for another change in education, especially in the areas of mathematics and science. Two different publications arose in the early 1980's that gave two separate viewpoints on how math education should be changed. The first publication was titled An Agenda for Action which was written by the National Council for of Teacher of Mathematics. The focus and changes that the article called for was focusing mathematics education on problem solving along with changes in pedagogy for mathematics. In this call for action, technology came into play as the first equalizer. The action stated that all students should have access to calculators to not allow basic computational skills to get in the way of problem solving. The emphasis on solving real world problems came to the forefront of math education during the late 1980's.

A second report was written in 1983 called "A Nation at Risk." This report was written by the Secretary of Education at that time Terrell Bell. This report attacked the core of the educational process calling it an act of war if it were a system that another country imposed on the United States. The report noted that there was a drastic increase in the remedial mathematics courses needed for both high school and college students to graduate. This was contributed to

the Open Education movement in the 1960s and 1970s. The report even brought to light the fact that schools that offer calculus enroll about 60% of their students into the course but only six percent of all students will complete the course. It was A Nation at Risk that first brought standardized testing to the forefront and thought process of the United States (National Council of Teachers of Mathematics, 1980)

The report went even further by stating that teachers were poorly educated and drawn from the bottom of the graduated in college. The article talked in depth that teacher preparation courses were also failing educational needs in the country. They stated that almost half of the time that teachers are in educational preparation programs the focus is on educational methods instead of mastery of content. The last major issue that the article addressed in education was the need for a reform in the textbook content. The textbooks of the 1980s was not rigorous enough to have the nation's students compete on a global level (National Commission on Excellence in Education, 1983)

The article was one of the only written documents of its type to make national news and headlines for education. The article sparked a national concern about education in just about every state in the United States. California was one of the few states that made reforms in education that most closely matched the ones suggested in the 1983 article. Ultimately however the creation of national standards in both language arts and mathematics is where education was headed.

National standards for mathematics education. In 1989 the nation responded to the "A Nation at Risk" report by developing national standards in education. In 1986, The National Council of Teachers of Mathematics developed the first draft of the standards for mathematics. These standards were the effort of four different groups appointed by the council at that time.

The standards were then given to teachers across the nation to review and give feedback during the 1987–1988 school year. The document was finally published in 1989. These standards were not viewed by the college institutions as true standards. Many universities regarded the standards as missing two key elements, the general attitude students should develop towards mathematics and the mathematical skills each grade level should master. Instead the standards were developed with four-year bands in which students would learn various topics. The standards took mathematical education back to the progressive era through the emphasis on discovery learning.

In 1989 George H. W. Bush attended the educational summit and announced that the nation's student will become first in the world in both mathematics and science by the year 2000. Following the success of the standards the National Council of Teachers of Mathematics published two follow up documents that included a focus on classroom pedagogy and testing in 1995. By 1997 most states had adopted the national math standards. The standards then turned into a program of its own with curriculum aligned to the standards, testing systems put in place for accountability, as well as systematics pedagogy. The program was not without public backlash.

The program continued to follow the standards in the lack teaching children the fundamentals of arithmetic and algebraic skills. The public became concerned over the program's focus and encouragement of elementary school students to develop their own algorithms instead of using the standardized methods that were tried and true to solve mathematical problems. Another major issue that the program has was the over use of calculators for simple mathematical calculations in every grade level. Learning of mathematical concepts became the responsibility of student discovery groups. The viewpoints varied between

those that were in favor of teaching basic mathematical skills versus those that thought that teaching conceptual understanding and critical thinking was more important. However, what the public does not understand is that "it is not possible to teach conceptual understanding in mathematics without the supporting basic skills, and basic skills are weakened by a lack of understanding" (Klein, 2003, p. 2). In 1995, a group was formed to help parents that were unhappy with the new math program their children were being taught with called Mathematically Correct. Mathematically Correct has a large role in 1997 in helping California to create new math standards (Klein, 2003)

Mathematically Correct helped to coordinate the input and instruction from mathematicians in the development of the new standards and framework for California during the 1990's. These standards and the framework that accompanied it underwent a lot of public scrutiny as well as comparisons. In 1998 an independent review of 46 states' math standards was conducted by a foundation and it was found that California's math standards scored the highest. The score was then compared to the standards taught in Japan and the California Standards still exceeded them (Klein, 2003). The new standards were hailed by the community and public for their focus back on the basic skills, but were attacked by the educational community for the lack of "creative problem solving, procedural skills, and critical thinking" (Klein, 2003, p. 17). Eventually the criticisms died down and California continued to implement the standards and develop textbooks. The textbooks were developed through a joined effort of mathematicians and classroom teachers. The California math standards continued to receive criticism from across the nation, insomuch that the NCTM developed another document. This document was titled Principles and Standards for School Mathematics which was released in

April 2000. This new document helped to shape the standards and national mathematics education across the country.

Learning theories and Design Thinking. Design thinking (DT) is an emerging learning and instructional strategy used to assist students in obtaining the skills they need for 21st century learning and career development with a strong emphasis on problem solving (Hasso Plattner School of Design, 2012). Three theories correspond with the philosophy behind DT, which includes psychology based, philosophy based, and progressive learning theory. Psychology-based learning theorists believed that learning is a series of trial and error. Psychology-based learning theorists also brought a school of thought that investigated learning in stages that limit the amount and type of information that students are able to take in based on age. These theories provide evidence that all elements of the Design thinking (DT) process are not appropriate for all grade. Psychology-based learning theorists like Edward Thorndike, B. F. Skinner, and Jean Piaget provided a foundation of social interaction and cooperative team development which ultimately added to the future development of the design thinking paradigm (Hilgard & Bower, 1975; Steiner, 2014).

Philosophy-based learning theory developed around the thought processes that learning has more to do with experiences provided to children than the concept that children learn by pure luck. Design thinking's overall process is due to the historic contributions of philosophers such as John Locke (1632- 1704), who believed that children's' minds are blank slates that are shaped by experiences and interactions (Hergenhahan, 1976); Jean-Jacques Rousseau (1712–1778), who believed that children are naturally curious about the world thus needing to explore and interact (Hilgard & Bower, 1975); and Immanuel Kant (1724–1804), who believed that knowledge can exist prior to experiences though the link of the mind and thinking (Hilgard & Bower, 1975).

These philosophers added perspectives on prior experiences, explorations, and interactions toward the conceptual development of design thinking (Elias & Merriam, 2004; Hergenhahan, 1976; Hilgard & Bower, 1975; Monroe, 1925; Zieber, 2006). Psychological and philosophical learning theories gave way to progressive learning theory and Problem-Based Learning (PBL), which align closely with DT.

Current learning and instructional practices are rooted in philosophical learning theories. Problem Based Learning (PBL), one of the most prominent instructional practices, uses philosophical learning theories (Savery & Duffy, 2001). Trinter, Moon, and Brighton (2015) define PBL as a process that utilizes inquiry to explore curiosities, uncertainties, and to answer questions. Using PBL in classroom instruction, students become self-directed, curious explorers who solve problems, gain collaboration skills, and develop their own meaning for their learning (Hung, Jonassen, & Liu, 2008). Studies have shown that secondary students benefit from PBL instruction by retaining more of the content they focus on (Dods, 1997; Gallagher & Stepien, 1996; Liu, Hsieh, Cho, & Schallert, 2006; Senocak, Taskesenligil, & Sozbilir, 2007). Project-based learning (PBL) is the foundation of design thinking (DT) as DT requires action and direction often through the use of a project.

Progressive Learning Theory. Progressive Learning Theory (PLT) directly focuses on the thinking, reflective, and experiential learning development of children. The philosophers that identify closely with progressive learning and design thinking (DT) include Joh Dewey, Maria Montessori, and Jerome Bruner. John Dewey was one of the first theorists to help define Progressive Learning Theory. Dewey's work presents student learning as influenced by the learner's experience and environment. He believed teachers needed to create environments that encourage self-directed learning such as in laboratory experiences (Wirth, 1966). As Dewey

wrote, “when education emphasizes the experience of students and learning is viewed to be a social process, the situation changes radically. The teacher loses the position of external boss or dictator but takes on that of a leader of group activities” (Dewey, 1938, p. 59). The design thinking model uses Dewey’s progressive method, as the teacher becomes the facilitator of the learning activities and guides students through the design thinking process. The learners direct the activities and experiences while teachers help learners to meet goals and deadlines (d.School, 2010).

In 1998, Maria Montessori introduced a new educational concept that allowed students the freedom to explore as the main component of learning development. Her theory also changed the main role of the teacher from a “knowledge authority” to a guide for student learning, which allowed the students freedom to express themselves. Montessori found that when students were not told exactly how to prove their learning but guided through options, their creativity and freedom were more readily expressed (Connell, 2013).

Jerome Bruner expanded the progressive theory of learning to include the concept of disciplines within education. His philosophy centered on guiding curriculum development to connect with a child’s development to the experiences presented. Bruner’s approach to learning included a spiral curriculum that continually helped students drive deeper and deeper into content as the student matures and cognitive development increases (Hilgard & Bower, 1975). Traces of the work by both Montessori and Bruner are noted in the design thinking (DT) model as learners probe deeper to explore ideas and solutions (Carroll et al., 2010).

In DT, the students are often encouraged to define their own learning path and their learning is spiraled or integrated throughout the process. Students start learning when they search for problems to solve and they continue learning through the empathy stages followed by

prototyping, testing, and reflecting stages. Through the DT process, experiential learning is 'looped' or continually integrated throughout the process and guided by the students' interests (d.School, 2010).

According to Smith (2013), "Double-loop learning" is attributed to the Progressive theorist, Chris Argyris. Double-loop learning focuses on targets for learning or growth followed by the actions needed to meet the targets. Double-loop learning starts with the target or end goal of learning, such as a particular math skill, then the teacher provides the needed to get a student to the goal. After assessing if a student met the goal set for them, new steps are taken to help them meet the goal if it was not met, this making it double-loop. The classroom and learning experience for students are then implemented and assessed. After the student is assessed on the skill, more learning or actions are put in place to further support that the student has mastered the skill (Tagg, 2007).

Within the classroom environment, Double-loop learning is often observed when students start with a large learning objective and cycle through the learning process (more than once) until they reach mastery. For students to master a concept using Double-Loop Learning requires a large amount of reflection. The students may make mistakes using this cycle. In education, it is important for the students to understand the process of failure. The "failure process," or the process by which students realized that every time something fails it is an opportunity to grow and learn, assists students to learn what did not work and to develop a way to continue learning from those lessons (Dweck, 2008). In learning theories and design thinking methods, looping back to the goal and outcomes is progressive and it promotes cognitive growth. Design thinking (DT) contains many of the same components of Double-Loop Learning especially the concept of reworking a process until a final, workable product is completed.

Design thinking. Design thinking (DT) is a newer concept than the learning theories previously described; however, it does combine the elements and thought processes from philosophical, psychological, and Progressive learning theorists. The difference is that DT is not a learning theory but an instructional philosophy and methodology. Kelley and Kelley (2013) define design thinking (DT) as a methodology that utilizes the mindset and creative tools of the user to meet all kinds of life challenges.

Lichtman (2014) takes Kelley and Kelley's definition further and aligns it with the world of education by stating:

> Design thinking is a way of organizing the thinking process that increases the generation of ideas and breaks new ground or the old ground in a new way. Design thinking is a set of tools that is naturally familiar to young students, because it aligns with how they think and allows them to put their ideas to the test and practice. (p. 152)

For this research study, DT will be defined as, a process that allows students to solve problems focused on the needs of others and finding innovative solutions.

History of Design Thinking (DT). DT contains parts of the three learning philosophies. Beyond the connections to these theories, the history of design thinking can be traced back to the 1960s in participatory design. Participatory design was in use until about the 1980s (Russo, 2012). Flaws were found in this method user-centered design including the extent to which a product can be used by specified users became more prevalent. User-centered design was the main strategy used in problem solving until the 1990s when service design became the new model. Service design, keeping the needs of others in mind when designing a product, eventually merged with Meta-design until 2000 when human-centered design took over (Russo, 2012). All

these steps helped experts and educators began the process to mold the DT model into the method used today.

Participatory design to current design thinking. Participatory design is defined as a system designed in which the user plays an active and empowered role in the creation of a product or experience (Steen, 2013). Participatory design is primarily used with computer programming projects and often it centers on making sure the end users of the program had input into the design in order to ensure their needs were meet. Some of the qualities and skills that participatory design helped its creators to develop were cooperation, curiosity, and creativity (Steen, 2013). When applied to education today, these same qualities exist in design thinking (DT).

Two main contributors to the participatory design method were Herbert Simon and Horst Rittel. According to Harter (2014), Herbert Simon's focus centered on "the way that human beings reason together in organizations. His conclusions pertain to understanding strategies of innovation" (p. 249). His contributions to participatory design have helped many people to change their current situations or contexts in order to improve their own situations (Barros, 2010; Chick & Micklethwaite, 2011; Harter, 2014).

Horst Rittel brought argumentation or creative conflicts into the design process though the ideation process. The ideation process is seen as brainstorming and coming up with as many solutions as possible (d.School, 2010). Rittel realized that complex problems could best be solved in cooperation and with deep, valuable argumentation. His work and views regarding the design process helped him develop the current ideation process but in a much less argumentative way. His work has allowed current design thinkers to see the value in deep, cross-discipline

collaboration (Rith & Dubberly, 2007a; Rith & Dubberly, 2007b). Ultimately, Participatory Design helped to contribute to the science and social collaboration we see in DT today.

User-Centered Design. When looking at how participatory design shifted to User-Centered Design by the inclusion of the end user in a significant role, rather than as tester for the usability of a product and more about their needs and interests in the products. The International Standards Organization (1998) defines usability as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (p. 9241). The challenge for this definition is the ability to say with absolute certainty that one product or idea has more usability than another (Bias, Larty, & Douglas, 2012). The idea that the user's needs is a major concept of design thinking (DT) today and is at the forefront of DT, yet all ideas are on the table to assess a design's usability.

The major contributor to design thinking (DT), and often coined as the Father of design thinking, is Donald Norman. Donald Norman believed the design process should be visible and transparent so that the user is part of the solution to any problems that may arise. Norman's main contribution was the form of communication and the language used in design including the use of technological language in user-centered design (Zachry, 2005). Significantly, the origins of Ideation in design thinking (DT) and the systems of mental models and mapping are apparent in the work of Norman (Zachry, 2005). In the classroom, mental models are often seen in outlines, mind maps, and graphic organizers. These processes and models are familiar to teachers, however applying them to the process of design thinking (DT) will require some training and testing.

User-centered design was viewed as the main design process until about 1990. Meta-Design design, or designing with multiple points of view and teams built upon different strengths

or departments, helped bring in empathy and the reflection stage to design thinking, as we know it today. In the 1990's meta-design was ushered in mainly by Ezio Manzini. The focus of meta-design is collaboration within interdisciplinary teams (Manzini & Rizzo, 2011).

Meta-design. The transition from user-centered design to meta-design shifted the viewpoint on the process of design. The user and their needs are still part of the process in Meta-Design however collaboration and building teams become a higher priority. Ezio Manzini was a designer who focused on creating creative communities of people to expand ideas and use their diverse perspectives to solve complex problems (Manzini, 2014). Manzini helped usher the design into a social platform. Solutions to social issues were first developed by interdisciplinary teams using design-style process (Manzini & Rizzo, 2011).

Meta-design helped bring service design, or the process of designing for service that people use, into design systems bringing the user into the forefront. Meta-Design did however bring interdisciplinary teams and and collaboration to the current design process. Service design continued to use teams and collaboration but more concentartion was placed on the customer's expereience. More importantly service design focused on how the user interacts with a product as well as what the user does or feels about the product or expereince. This shift provided an inquiry approach to problem-solving (Kimball, 2011). In educational design thinking, service design brought the problem finding and defining focus steps to the design thinking process.

For middle school teachers, the shift from teaching in isolation or possibly from a single content area to one of true cross-cultural collaboration is new. Teachers will need the proper guidance, time, and training to be able to collaborate with other content areas on projects or concepts. Students will also struggle through the process of effective collaboration. Teachers

will need to develop plans and build the skills necessary for the collaboration that design thinking (DT) requires.

Human-centered design. From Participatory Design to service design models, each contributed to some element of design thinking and Human-centered design is no exception. For years, user-centered design and Human-centered design were used interchangeably and most people saw them as the same method; however, the two are quite different in focus. User-centered design focuses primarily on the experience with the end product or 'experience', whereas human-centered design focuses on the social system and improvements to the systems that people interact with along with a major focus on empathy. Human-centered design ultimately changed the mindset of designers and brought the cognition of others into design (Russo, 2012).

Design thinking evolved from this mix of learning theories and design elements. Each element of the process is rooted in history and is explained in the following sections. The historical connections will be brought back into the discussion for reference.

Design thinking process. Design thinking is viewed as both a mindset and a process to solve complex, real world problems. The process and model that design thinkers follow contribute to the success in problem solving. Research shows that there are several popular models of design thinking that have become the basis for most programs and businesses. A design problem keeps changing while it is treated, because the understanding of what ought to be accomplished, and how it might be accomplished is continually shifting (Lichtman, 2014).

Brown (2009) referred to as overlapping spaces and activities such as inspiration, ideation, and implementation. His model used a Venn diagram graphic to show where each of

his three spaces overlap to create innovation and problem solving. Brown (2009) calls the intersection of the three spaces as the sweet spot or experience.

The process or model that will be used for this study includes six main steps that are widely accepted by those who use design thinking (Kwek, 2011; Liu, Hsieh, Cho, & Schallert, 2006; Russo, 2012). These steps include empathy, defining the focus, ideation, prototype, testing, and reflection. Each of these steps are necessary parts of the design thinking process with roots founded in theories and eras of history.

Empathy. Empathy is the starting point for most design thinkers. Empathy is focused on the needs, desires of the user before ideas are generated and a solution is made. Empathy can be traced back to user-centered design and human-centered design. User-centered design brought about the focus on the user at the end of the process, which is important for reflection, while human-centered design helped bring empathy to the beginning of the planning. IDEO partner Chris Fink (as cited in Kelley and Kelley, 2013) stated, "We find that connecting with the needs, desires, and motivations of real people helps to inspire and provoke fresh ideas" (p. 22) which is vital to both businesses and education organizations.

In education, empathy has become a significant part of the instruction in many history classrooms in the United States. Brooks (2009) discussed the interest social studies teachers have in using historical empathy because it allows students to identify and infer from the evidence and viewpoint of those who participated in the historical event more than just remembering the dates and facts of the event. Empathy stems from seeing other people's points of view, their beliefs, and goals. Many teachers use debate and writing to build feelings of empathy in their classrooms. For many educators, historical empathy seems like a natural fit; however, Blake (as cited in Brooks, 2009) extends the concept of historical empathy to one that

involves “a range of skills, insights, and feelings, which are commonly applied in any field of study concerned with the knowledge of the other” (p. 217).

Most middle school students in grade levels six through eight are not naturally empathetic. Most middle school teachers and administrators can tell you from experience that students in these grade levels often do not think that their actions affect others. Empathy is contrary to the normal culture in middle school, but making the shift allows for creativity and problem-solving to excel (Brooks, 2009).

Defining the focus. Design thinking (DT) focuses on the needs of a user to solve a problem. One way to accomplish this is by having the student use the information gained in the empathy stage of the process to focus on only one aspect of the problem to solve. At the end of this stage of the DT process a statement, called a Needs Statement, is created that helps to guide the student to develop a variety solutions they ideate and prototype. Stanford’s d.School K–12 Lab discusses a ‘needs statement’ as way to put to user first because the focus is on the users’ needs not just any solution (Hasso Plattner School of Design, 2012; Kelley & Kelley, 2013). This step in design thinking process brings a uniqueness to a classroom and is an invaluable tool. It develops a focus beyond the student and brings in the real world. The first step to a ‘needs statement’ is to identify the user. The user can include another student, someone in the community, a character in a novel, a historical figure, or even someone in another country. After the student identifies the user, they need to focus on the user’s needs. The needs of the user come from the empathy that the student gained. The needs portion of the statement should really dig deep into the emotions of the problem and need based on the empathy that was gained. Lastly the student defines the problem they are going to try and solve (Carroll et al., 2010; Hasso Plattner School of Design, 2012). In most K–12 design thinking classes, students are given a fill in the

blank template like that of figure 3 (Hasso Plattner School of Design, 2012). This process helps focus the problem and creates solutions. Figure 1 below is an example teachers often use to help students indentify their focus of the problem they are looking at solving. Providing students with a template for this step of the design thinking (DT) process like the one below helps narrow the focus. The d.School at Stanford explain that this step is often the hardest for students to complete successfully but without it the process often fails because the true problem has not been identified.

_____
(user)
_____ so as to/because
(user's needs)
_____.
(surprising insights / underlying problems).

Figure 1. Mad-lib used with students for Defining the Focus (Used with permission)

Ideation. Ideation is typically seen in education as brainstorming or as concept generation (White, Wood, & Jensen, 2012). In design thinking (DT) ideation is about quantity mixed with quality, or the more ideas that a team can generate the more likely it is that a new approach or concept will be created. Brainstorming is a tool that is found in almost every classroom in the United States and is not a new or novel idea. A study conducted by Isaksen and Gaulin (2005) studied successful brainstorming methods with students and concluded that there are many different elements needed in order for brainstorming to be part of a larger problem-solving process. It must include a facilitator for the success of the brainstorming session, and it must use brainstorming is both an individual and group process. When students are engaged in both group and individual brainstorming that was structured the study showed that an increased

number of solutions to a problem were produced when compared to groups without structure and training in brainstorming (Isaksen & Gaulin, 2005).

For design thinking (DT), ideation uses many of the brainstorming concepts discussed previously. Students use both individual and group brainstorming. DT does not use a facilitator to produce ideas, but instead focuses on a process for brainstorming and contributing to the ideas of others. One of the main rules of ideation includes the deferment of judgment of other students' ideas along with encouragement to "become silly, savvy, risk takers, wishful thinkers and dreamers of the impossible… and the possible" (Carroll et al., 2010, p. 40). Stanford's d. School discusses the why of ideation as being powerful in increasing innovation, creating a volume of ideas as well as a variety of ideas, and the power of ideation to drive the team beyond the obvious (Hasso Plattner School of Design, 2012). One defining factor of ideation and its success in DT is the eclectic mix of participants during the ideation phase. A diverse group of people from either a variety of disciplines or students that have different points of view or backgrounds allows ideation and ideas as diverse as the group involved (Carroll et al., 2010; Goldman, Kabayadondo, Royalty, Carroll, & Ruth, 2013; Hasso Plattner School of Design, 2012; Kwek, 2011; Liedtka, 2014; Martin, 2010). These changes help make the DT ideation stage different from standard classroom brainstorming. In ideation classrooms whiteboards, sticky notes, and even electronic boards are used to house and organize ideas into mind maps, sketches, or graphic organizers (Hasso Plattner School of Design, 2012; White, Wood, & Jensen, 2012).

Prototype. Creating a prototype is at the heart and soul of design thinking (DT). A prototype is anything that a user can interact with and can include a post-it note, paper, or tangible product (Hasso Plattner School of Design, 2012). One part of the process that set's DT

apart from so many other strategies in the classroom is the bias towards action (Hasso Plattner School of Design, 2012). Purdy (2014) discusses prototypes as being necessary to gain insight and to begin the process toward a solution. Prototyping starts as low resolution, or prototypes made from easily accessed materials like paper, cardboard, and tape, for students so they can create more than one prototype as a team. Many educators that teach mathematics or language arts look at prototyping as physical products that lend itself to science or history. When the concept of prototyping is utilized the possibilities extended to mathematics and language arts can produce amazing prototypes. Prototypes typically are seen as physical products, however in education they can be essays, character analysis, new ending to a novel, a presentation, or debate (Hasso Plattner School of Design, 2012). Carroll (2014) discusses the need to develop a "prototyping mindset" (p. 1). Many students struggle with the ability to see a product as a learning point when it fails or does not work the first time. It takes a shift in school culture and student mindset to allow failure and to change the mindset for successful prototyping.

When educational institutions wish to change to DT or to start prototyping, they create a "maker space" to allow for prototyping. Maker spaces are often areas on campus that house different construction and artistic materials, including those considered by many people to simply be trash. In a study conducted by Kurti, Kurti and Fleming (2014) they found that maker spaces are places that encourage creativity and deeper learning, allow students to take ownership of their learning, and spaces that do not require technical experts to supervise them. More specifically "maker education and educational maker spaces leads to determination, independent and creative problem solving and an authentic preparation for the real world by simulating real-world challenges" (Kurti, Kurti, & Fleming, 2014, p. 11). Taking maker spaces to the next level

allows DT to spread to multiple content areas and to expand the success of prototypes beyond the physical objects that are typically produced by the designers.

Test and Reflect. Educational testing in education has developed the reputation of being summative in nature. Standardized tests were defined as "a test designed to yield either norm-referenced or criterion-referenced inferences, that is administered, scored, and interpreted in a standard, pre-determined manner" (Popham, 2011, p. 308). A process that often involves multiple-choice questions, paper and pencils, and one overall score. These tests typically take place over the course of one or two days. Standardized tests are not the type of testing that DT uses. Testing in DT focuses on feedback from the user. If the prototype is not a physical product, testing the solution can occur through multiple creative means like peer feedback or an analyzation of a scenario of an event (Hasso Plattner School of Design, 2012). The main goal of testing is to empathize more with the user and to allow the solution to be refined through reflection.

DT in education looks different from other DT processes like those used in business because of the use of reflection. Muir et al. (2014) defined reflection as "a form of practice which seeks to reappraise many situations of professional performance to that practitioners can continue to learn, grow and develop in and through practice" (p. 25). In classrooms, teachers will often use reflection to help students develop an understanding of their work and ways to improve. Reflections can include peer reviews, self-evaluations, interviews, questioning, and journaling are the most common forms of reflection in education today (Costa & Kallick, 2008). design thinking (DT) takes all the elements of reflection seen in education and combines it with industry reflection for refinement. Reflection combines the professional definition calling for

growth and development with the educational viewpoint of reflection for complex learning and connection.

Current research on design thinking in education. The exact time that design thinking (DT) entered into the field of K–12 education is unknown. Although the philosophies have been traced back to learning itself, steps for critical thinking and problem solving have not. The first elements of DT in education come from the d.School at Stanford. It was there that David Kelley took his success of using DT at his firm IDEO to Stanford to help his students become innovative and expand their learning in their chosen fields. The same concept has now started to appear in K–12 education (Kelley & Kelley, 2013).

During the research phase of the study, four major studies have been completed on DT in education, along with websites and companies like Lime Design (Carroll et al., 2010; Cupps, 2014; Kwek, 2011; Russo, 2012). The first study looked specifically at DT in undergraduate work, whereas the other three looked specifically at DT in K–12 education. A second study focused on the same grade levels as this study, and one focuses on an elementary school district. Each study utilized DT in slightly different ways and for different reasons. One study utilized the DT process to innovate a new vision and path for a school district. A second study created a course in design thinking (DT) for college sophomores and juniors to allow them the skills needed for collaboration and problem-solving leadership. The third study focused on the motivations of middle school teachers to adopt DT along with how it is used in core content learning. The fourth study most aligns with this study looking at the role DT has in a middle school classroom including the connection DT had to core content learning.

In the study by Cupps (2014), DT was taught as an individual course in college to help prepare students for collaboration and problem-solving leadership skills needed for success in

any career field. This study looked at the constraints, basic pedagogy, and the syllabus needed to teach DT to students not in design-oriented majors. The study lacks the use of student quantitative data to show the success of the unit that was created. The study also lacked an assessment method for student work. The development of skills and elements needed for a class in DT to be successful was provided in this study. Those elements include allowing students to explore where needed in the steps of the process. Learning of DT should not be linear in fashion and the problems presented needs to be "wicked" in nature or within the scope of natural learning (Cupps, 2014).

Campos (2011) conducted the second major study in the field of design thinking (DT). In this study, the researcher focused on how the DT process was utilized by a team in the district to help transform the district to try to meet the 21st century skills student need to be successful in college and careers. The study reported that the use of DT for innovation focused the team and changed many of the participant's mindsets. The team was able to produce prototypes that included project-based learning, technology in all schools, design learning, and a common vision for teaching and learning for the district. The study did reveal that DT has to be taught to teachers in a manner that allows them to see beyond giving students materials and asking them to produce a solution to a problem, and more as a process that integrates communication, collaboration, problem-solving, and creativity in anything taught. The study found that too many teachers were frustrated at the thought of teaching design thinking (DT) in their classrooms because of the lack of proper training (Campos, 2011).

A study conducted by Kwek (2011) using DT for 21st century learning focused on a middle school that integrated DT into the content and culture of the school. The study focused on three main areas which included the key considerations teachers have when using DT, how

the considerations affect or influence the use of DT in the classroom, and how DT connects with the academic content. The study found that DT increased student motivation by allowing students to feel successful and confident in their learning. The students had to utilize DT in a variety of ways and in different degrees for successful implementation. Lastly, DT was seen in in classrooms as an activity only labeled as DT, (one-step of the process used), or in a multidisciplinary project. The importance of school leadership in the transformation to DT instructional methods in the classrooms emerged as an outcome of the study. The researcher emphasized that school leadership needs to model and support the learning curve of teachers for DT to be a success (Kwek, 2011). The study did not include any quantitative data to show the academic success of using DT in core content areas.

The study by Carroll, Goldman, Britos, Koh, Royalty, and Hornstein (2010) focused on the implementation of DT in middle school classrooms. This study used university instructors to create interdisciplinary curriculum using DT. This study discussed how students expressed understanding of DT through classroom activities, how affective elements affected DT in the classroom, and how DT connected to academic standards and content. The study found that students are able to grasp the elements of design through classroom activities and that students used specific vocabulary but a variety of approaches to projects. The study also found that DT helped students gain the needed skills and is a tool for metacognition. DT is able to build the capacity for students to understand the process of learning itself. The study also found that DT helped to foster collaboration, gave them voice and choice, and allowed for powerful engagement. More importantly, the study found that the curriculum did not allow for the connection to core content standards while using the DT process. The lack of connection seemed to come from the lack of the geography standards and content by the instructors that created the

curriculum as well as the lack of value the teachers saw in using DT. From this study, the importance of DT properly integrated into core content and not used as a stand-alone process is highly important.

Two critiques of this study (Carroll et al., 2010) are that it was only conducted in one charter school and the teachers did not have complete control over the units and curriculum. As a charter school, the school had more control over what was taught and how it was taught. Lastly, this study only integrated geography standards and it did not look at major core content that is tested like mathematics, language arts, history, or science. These critiques are a call for more in-depth research in DT in which teachers have the opportunity and expectation to integrate DT into core content. The need for more classes and a larger sample size in a study is also needed for the success of DT as a problem-solving strategy in classrooms. This study, in part, is also a response to these two critiques and will consider these critiques and provide teachers with the opportunity and requirement of collaboration and control over their units as well as enlarging the sample size in standard public schools.

Watson (2015) conducted a study in his own art classroom in which he intentionally taught a version of design thinking developed by Nick DiGiorgio. This process is similar to the one used in this study with the exception of the titles of each step. Watson used a six-step process including ask, imagine, design, build, evaluate then either refine or share. This process was taught to high school art students, then students evaluated and gave their perspective on design thinking and if it was relevant in their lives. Watson used observational skills to conclude that most of his students found design thinking (DT) as a useful strategy to "make sense of ambiguity, to emphasize with others, to think creatively, to communicate ideas, to collaborate, and to make people laugh" (Watson, 2015, p. 18).

One of the students in the study was taught the formalized process that she used naturally in art and applied it to her work. She was able to raise $13,000 for a charity using the design thinking process she learned in her art class and states without it she would have given up if it weren't for understanding DT. Another student reported that knowing the process and concept of DT allowed him to take on complex projects at home like building a golf cart. The study showed that students who learned about the DT process did indeed transfer it successfully to other aspects of their lives. Most students reported that their outlook and perseverance towards a hard problem or task in which they would naturally get stuck and give up changed for the positive (Watson, 2015).

In a study conducted in an entrepreneurship environment using a similar process to design thinking (DT) called DesUni. In this process entrepreneurship students were taught to use the DesUni process which includes five questions students ask themselves as they explore business options including "why, for whom, for which results, what, and how" (Nielsen & Stovang, 2015, p. 982). The authors believed that this process could be applied not only to entrepreneurship education but to differing levels of learning and subjects. These five questions are similar to the steps of DT and were derived from the DT model. What the study showed was the model of learning transformed the education of students studying to be entrepreneurs from rational to reflective. The authors believed students in all disciplines and levels could benefit from similar processes.

Purdy (2014) used design thinking and the concept of design to analyze an approach to writing studies. The start of the study was to analyze articles that either contained design in the title or design within the article. The analyzation showed that teacher-scholars used design to plan or structure their writing, compose writing as multimodal or the use if text features as

words, to recognize different formats of writing including multimedia, to draw attention to writing practices, and to bring into discussion academic disciplines. Not all of these design terms used the process of DT as their focus on design. The process of DT that the researcher used in this study included to understand, observe, define, ideate prototype and test. The researcher aligned these steps to the writing process as follows with the DT process listed first and the writing process step listed second: Understand to research, observe to question, define to analyze audience, ideate to brainstorm, prototype to write rough draft, and test to share and revise.

In a specific example the researcher gave the focus on the element of empathy within the writing project was emphasized. The subjects used the DT process to help develop a project called SOS. This project specifically focused on English Language Learners and the Common Core State Standards (CCSS). The subjects started their design through empathizing with ELL students and their capacity to identify culturally with their peers. They then defined the need of these students in regard to digital literacy, ideated possible solutions to help this target group then prototyped a multimodal solution and tested them on ELL students in the fourth and fifth grade. The end product was a new curriculum that has been shared to multitudes of teacher to address standards of writing within an inclusive classroom. Overall, the study showed that writers who are aware of the DT process and utilize the steps in writing both individual projects as well as curriculum the end product can transform learning (Purdy, 2014).

The field of graphic designers have also looked into ways in which to use the process of design thinking (DT) for graphic design students. One study looked at the use of creating Interactive Museum exhibits using the DT process for their graphic design students. Students in the project are first introduced to Dewey's theory on experiential learning. They explore

multiple intelligences in order to understand all the different ways people learn. Next students visit museums to gain empathy of observe people interaction or lack of interaction with exhibits. Next students are introduced to different mediums of interactions including "role-play, create and build, search and discover, demonstrate a principle, test your abilities, and explore emotions" (Fontaine, 2014, p. 50). Students then move to the ideation phase. In this phase, the students generated ideas on different interaction mediums and develop three proposals. Each proposal had to focus in the interaction types as well as the learning outcomes associated with the exhibit. Once one of the proposals are chosen each student then create a prototype for guests to interact with. They had to test their prototype with family and friends to gain feedback. The researcher was able to conclude that students who went through this design thinking challenge were better suited to be creative and unique graphic designers in the field because the experience taught the students that focusing on user needs and not just the product itself.

The current research has focused primarily on upper education and different industries that it can affect. Limited amount of research has been done to look into the applications of K–12 educational experiences and learning using design thinking (DT). What the current research shows is the expansion of the problem-solving method and that most of the research is geared towards the perspectives of the users of the method. These perspectives have allowed the growth of DT into industries and post-secondary education.

Research on growth mindset. Problem solving and the design thinking (DT) process can only be successful when students have a clear understanding of the growth mindset. Carol Dweck started her research and work on a concept she called Growth Mindset. This concept stresses that success comes from the "belief that your basic qualities are things you can cultivate through your efforts" (Dweck, 2008, p. 7). Studies have shown that students lose the ability to

view their learning through a growth mindset at an early age which causes an increase in high school dropouts as well as a decrease in the percentage of high school students that are eligible to attend four year universities upon graduation (Bedford, 2017; Bettinger, Ludvigsen, Rege, Solli, & Yeager, 2018; Yeager et al., 2016). Developing a growth mindset in students has proven to help with mathematical success as well as in the transition to high school.

In a study conducted by Yeager et al. (2016) researchers looked at the use of design thinking to improve growth mindset through asking the simple question "is it possible to take an existing, initially effective psychological intervention and redesign it to improve the outcomes for a population of students undergoing a similar life transition?" (p. 389). The study looked specifically at the use of design thinking strategies to increase middle school student's growth mindset as they transition into high school. The study found that using an intervention method in which students are given an article to read and analyze on growing intelligence then asked to repeat it to others. Researchers came up with variations of the article including articles that either explained why it is important to grow their intelligence gave them to different groups of students. After each group was given the articles they were asked to either just restate what they read and learned or to contribute information to help other 9th grade students. The data gave insight into the effectiveness of both methods and found that asking students to contribute for other students was more effective of a mindset intervention than just simply having student restate what they read had a greater impact. The second focus of the study was looking at the effects of using the growth mindset of the grades of 9th grade students after each intervention type. The overall success of using a design centered or design thinking approach to help students develop a growth mindset through asking them to design and contribute to information that will help other 9th grade students on grades of previously poor achieving students was noted.

A second study conducted by Moser et al. (2011) looked at the link between corrective feedback and a growth mindset. The study used error positivity in conjunction with brain scans to determine how positive error corrections changed the brain output. The study found that people who currently have a growth mindset was "associated with enhanced attention to corrective feedback following errors and subsequent error correction" (Moser, Schroder, Heeter, Moran, & Lee, 2011, p. 1487) . The results of the study showed that a growth mindset can be enhanced and taught and using error positivity strategies. Participants in the study were better able to adapt to their errors because of a growth mindset.

A third study conducted by Bedford (2017) focused on the development of a growth mindset for student in secondary education specifically in the area of science. This study focused on using a 10-week intervention program with science students to develop a growth mindset. The intervention program specifically targeted the motivation in 5 categories including self-efficacy, task value, learning goal orientation, self-regulation, and learning environment. The study found that students can overcome a lack of prior attainment in science classes by developing a growth mindset and thus changing the motivation of students through their learning environment. Students in the study were able to identify that task value is the greatest lack in secondary science classes and that focusing on the value of each task they are learning helps to stay motivated in the content area.

A similar study was conducted in Norway focusing on mathematics as the subject. In this study researchers investigated how schools used mindsets with students to increase students' perseverance in math. The interventions that the researchers developed and used included three online sessions in which the first two were interventions on growth mindset while the third session asked to students to solve a series of algebraic questions. Overall the study was able to

provide evidence that for students who have a fixed mindset or who are previously low achieving can be changed and an increase in their success in mathematics can be seen.

All of these studies show that growth mindsets have an impact on student achievement and success. These studies also show that mindsets can be grown and changed over time. Through the use of one intervention method or another, students who are low achieving can show an increase in success through the development of their mindset. Design thinking is shown to be one of those concepts that help to grow a student's mindset and success in school.

Research on Common Core State Standards

The Common Core State Standards (CCSS) were developed by for multiple reasons. The first major change that CCSS brought to education are standards for college and career readiness. Research has shown that there was a disconnect between K–12 education and the requirements needed for success in college. To help improve post-graduation education rates, a change in K–12 education was needed (Jones & King, 2012; Smith & Teasley, 2014). The California Department of Education identified students being ready for college in English Language arts as students who can "demonstrate independence; have strong content knowledge; respond to the varying demands of audience, task, purpose, and discipline; comprehend as well as critique; value evidence; use technology and digital media strategically and capably; and come to understand other perspectives and cultures" (Common Core State Standards Initiative, 2015). CCSS shifts to fewer standards in both English Language Arts and Math, but adds rigor and the 4 Cs of creativity, critical thinking, communication, and collaboration.

The Common Core State Standards (CCSS) have many negative critics. Past educational standards as being mediocre and without positive results (Bleiberg & West, 2014). NAEP test scores have yet to result in a strong connection to the rigor of the standards of the past as well as

student achievement. CCSS was designed with “teacher, researcher, and pedagogy expert feedback” (Bleiberg & West, 2014, p. 4) and difference in student outcome is predicted to increase and change.

Review of Methodological Issues

In a review of the literature, one of the issues that kept arising is the shortage of research on design thinking (DT) as this stragetgy is a newer area in education. Thus, this literature review will look at the process of learning, the theories that have been used in education to date, and a history of the DT process. The literature was reviewed in order to build an overview of learning and a basis for why DT could be used in the educational setting. The literature was also reviewed to allow an understanding of the process itself The focus of the literature review utilized existing literature spanning from 1925 to 2016. The majority of research pertaining to design thinking was taken from studies conducted within the past few years. Johnson (2010) provided the context that "non-experimental research is frequently an important and appropriate model of research in education" (p.3). The use of a multiple case study in qualitative research provides the needed lens for this type of research.

In qualitative research interviews, observations, field notes, and focus groups are often used to gather the needed data. Cupp (2014) used interviews, observations, exit surveys, and personal reflections in the study looking at transdisciplinary design thinking in early undersraduate education. This study lacked a cohesive thread to tie all of these elements together. The use of personal reflections and insight as part of the data also makes the qualitative data less credible. Campos (2011) looked at DT being used by a district administration to help meet the needs of the students in 21st century skills. Campos used similar methodology as Cupp

including semi-structured interviews, observations, and document analysis. The methodology produced the needed data for the study.

Kweck (2011) conduced a study looking at DT in the classroom using methodology similar to the other DT studies including observations and interviews. The interviews were conducted as formal interviews. Using a formal interview process does not allow for question flexability as well as limits the entire scope of the participant. Formal interviews did however provide the exact needed data needed from the researcher but limits the interviewee to the information and personal viewpoint they are able to provide. Carroll et al. (2010) conducted a study in which the researchers observed middle school geography students learning DT through the use of university students. The methodology used in the study was observations, video recordings, and notes taken by the observer. Within this methodology only observations were used to collect data which excluded other methods to keep the bias and complete overview of data they were trying to show.

Qualitative research methods often require extensive time and exposure to the research subjects. This study utilizes interviews and artifacts (Creswell, 2013). One issue with these methods is a lack of consistency, or opportunity to see if feelings or experiences change over time, as participants are only interviewed once. Only being interviewed once could possibly mean that participants may have answers that are skewed based on current mood or issues that may have happened that day. Using artifacts, such as reflections and lesson plans, to support their statements should help to overcome the single interview issue.

Synthesis of Research Findings

Starting with learning theories and moving into design thinking, the research has shown that in limited studies design thinking (DT) has shown promising results in an educational

setting. Taking the research from the beginning point of student learning then guiding it into different learning methods and phiolosphies has provided a guide into the concept of DT. Problem solving has been on the forefront of educational learning, but is being pushed to new heights with the addition of Common Core State Standards (CCSS). The research shows that DT may have a successful impact of students learning when applied in the classroom through continual use and repetition. Looking at the research surrounding DT, Common Core State Standards (CCSS), and Growth Mindset and finding the connections between them has set the stage for this study.

Critique of Previous Research

This study utilizes research on DT. Each previous research study has missing elements that are essential to innovation and transformation for Common Core State Standards and the success of students. Jean Piaget's work on stages of development shows that DT as a creative, critical thinking, problem-solving process is not developmentally appropriate for all students including those ages birth to eleven years of age (Hilgard & Bower, 1975). Children from birth to eleven are still working on the cognitive abilities to reason and think beyond themselves. Therefore, opponents of DT state that the strategy and tool should not be used in grades kindergarten through third. Elements in DT may be developmentally appropriate to use in those grades but not the entire process as a whole cycle. Prototyping can be seen in children ages five to eight who are developmentally capable of creativity based learning through observation, and exploration by creating something with their hands or devices (Lichtman, 2014).

Critique of research in design thinking. Currently there is a lack of research on design thinking (DT) in K–12 education. Past research has focused on district level changes using the DT process, or a small sample of populations that have implemented DT in some way (Carroll et

al., 2010). The missing piece in the current research on DT is quantitative data showing the connections or lack of connections to student achievement in core content. The studies also have not examined the methods teachers may need to use in order to learn what DT methods are or how to integrate these methods successfully into the fabric and daily curriculum of their work.

The current studies on DT also lack large sample sizes. This study will take into account the sample size and ensure the use of multiple classrooms. Each previous DT school study has used single small school or classroom. One teacher may be well equipped or understand DT and be integrating design thinking (DT); but for an entire school to transition to DT may not yield the same results. One study was conducted in a charter school that might have been allowed to operate under a different set of regulations than public schools. Many charter schools run under different schedules, regulations, and resources.

The final critique is the lack of teacher selected curriculum in DT. Every current study in DT in core content has used outside university professors to write the core content using DT. The issues are the 'buy-in' and internalization that teachers must make when they are writing and collaborating within their own content and using the DT process to create their curriculum. That study (Carroll et al., 2010) gives insight to schools looking at using someone else's innovation but does not look at how to train teachers to create their own curriculum or to integrate DT into their current curriculum. More research is needed in the area of DT as a process integrated into content areas, not just a single content area. More research focusing on quantitative data from student achievement using DT (Kwek, 2011), especially research that shows the success that DT has on state standardized testing is also needed.

Summary

Change in education is inevitable, however, Fullan (2007) writes that people have to be willing to change, "If people were given a literal choice of change or die, do you think most people would choose change? If you said yes, think again" (p. 2). For administrators, the key is to help support teachers during the change process by giving them tools for success. Common Core State Standards (CCSS) has called for a shift in the focus of education from the era of 'multiple-choice learning' to creativity, collaboration, communication, and critical thinking. This educational transition has allowed teachers and school administrators to investigate new tools and strategies for teaching using the CCSS. One of the tools and methodologies that schools have started to explore is design thinking (DT).

Design thinking has been a process of collaborative problem solving in business for years. Yet, research studies on DT in education in have been small and isolated in nature. These studies have often looked at DT as a method for district leaders to use to create innovation and change in the district. Another study examined university-created lessons for DT in geography and its effectiveness in middle school. The last study looked at how well teachers integrated DT into a single subject content area. What is missing in these studies is a holistic and overall view of the experience of teachers that are utilizing and integrating DT into their core curriculum. This experience and perception of the success of the strategy can help other teachers and schools looking for new ways for students to meet the changes in standards.

Chapter 3: Methodology

Introduction

As standards and expectations for student learning change from No Child Left Behind standards to Common Core curriculum, students are being asked to critically think and problem solve. These new standards have caused many schools and teachers to look for problem solving strategies. Design thinking (DT) is one emergent strategy that might be used by education leaders. DT gives students a common vocabulary, process, and meaning to solving problems. As teachers and schools look to use this strategy it is important for their experience of integrating and transitioning into using DT to be understood. This study aimed to provide insight into the experiences of the teachers on the forefront of the strategy.

Research Question

Currently there is a lack of research in the use of design thinking (DT) as a classroom strategy integrated into core curriculum. With little to no research on the shared experience as a teacher trying to use DT as a problem-solving strategy, this study aimed to enlighten educational practitioners who might be looking at DT integration with an overview and essence of teachers who are integrating DT into their core instruction and curriculum. Using multiple case study research, this study will answer the following research question:

- How do teachers perceive the impact of design thinking strategies on a student's ability to meet Common Core State Standards (CCSS) in mathematics?

After thorough research into the changes in instruction and student outcomes needed for success in the Common Core State Standards (Russell, 2012), it is easy to identify the need for an instructional change. The use of DT in core content instruction will allow students the opportunity to develop problem-solving strategies around the Common Core State Standards

(CCSS) four main concept ideas of critical thinking, creativity, communication, and collaboration. After interviewing teachers, this study may show that teachers may identify an increase in empathy, a common language across content areas, as well as critical thinking skills in students. There may also be an increase in the frustration teachers face in trying to incorporate all aspects of the DT process into all content areas. Teachers may also identify a need for further collaboration time and professional development.

Purpose and Design of the Study

The objective of this study is to provide a holistic overview of the phenomenon of integrating DT into mathematics instruction for student success with the Common Core State Standards in meeting both its problem-solving and its 4 Cs of creativity, communication, critical thinking, and collaboration. By presenting the entire experience of the phenomenon, more schools and teachers will have the insight to make an informed decision to follow in the same path or to make changes to their current pedagogy. Many teachers lack the training and tools to teach to the new standards.

One instructional approach to help students learn the skills of critical thinking and problem solving for CCSS is design thinking. Design thinking (DT) has been used in business and industry for many years as a process to bring different viewpoints together to solve complex problems (Kelley & Kelley, 2013). Education leaders are beginning to see the benefits of using this process to help students develop real world problem solving skills in collaboration, communication, and critical thinking (Common Core State Standards Initiative, 2015). The purpose of this study was to provide the insight and experience of teachers integrating design thinking (DT) into middle school mathematic classrooms including the perception of mastery of the Common Core State Standards (CCSS).

The first element of the research design is the background, beliefs, and biases of the researcher. As the researcher, it is important for me to identify myself as a teacher and administrator. I have taught in California middle schools before the adoption of Common Core State Standards (CCSS) and the year after CCSS was adopted, specifically in the content areas of mathematics and science. This experience gives me personal insight into classroom needs as well as empathy for the transition students and teachers are undergoing. Along with the experience of teaching the new CCSS, I also have spent two years as administrator of a school as CCSS are being implemented. This background is important to acknowledge as it influences the focus of this study and may guide the study design and interpretation of the data.

Beyond being a classroom teacher and administrator, I have also been part of a school development team that opened a DT middle school. Researching DT in schools as well as developing the integration of design thinking (DT) in all aspects of instruction can bring a level of rigor to a school. In the development of the school, I gained a belief in DT as a process for student learning in middle school and gained interest in other teachers' perspective.

This study used a qualitative multiple case study design, specifically a multiple case study approach to the research question. Within the multiple case study model a unit on analysis is required (Yin, 2014). For this study, the unit of analysis is student mastery. Mastery has many definitions including the use of standards (Bloom, 1968). The use of Wiggins and McTighe's (as cited in Wiggins, 2014) definition of mastery will be the use of "complex, worthy, and valid tasks on which students must demonstrate high-level ability" (p. 11). A cross case analysis will then be conducted by comparing the teacher's perception of design thinking for meeting mastery in mathematics at each school site.

Creswell (2013) explains that there are five major approaches to qualitative research including narrative research, which focuses on the experience or life of a single individual; phenomenology, which describes experiences of a small group of individuals; grounded theory, which is used to discover or generate a theory; Ethnographic research, which focuses on explaining a culture or group as a whole; and case study research, which looks to explain a single case or problem. To explain the phenomenon of DT in classrooms from the viewpoint of teachers, a multiple case study approach is the most logical approach for this study. Within Multiple Case Study method there is a need for a common unit of analysis. The unit that was used in this study was mastery.

As a researcher, my background inevitably influences my philosophical assumptions, which guide my study. More specifically, ontology, epistemology, and axiology represent three aspects of a researcher's philosophical assumptions. The ontology for this study will include the experiences, backgrounds, and views of the teachers and administrators participating in the study. My belief is that reality only exists, as an individual perceives it, so my goal is to understand how the participants in this study perceive reality. The epistemology will be seen as the understanding and analyzing of the perspectives of the participants, which will allow their views to be taken into account as the program is implemented and evaluated. Finally, the axiology, or the value of the paradigm, is added to the epistemology to show what I value as a researcher. I greatly value real-world learning, students seeing solutions to problems, and most importantly using DT in classroom instruction. The experience that I have using DT in middle school, my eight years of classroom teaching, as well as my experience in developing and conducting professional development will add value to the study specifically in credibility that the teachers and administrators may see in the program (Creswell, 2013). My experience and

background enhances my expertise and should not influence how your research targets perceive, respond, value DT. This study is about teachers' perspectives.

When looking at the different qualitative sampling techniques, the best choice for this study is the use of criterion sampling, or the use of a specific criteria to choose a sample population (Jacobs, 2013). The criterion that was used for selection of the cases included the use of the Common Core State Standards, grade levels, and full school participation in integration of design thinking (DT). The data that was collected and analyzed included interview transcripts as well as artifacts which included lesson plans and reflections from teachers implementing DT into their instruction. The artifacts provided by the teachers in a digital portfolio or collection of artifacts in a digital website.

The interviews took place at the school location or virtually, based on teacher preference. The interview aimed to identify the experience before and during implementation of DT into their classroom. The goal of the interview was to identify the changes in pedagogy, the challenges the teachers faces, the success of the students, suggestions for other teachers, and how each element is used to help students succeed or not succeed meeting the Common Core State Standards (CCSS). Each interview was transcribed and coded to find themes and identify an overall experience.

The last instrument used in this study included two different artifacts including reflections and lesson plans. Each artifact was used to show how each teacher is implementing the DT elements and their overall success in each attempt. The specific artifacts that were collected included lesson plans and teacher reflections. For each type of artifact that was collected, a rubric, created by the researcher and screened by each participant for feedback prior to finalization, was used. The rubric focused on the use of the DT elements and level of mastery

as seen in each artifact. The rubric elements included focus areas of successes, failures, and mastery level of the students (see appendix A). The artifacts provided evidence and support of information gained in the interviews.

The reflections that teachers completed were completed both pre-lesson and post lesson each focused on different elements. For the pre-reflections teachers were asked to reflect on their possible and predicted outcomes. The pre-reflection also asked teachers to consider the design thinking process and how they planned on it helping students gain mastery. The post lesson reflections focused on the perception of mastery that the teachers have. It also asked teachers to reflect on the success, failures, process, and changes they would make. Overall each teacher interviewed submitted two pre-lesson and post-lesson reflections.

Sampling Method and Target Population

The target population search started with the identification of the cases or schools that matched the criteria for this study. Logical criteria for this study included schools which were using design thinking in the classroom as well as the Common Core State Standards (CCSS). The target grade levels were teachers who taught in grades 6-8. Middle school teachers were chosen for this study because of the extreme change in pedagogy needed by students and teachers at this level (Calkins, Ehrenworth, & Lehman, 2012). The criteria used in selecting teachers as participants was the subject of mathematics. Teachers had to be currently teaching math to middle school students using design thinking (DT) as a strategy when teaching cases for this study. Both cases came about because both cases used in the study have similarities that bind them together (Swanborn, 2010). Each school has similar enough criteria to be considered their own bounded or combined criteria case.

The target population for this study was middle schools using CCSS and design thinking (DT) within their classrooms. A total of 10 teachers from each school were selected to make a total of 20 participants in the study. The schools that were selected from an online inquiry into design schools utilizing the DT process. A list of schools was curated from Twitter, blogs, other social media sites, and the Department of Education for schools using DT. Students were not involved in the study as the integration of DT into the classroom instruction is the focus.

Instrumentation

Qualitative research offers a full range of data collection instruments. Creswell (2013) explained that multiple case studies should use instruments such as observations, focus groups, artifacts, and interviews that include open-ended questions. However, the major instrument that was used in this study was interviews. In a multiple case study that is looking at the perspectives of people semi-structured interviews are one of the only techniques to gain the data. All interviews were semi-structured or responsive interviewing, meaning that the interview will be specific to learning about the perspective of the teacher utilizing DT but with a limited amount of prepared flexible questions that will evolve as each interview proceeds (Rubin & Rubin, 2012). The use of semi-structued interviews was important to allow important balance of focus and felxability which was important for participants to fully provide their perspective. The nature of the questions allows for the development of rich data of personal experiences. The interview with the teachers focused on questions surrounding current pedagogical practices within their classrooms and current use of each DT element (See Appendix B). All interviews will be recorded to ensure accuracy of transcription.

Major instruments in this study were the interviews and the artifacts produced by the teachers. Posavac (2011) discusses the value of interviews and artifacts for program evaluation.

The artifacts for this study included lesson plans and teacher reflections. Each of these artifacts were placed by teachers into a digital potfolio. Each teacher was given a link to a private online website to submit each artifact element to. Each math lesson or unit plan was placed into a digital portfolio and included a pre-reflection and post reflection. The pre-lesson reflection focused on lesson or unit creation and the design thinking Process. The post lesson or unit reflection focused on success, failures, and overall perception of mastery of the math concept being taught. These artifacts were combined with teacher interviews to allow for a clear evaluation of the perceptions that teachers have of how DT meeting the needs students have for success in meeting CCSS in math.

Data Collection

During the study, the collected data included answers from interviews as well as artifacts from the portfolios. Each was collected in a manner that allowed for triangulation. The interviews were collected by me as the researcher through a series of semi-structured questions. The interviews were conducted through semi-structured questions which allowed for stories to be told and elaborated on. These stories helped to determine the ultimate perspective of the teachers involved. Each interview was conducted using the online platform called Google Hangouts. Each interview was recorded to ensure that each of the interviews were coded correctly.

The portfolios contained teacher reflections as well as lesson/unit plans. These were collected on a private website that only myself and each teacher had access to. Each portfolio piece was coded to allow the data and themes to be triangulated with the interviews. The reflections became the key piece in the conenctions as each reflection told a story within itself. Each pre-reflection was submitted with the unit/lesson plan and focused on the goals the teacher hoped students would accomplish via the design thinking (DT) process. The teachers then

submitted a post reflection focusing on the success, failure, and perspective on mastery of the lesson or unit.

In all qualitative research the researcher serves as the primary data collection instrument. As the researcher in qualitative research all data is being collected, observed, analyzed, and interpreted by a human being. Researchers have to ensure that proper check and balances are put in place to not allow personal biases and feelings to be injected into data anlaysis. Qualitative research does provide the essesntial viewpoints, feelings, and overall perceptions of people involved which does provide important insight into concepts, procedures, and student learning.

Data Analysis Procedures

Analyzing qualitative data requires the researcher to create a code that captures and represents the essence of the data (Saldaña, 2012). The data was coded, sorted, and synthesized. The type of coding that was used for this study includes process coding, value coding, and narrative coding (Saldaña, 2012). Process coding is action coding or creating codes for observable activity. The process was used to code teacher observations and reflections. The code consisted of letters and numbers of both the steps and process of DT as well as feelings of excitement, fear, failure, and change. Value coding was used for instruments measuring participants' values, attitudes, and beliefs. Interviews were value coded looking for their beliefs in the program, values in their teaching, and attitudes towards the program and process. Lastly, narrative coding was used to code stories and allow for re-telling of those stories. Narrative coding was used for the interviews conducted with each participant. After each interview and for each artifact are coded, the major themes will be compiled to determine the experience and essence of being a teacher who is integrating DT.

Triangulation. Triangulation was a necessary component of both the design of the study as well as the validity of the study. Triangulation is defined as the use of multiple measurements to help prove a theory or view point in a qualitative study (Creswell & Plano Clark, 2010; Posavac, 2011; Rubin & Rubin, 2012). The multiple measures used in this study was the teacher interview and the digital portfolio submitted by each teacher interviewed. The digital portfolio contained its own multiple methods which were used to determine themes and to triangulate the results with what the teachers reported in their interviews.

Limitations

Any case study that focuses on an instructional strategy will have limitations. The lack of generalizing a study to larger groups is one major limitation of a multiple case study qualitative study. The researcher understands limitations of this study include transferability as not all teachers or schools have the resources and training in design thinking (DT) as the teachers in the study. Another limitation is the transferability to grades Kindergarten through third grade.

Expected Findings

In a qualitative study the findings should show shared areas of concern, triumph and improvements. This study is expected to find areas of the design thinking process that are easy to incorporate as pedagogy into core curriculum and instruction like Ideation and prototyping as well as areas of the process that they each struggle to incorporate like empathy. These areas will have commonalities throughout all schools and subjects, as well as similarities within subjects and grades. Overall, the expected findings will show students who have a practical understanding of their content areas using design thinking.

Ethical Issues

Both qualitative and quantitative research studies consist of ethical aspects including informed consent, privacy, researcher integrity, and confidentiality (Shaw, 2003). Qualitative research elevates the ethical issues faced due to the prolonged exposure to the research participants. The ethical concerns are also strengths in the research including a full and authentic view into the experience of the participants. To help ensure that informed consent of the participants, privacy, and confidentiality each participant will be provided both verbally and in writing an overview of the purpose and process of the study to all participants including their voluntary participation. Also, the coding of all interview transcripts and rubrics were done by the researcher and kept under password protection and locked secure location during and after data analysis. The last measure was the use of pseudonyms for the schools and letter/number codes for participants.

Credibility. Rubin and Rubin (2012) define credibility as the presence of evidence that convinces the reader that the study has a conclusion. This study was designed in a manner to allow the words of the participants as well as examples from the classroom to be documented and triangulated. The use of semi-structured interviews provided the needed flexability for participants to expans upon their thoughts and perceptions but still provding the needed base of data. When the semi-structured interviews were combined with digial portfolios as artifacts the perception was strengthened and so was the credibility. Within the manuscript the use of direct quotes from participants futher provided the needed evidence.

Trustworthiness. Hendricks (2009) talks about trustworthiness being established by a researcher through four criteria: truth-value vailidity, applicability/transferability,

consistency/dependability, and neutrality/confirmability. For quantitative research the term of validity is used to describe

> the deree to which results are true for participants . . . the degree to which the reults can be generalized beyond the participants study . . . or the degree to which a test or assessment measures what it is supposed to measure. (Hendricks, 2009, p. 111)

Qualitative research uses similar definitions but uses the term trustworthiness inplace of validity.

Within this study the use of the following methods were used to strengethen the trustworthiness including acruate data recording, member checks, and triangulation of data sources. To ensure that all data was acruately recorded all interviews via a computer program. Those inviews were then transcribed and double checked. The next method used to strengthen the trustworthiness of the study was member checks. All participants were given a copy of their transcribed interviews to check and review accuracy. After the interpretations of the data was completed the overall concepts were reviewed with each participant for input. The last and final method used for trustworthiness was triangulation of data. The use of the interviews, lesson plans, and reflections were used to solidify the themes.

Chapter 3 Summary

With teachers looking for strategies and problem-solving methods to teach students within their classroom, DT has started to gain attention. Many teachers however are not sure what the integration of DT looks like from the teacher's perspective and experience. This study gives others who lack experience in design thinking the vantage point of that experience by utilizing a multiple case study approach. The use of rubrics and coding will allow researcher bias to be overcome because it gives a consistent check and analysis tool.

Chapter 4: Data Analysis and Results

Introduction

This study focused on teacher perceptions of design thinking (DT) as a mathematics strategy in the classroom to help students master the transition to the Common Core State Standards (CCSS). The research question specifically asked:

- How do teachers perceive the impact of design thinking strategies on a student ability to meet Common Core State Standards (CCSS) in mathematics?

This chapter will provide a description of the sample that was used for the study, research methods and analysis, summary of the findings, and presentation of the data and results.

The role of the researcher becomes important to understand in qualitative studies, since the measurement tool used in the study for data collection is the researcher (Denzin & Lincoln, 2003). I have a background in DT which led me to conduct the study. As a previous science teacher that used DT in my own classroom before becoming an administrator in another district, the question that I always wanted to know was how teachers viewed the success or lack of success DT had in meeting the needs of students in mathematics. Ultimately, I determined that this probing question was worth studying. The methodological approach included the use of two cases bound using both CCSS and DT. Each case the schools have been integrating DT for the same amount of years, and teachers have both undergone similar training, and use similar visions and missions for educating students.

During the study teachers from both schools were interviewed using semi-structured questions. These questions were targeted to gain perspective and insight of the teacher using DT as a strategy in their instruction to master the content standards in mathematics. During the interviews, teachers shared stories of both success and failure. These stories allowed a full

perspective on their experience and overall perception. Each interview was coded using the methods described by Saldana (2012). Using the following definition of mastery from Wiggins and McTighe (as cited in Wiggins, 2014): "complex, worthy, and valid tasks on which students must demonstrate high-level ability" (p. 11) the results of the interviews combined with the portfolios showed three major trends in the perceptions of the teachers. Those three areas were failure, process, and understanding by the students. These three areas linked with the concepts in the interviews. The interviews as well as the portfolios did show an overall perception by the teachers that students were better equipped to master CCSS when using either some or all the elements of DT.

Description of the Sample

The sample for this study included ten teachers from each of the two school sites. The first school site is a magnet school in Southern California. The school services students grade 6-8. The students must apply to be chosen through a lottery process. The theme of the school is design and innovation meaning that students use design thinking as a learning and problem strategy as well as look at ways to be creative through innovation. There are approximately 750 students in the school broken down evenly between 6th, 7th, and 8th grade. The second school is also located in Southern California. This school has been using design thinking in its instructional methodology for the past three years. The school services transitional Kindergarten through 8th grade. There are approximately 800 of students in grades transition Kindergarten to 8th grade, with only 200 in 6-8th grade. Both school sites completed similar trainings in design thinking as well as collaborated.

Ten teachers at each school were selected to participate in the study. The participants were an even mix of males and female teachers. The participants' age ranged from 26 to 51,

with teaching experience that ranged from two to twenty. Each teacher only had three years or less experience in using design thinking (DT) as a teaching and problem-solving strategy.

Research Methodology and Analysis

This study used a qualitative multi-case study design explain the outsome to the research question. Within the multiple case study model a unit on analysis is required (Yin, 2014). For this study, the unit of analysis is student mastery. Mastery has many definitions including the use of standards (Bloom, 1968). For this study, the use of Wiggins and McTighe's (as cited in Wiggins, 2014) definition of mastery will be the use of "complex, worthy, and valid tasks on which students must demonstrate high-level ability" (p. 11). A cross- case analysis was conducted by comparing the teacher's perception of design thinking for meeting mastery in mathematics at each school site.

The major instrument that was used in this study were interviews. The researcher conducted the interviews. All interviews were semi-structured or responsive interviews, meaning that the interview was specific to learning about the perspective of the teacher utilizing DT but with a limited amount of prepared flexible questions that will evolve as each interview proceeds (Rubin & Rubin, 2012). The interview with the teachers focused on questions surrounding current pedagogical practices within their classrooms, needs for problem solving, and current use of each DT element (see Appendix B). All interviews were recorded to ensure accuracy.

The artifacts produced by the teachers were used to triangulate and support the data from the interviews. The artifacts for this study included lesson plans and teacher reflections. The artifacts were compiled into digital portfolios.

Analyzing qualitative data required the researcher to create a code that captured and represented the essence of the data (Saldana, 2012). The data was coded, sorted, synthesized,

then put into a theory or outcome. The type of coding that was needed for this study included evaluation coding, value coding, and narrative coding (Saldaña, 2012). Process coding is action coding or creating codes for observable activity. The process was used to code teacher observations and reflections. The coding process consisted of letters and numbers that included the 4 Cs of Common Core State Standards which are creativity, communication, collaboration, and critical thinking as well as words that were used in the definition of mastery. Value coding was used for instruments measuring participants' values, attitudes, and beliefs. Interviews were value coded looking for their beliefs in design thinking (DT), mastery of mathematics standards through DT, and attitudes towards the program and process. After each interview and for each artifact are coded, the major themes were developed to determine the experience and essence of being a teacher who is integrating DT.

Each of the 10 teachers from the school site locations were given two options on how they would like the interview conducted either face-to-face or through Google hangouts. All 20 teachers choose the option of having online interviews via Google Hangout. These hangout sessions were audio recorded to allow for transcription of the data. During each interview, the researcher only took notes on the non-verbal communication that was noticed during the interview. After each interview, the information was transcribed. Each interview was then coded into the following categories: creativity, communication, collaboration, critical thinking, and mastery. Portfolios were then completed and sent to me for comparison with the interview data. The artifacts were also coded into the same categories. Each category was then sub-coded into success and failures. These number were the quantified to show teachers' perceptions. Together both sets of data provided a story and vision into the teacher's perceptions of how design

thinking (DT) as a problem-solving tool helped or didn't help students master Common Core State Standards (CCSS).

During the first level of the coding process the researcher was looking for the main theme of Mastery and words that showed successful mastery or non-successful mastery. From there the second level of coding were sub themes that naturally seemed to show up during the interview. These themes naturally came from the main changes in Common Core State Standards which include the 4 Cs: creativity, critical thinking, communication, and collaboration. The other main sub-theme that was present in all interviews was the concept of failure.

Summary of the Findings

During the analysis of the data using Mastery as the standard of measure, five main categories came up. Within all interviews and portfolio samples the themes of creativity, collaboration, critical thinking, communication, and failure were mentioned frequently. Overall, teachers who had been trained in, understand, and use a design thinking Process in their classroom on a regular basis did perceive an increase in mastery. All teachers observed that students gained empathy by being put in a real life situation in which the math had to be used. Students, more than ever, were using communication to not only explain answers but to interview others in the gaining Empathy phase of the DT process. Most of the teachers also pointed out that the critical thinking skills of the students have increased over the past three years as students are being asked in math to continually ideate and come up with ideas. The one area that was mentioned most by the participants besides the perception that design thinking (DT) did help students master the new Common Core mathematical standards, was the concept that DT helped students to understand and accept failure as part of the learning process.

The portfolios collected as part of the evidence provided a snapshot into lessons that were being utilized within the classroom. The lesson plans showed evidence of the DT elements that students were asked to use in their learning and to ensure that this study was based on teacher actually implementing DT into their classroom. For each of these lessons teachers provided a pre-lesson reflection. In the pre-lesson reflections teachers focused on the idea of the lesson, planning, and expected outcomes. In these reflections valuable information was collected like the trends and how teachers expected to students to master the concepts.

Teachers also were able to reflect upon the choice of standard and how they expected the learning to take placed. The teachers then completed a post lesson reflection after students completed the lesson. In these reflections teachers focused on the mastey, success and failures of the lesson. Not all pre-lesson and post-reflections contained the exact elements, however all of them answered the above information. Ultimately these portfolios allowed this study to bring in the day to day perspective on specific learning that supplemented the interviews. Within the portfolios there were failures that teachers expressed which shows the human side of this study.

Presentation of Data and Results

Two separate instruments were used to collect the data. The first main instrument used for the study was a semi-structured interviews. Each semi-structured interview used the elements contained in Appendix B to start and guide the interview, however each interview had their own flow and some individual guiding questions emerged. The second instrument used was artifact placement into a digital portfolio. Each teacher was asked to provide two lesson or unit plans that utilized design thinking. Appendix C shows what was asked for each lesson or unit plan including a pre-reflection focusing on their thoughts when planning the unit as well as a post reflection asking them to provide their insight into how successful the lesson/unit was what

changes could be made, as well as any other insight from the lens of mastery was made. From these two sets of instruments six main themes emerged when addressing the research question from both the interviews and portfolios which were: creativity, communication, collaboration, critical thinking, failure, and real-world problems. These six themes fit within the definition of Mastery this study used which was "complex, worthy, and valid tasks on which students must demonstrate high-level ability" (Wiggins, 2014, p. 11). Although none of the teachers specifically used the terminology, the six themes were there. The definition of mastery (Wiggins, 2014) states that the use of complex tasks is essential to reaching mastery which correlates with critical thinking found in the study results, whereas worthy correlates directly with real-world problems and creativity. The last part of the definition of mastery states high-level ability which directly correlates with the need for collaboration and communication. Each part of the definition of master is a theme that will be highlighted with data below.

Creativity's Cnnection to the Theme of Worthy Tasks.

The research demonstrated that teacher's perception of students being able to complete worthy tasks was accomplished when students were given tasks asking for the use of the design thinking Process or parts of the process. All 20 teachers used the terminology of creativity, choice, and real-world during their interviews. All lessons submitted in the teacher's portfolios also showed the real-world connection. Those connections included developing products for younger students, developing environmental solutions to droughts and logging, purchasing cars, rising costs of health care, and even college tuition issues.

Many of the comments made by teachers, such as "Design thinking offers students to think critically and creatively as they solve problems. To explore a topic deeply, students have the perfect process to dive into a subject" (Teacher A-2). Many of the comments teachers made

about creativity stated: “A few of my favorite quotes from my students include ‘I feel more creative…. I am challenging and analyzing what I’m being told more’ which shows me that when design thinking is used in learning, students not only produce creative work but feel creative” (Teacher B-1). “One student told me that they feel alive and like a great citizen when they work at new and creative solutions to a problem. Nothing is more rewarding now that students are excited and wanting to come to me class, not because of me but because they are challenged in their learning and love being creative” (Teacher A-10).

Many of the teachers viewed worthy work and learning as real-world learning including The real-world connection is where students really dive into worthy tasks, especially in math. Creativity comes into math by giving students real world problems to solve with options. Choice and voice is what I like to call it. The answers are not right in front of them which makes them must really think, but in a unique and creative way. An example includes my car buying project. Students will be working through system of linear equations. Students are given a profile of family or person that needs to buy a car. They are placed in the position of being a car buying expert. Students have to gain empathy for the family, define the focus by identifying the key needs of a car for them, research cars, prices, and interest rates. They then put all those items together graphically, mathematically, and present them to the class (Teacher A-8).

When evaluating the digital portfolios, teachers provided their insights and feelings that creativity is one of the greatest benefits of using the design thinking (DT) process. It means that the teachers naturally added creativity for students into their learning. Naturally the process allows students to have choice in a lot of elements. The lessons teachers provided all showed the use of choice to promote the creativity throughout the lesson. Many of the post-lesson reflections showed new ideas for choice for students to expand their creativity. Some of the new

ideas that came about from the post-lesson reflections included the use of menus for students' prototypes and testing methods menus. Teacher B-3 stated that "I never realized that giving students choice through a menu of options only jump starts their creativity. More of my students are asking to develop their own item for their testing methods than ever".

> I was surprised when a group of students came to me and asked for my permission to test their prototype of a presentation online with a virtual group. This was not a method I had previously even considered. I watched them create a virtual group of people from all over the world through a twitter post, then presented their presentation of findings and ideas to the group. The students received a lot of great feedback from this mixed group of people online. (Teacher A-3)

Most importantly many teachers reported in both their pre-lesson and post-lesson reflections that the process of integrating DT has caused them to bring creativity into student learning through lesson design. The process of DT shows that teachers have to really think about real world examples and problems for students to solve that integrate their math material.

The number of times the words creativity or creative was mentioned within the interviews and reflections from each school was counted. Teachers from School A used the word creativity or create a total of 233 times, whereas teachers from school B used those words a total of 192 times. These numbers average to about 20 times per teacher. That is a significant number of times in an approximately 30-minute interview and four reflections. With the amount of times creativity is mentioned and the call for creativity in education, the teacher's perspectives can be seen that design thinking (DT) helps to bring creativity into the classroom.

Most of the reflections found in the digital portfolios keyed into creativity and the opportunity for students to create as the main element of the DT process that teachers most

appreciated and why they used the strategy in their classroom. "I loved that this unit has been the one in which students have really blown me away with how creative they can be. When I designed the unit I never thought that my students would come up with the solutions they did. I laughed and smiled so much when the classes presented their solutions and that is why I became a teacher, for times like this! In the 8 years of teaching I have not seen creativity like this and I know it is only because I used design thinking!" (Teacher B-6).

Many teachers talked about their own growth in creativity due to the creating of DT projects. "I often thought that I was a creative teacher until I was introduced to design thinking. Having to stay current with real world topics and events and incorporate them into student learning has pushed my creativity to the extremes" (Teacher A-4). The reflections showed that students followed the teacher's lead in creativity "I was able to see many of my students rise to my own level of creativity when given the challenge to develop a solution to global warming. They shocked me as to the solutions they developed even if they seemed impossible they still went full force in their solution" (Teacher B-8).

Critical Thinking Connection to Complex Tasks

This research showed that teachers perceived that design thinking when used in the classroom and as a planning tool for the teachers provides the complex and critical thinking students need. Most of the teachers discussed the transition that Common Core State Standards (CCSS) has brought about in math. One teacher stated that "This process (design thinking) helps students to dive deep into the root of the standards of Common Core instead of just memorizing the facts like they used to" (Teacher A-9). Many of the portfolio items provided allowed students a choice and asked them not just simple computational answers and explanations but to really apply it to real world situations which were not just straight forward. "When I moved

from just giving students one way to explain or show that they have mastered a math concept to having students solve complex problems using the math they know, learning not only stuck but turned students onto the subject of math" (Teacher A-3). "This is one area I continually struggle with, are the tasks I give the students really worth and complex? I can't really judge this until I have a group try the task and get their feedback as well as the outcome of their learning" (Teacher B-9).

The California Common Core State Standards for Mathematics gives teachers specific language and examples of what mathematically competent students should be able to complete. Specifically they state that "Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is" (Common Core State Standards Initiative, 2015, p. 6). These arguments, logic, and reasoning was talked about by teacher A-5 in their interview.

> Working with middle school students means they love to argue points. They have never really thought about arguing about math concets until I provided a unit in which my students created a court case to argue for the best way to solve quadratic equations. Students had to use critical thinking skills and really have to be ready to provide counter arguments, evidence, and really understand what the other side is trying to prove. By asking the students to reason and have to be ready with counter arguments, their critical thinking skills have greatly increased, probably due to the fact that the students see value in understanding the concept as well as the exctiment that the information means something to them. One student told me that he felt so smart as he argued using math

concepts, terms, and facts. He said he was even proud that he was able to aruge why the math was an important concept in life. (A-5)

Teachers used a variety of terms or key words when defining and talking about critical thinking and complex tasks including: deep dive, complicated, choice, and multiple. When asked about the definition of deep dive one teacher stated that "a deep dive is really about the students exploring a topic fully, from the conceptual to the figurative, to the abstract. When students conduct a deep dive, they know that the answer will not be simple or easy, there will be multiple solutions to the problem, and complex thinking will have to take place" (Teacher B-10). Table 1 shows the number of times each of these terms including "critical thinking" and "complex" were used during interviews and reflections.

Table 1

Use of Terms Related to Critical Thinking and Complex

School	Word Count for Deep Dive	Word Count for Complicated	Word Count for Choice	Word Count for Multiple	Word Count for Complex	Word Count for Critical Thinking
A	38	18	28	15	43	16
B	27	22	39	12	29	24

Each of these words can be seen in the definitions of critical thinking and complex the teachers gave to us during interviews. "I would define critical thinking as a process in which an unknown task in given to students which requires them to dive deep to find multiple solutions" (Teacher B-4). "Choice, voice and complicated would be a major part of complex and critical thinking (Teacher A-5).

The findings demonstrate that the perception of teachers that use design thinking in their classroom as a problem-solving strategy do find that it helps students to master mathematical

concepts. All teachers involved in the study agreed that design thinking provides not only a process for students to follow but a template for teacher planning as well. "I never thought that I would have to use design thinking for myself. I wish I had been taught about the design thinking process in my teacher classes because I wouldn't have spent 10 years not being the best teacher I can be" (Teacher A-3). They all reported that the entire process cannot and does not always need to be used for every concept, but planning on having students use part of the process helps students meet mastery. Most teachers also reported an unpredicted outcome of using design thinking (DT) in their classroom which was the concept of failure as a by-product.

Failure. Failure was defined by almost all the teachers as being the students first attempt in learning. Failure became a natural part of the learning process and was described by a few teachers as the by-product of DT. During the interviews teachers were asked about the essence of integrating DT into their classroom and the main theme to that question as well in their post-reflection from their lessons in their portfolios teachers made comments relating specifically to failure including, "Before bringing design thinking into my classroom, students would often give up when they didn't do something right. Now however, my students will try again and again even if what they produced failed, or the answer was wrong" (Teacher B-10). "Failure is something that DT brought into the focus in my classroom. In fact, I have the failure award I give out every other week which recognizes a student for failing but then persevering and becoming successful" (Teacher A-6). During the interviews in which the teachers gave these quotes, the non-verbal from each teacher showed a change in body language. Both teachers sat up more, leaned more on the desk, and had an elevated tone in their voice. The interpretation is that they were excited by what they had to share on failure.

Many of the teachers associated the concept of failure to that of a growth mindset. One teacher talked about reading and understanding the development and importance of a growth mindset for students, but did not intentionally bring design thinking (DT) into the classroom to develop a growth mindset. “I spent time at the beginning of the school year trying to help students understand and develop a growth mindset, however the greatest tool I found to develop this growth mindset and have students conquer failure has been the design thinking process” (Teacher A-10). “Failure has been a barrier in the learning of mathematics because the subject is so black and white, either your answer is right or wrong and in the past, I just gave my students the correct answer and moved forward, now through the test and reflect process students understand they can try again and again instead of get the right answer from someone else and move on” (Teacher B-7) explained during the interview process.

Every teacher mentioned failure multiple times in both the semi-structured interviews as well as in their post reflections. The number of times in which each set of teachers from each school used the word fail or failure in the interviews and reflections by the teachers at each school shows insight into the importance this concept has on their view of mastery. At School A teachers used the word failure or fail a total of 156 times during the interviews, whereas school B used those words a total of 118 times. The numbers above show that failure plays a significant role to the teachers as failure was used an averaged of 13.7 times during reflections and interviews. “I was very unsure how my students would adapt to the test, reflect, and refine process of design thinking. They are not used to things not working out and having to try again, although it was real life. I love seeing them fail and try again” (Teacher B-6). Another teacher talked about being able to celebrate failure within the classroom “I created a weekly failure award in which students are able to submit their greatest failure both inside and outside the

classroom. They have to tell me how they failed, then how they continued to try and the final outcome. This has been a fun change to awards I give out" (Teacher A-4).

Not all teachers were able to see and understand failure as a concept they themselves could overcome. "During my formal observation this year, I was asked to show a design thinking lesson and activity. I struggled to comply with that request because I feared being a failure and the lesson tanking. That fear drove me to go back to a lesson I used to do that I knew was successful in teaching the concept" (Teacher B-5). Although teachers stated it was an unexpected byproduct, for this study it is important because the transition to CCSS can cause students frustration and the concept of perseverance through failure is vital.

Communication's connection with mastery. The definition of mastery does not directly use the language of communication, however for a student to truly demonstrate complex learning they need to adequately communicate their thoughts, findings, or solutions to the tasks given. In both the interviews and the artifacts, there were many examples of teachers discussing a notable increase in both verbal and written communication by their students. During the design thinking process, gaining empathy was continually mentioned as a key element that teachers purposefully built into lesson or units. Many times, students would gain empathy through interviews. Teacher A-7 provided a lesson plan that showed that students had to take the opportunity to interview other students about the kind of car their family had. The goal was to gain empathy for people buying a type of car based on their family needs for a math lesson. Students had to listen as well as formulate questions during these interviews. The teacher reflection on the unit showed that the teacher observed students being able to accurately communicate the needs of others when buying a car as well as the math they used to create their car buying plan.

Teacher B-2 provided similar insight during their interview about communication. The teacher talked about their student's lack of being able to explain why they did each step in a math problem at the beginning of the year. The students struggled to interpret what they had done in a problem in a way that other students could model it. When they introduced design thinking and the use of team communication, questioning, and testing their solutions the teacher could see a great increase in their communication skills. The students who typically lacked both confidence, as well as skills in communication, were forced to communicate with one another to be successful. The teacher reflected specifically in their portfolio about a student who did not work with groups well because of their lack of confidence in their communication skills. The student knew the math but would never add input. During the lesson, the student was more engaged in the topic as they were looking at endangered species data. The student ended up carrying the group and presenting their solution or test to the class. This was a huge victory for the student and the teacher.

Communication includes listening, speaking, and displaying information in a way for others to understand. Teacher A-1 reflected in a post-lesson reflection in the digital portfolio on the need to ensure that all areas of communication are incorporated into the planning of projects.

> Often times I was forgetting to include a listening component into my projects. In this unit I made a specific choice to include all areas of communication. Students had to listen and take notes in their peers presentations, get public feedback on their project, as well as present and articulate their findings. I found that many students struggled to stay focused while others were presenting and could not accept feedback from others to improve their findings. These are areas I need to include more and help my students with. (Teacher A-1)

Communication skills are vital with working with processes and numbers like in mathematics. Students are able to go up to whiteboards and show each step of a process to answer a math problem, but students struggle when asked to explain why each step works or why each step was chosen (Liu, Hsieh, Cho, & Schallert, 2006). "To avoid embarrassing my students I used to just ask my students to go through each step of a math problem but stop them as soon as they started to struggle. Now that I have student groups solve problems they have a team to work with when explaining math concepts and why they made the choices they did. Because they struggled through creating something they usually do well with explaining and communicating their learning" (Teacher B-1). Teacher A-8 explained that "watching the excitement that students now exhibit when communicating with their classmates what they have learned has been a highlight of my career. They always want to come and share what they learned from others during their empathy phase of learning". "Communication is a two-way process and for the first time I watch my students really listening to each other and caring about what each person has to say. I attribute this to the fact that each solution is unique and interesting because of design thinking" (Teacher B-7).

Throughout the interviews and artifacts teachers used words that related back to communication a total of 78 times. All words, phrases, or answers that were seen showed an increase in student communication skills as seen in the above example. Based on the evidence, communication skills that students displayed showed that most students could display mastery or growth towards mastery in math when they are introduced to and use design thinking (DT) and students used it regularly in their learning.

Collaboration. As seen in this research, collaboration is a vital skill that students need to develop for success in careers and has become a focus in the Common Core State Standards

(CCSS). During the study, teachers provided artifacts and reflections that focused on establishing opportunities for collaboration. One lesson plan provided by teacher A-5 specifically focused on the collaboration with the team assigning teach team member an aspect of the project to provide different view-points and parts to the presentation. The project focused on biomes. Each group member had a different biome but had to find a solution for each that worked. If students did not accurately pull their weight and bring their part to the project the entire group would not have been able to complete the project. Students had to analyze the math behind living in each biome and creating a house that would allow people to live in each biome. During one teacher reflection, they stated

> I loved seeing how students interacted with one another in their teams and saw many of the students providing ideas and inputs. What I need to do better is in establishing individual accountability for each member of my groups to ensure everyone is heard as well as is pushed outside their comfort zone. (Teacher B-3)

Many teachers also mentioned collaboration and situations like the one above when being interviewed. All teachers provided some comments, stories, situations, or artifacts that showed that the process of DT meant students had to collaborate and work in teams to be successful and use the process. One teacher mentioned

> Using design thinking as a platform for my unit development has forced me to ensure that students have the time to collaborate throughout the entire process. The students should have ideation time in teams, time to collaborate through empathy, as well as time to collaborate during the testing and reflecting stage. I have never used a learning strategy in my classroom that focused so much on collaboration than design thinking. I love the

culture and atmosphere that collaboration and design thinking has created in my classroom!" (Teacher A-2)

Collaboration was not readily a focus in any of the pre-lesson and post lesson reflections. Teachers talked about the unique aspect that design thinking (DT) brought to collaboration, but did not specifically mention it as an element for mastery. Although collaboration is an important skill for students to develop, it does not specifically get mentioned for mastery. "It is hard to prove through the means of collaboration alone that a student has mastered a mathematical concept. I have to combine the DT project with some kind of individual assessment to help prove mastery. What collaboration does is help struggling students work together with a group to help them gain confidence in the concept" (Teacher B-9). The use of peers was mentioned by teachers as usefull for students who were struggling with the problems presented to them, but felt that it was not a necessary element.

> I found it interesting that the choice of partners in this lesson made the difference for so many students in their success. If I had let the students choose their own groups for the project I don't think that the learning outcome would have been the same for some of the students in my classes. I need to ensure that when setting up project I think about the groups students work with and if the results would be the same if students were allowed to pick their own groups." (Teacher B-6)

Many of the teachers tied the concept of collaboration with the use of real-world and engaging tasks. The study did show that collaboration was increased and students were able to communicate mastery in different ways through the process of design thinking (DT).

Real-world problems and yasks. The link that this study showed for student mastery was providing the meaningful tasks that put students in real-world situations. In the artifacts

provided by teachers, most pre-reflections mentioned the need to find situations in which students can practice math skills, find meaning to the math, and ultimately master the concept through connections. All the lesson plans that were submitted as artifacts demonstrated real-world problems that students were trying to solve.

Examples of a few of these real-world problems included buying a car, building a city, ballistics analysis, chemical reactions for blowing up a watermelon, bio-diversity, and ecosystem creation. "So far every year my favorite real-world challenge I have brought into my classroom changes. For now, my favorite project is my explosion unit. I combine what students are learning about chemical reactions with mathematical formulas. Students have to find the proper ratios of chemicals needed to blow up either a pumpkin or watermelon. Students have to find the weight of their pumpkin or watermelon then develop a formula for blowing it up. Not only do students love blowing things up but they love seeing how formulas control things like fireworks, medicine, etc." (Teacher A-1). "In this day and age I really struggle to bring the real-world issues into my classroom because so many have very opposing sides. Although controversy helps students to learn and be engaged I stay away from too many issues in the news. Instead I focus on fun ways to have students link math to life without bringing in the news" (Teacher B-4).

All teachers made multiple comments in their interviews stating that using design thinking (DT) has really made them create learning opportunities that involve real-world situations due to the steps students needed to take. "For students to be able to solve a problem, I have to design a unit that involves something they can really solve; thus, being something interesting and part of their world" (Teacher A-7). "My goal in every lesson I design for students is to take away the question of why do I need to know this and I can only accomplish that if

students can find the link between their world and the math." (Teacher B-2). In many of the post lesson reflections teachers focused on the real-world aspect of DT.

Looking at the number of times teachers used the term Real-World gives an insight into its importance. School A used the term real-world a total of 54 times, School B used the term 67 times. Although these numbers are lower than some other terms and words analyzed in this study, these numbers still show a significance for the teachers involved. "When I first learned about design thinking I was most excited that math could come to life for the first time in my teaching career because math will have true meaning because they are solving real-world related problems" (Teacher B-8). "Bringing the real-world into the classroom seems easy and is for most subjects except math. I struggle daily with the best ways to do this. I figure as long as I try something it is better than not trying to being in anything relatable into my room (Teacher B-5).

> Not all teachers feel the need to connect to real world content in math.
>
> Math and life are often not linked for students because not all math needs to be used. I struggle to continually find the real world connection for the students because it's not there. I often give up and don't try. I still believe that there are times that students just need to do math for the sake of doing math." (A-6)

Another teacher talked about the balance they strive to make in providng real world connections through DT projects, and just plan doing math because they need to know it for the next grade level. "Balance is the best word I can use when I look at my teaching approach. Math can't be all just project based and DT projects, but used when great examples or new thinking can be used by the students. Students are able to see connections to become concepts to real life and other concepts they connect to math itself, just because that is what they need. The statement that

some math concepts won't be used in a students life is very true and I try not to mislead my students. That is why I call my approach to math balanced" (A-8).

Overall, part of the definition of mastery that was used for this study included complex and worthy tasks which leads to teachers using real-world problems and situations for students in learning. All teachers in both interviews and artifacts showed the use of these problems did help students master the mathematical concepts. "For anyone looking to use design thinking in their own classroom has to understand and embrace a love of problem-solving themselves. I often have to spend hours thinking about tasks that challenge my student's thinking and this helps to develop the real-world part of learning. I also have found that I am changing the problem as new issues in the world or the lives of my students arise. This is both fun and exhausting, but totally worth it when you see how much your students absorb and enjoy learning" (Teacher A-9).

Chapter 4 Summary

Often teacher perspectives are not considered when looking at the success of an instructional tool like design thinking (DT). This study aimed at providing just that the teacher's perspective on the success specifically in the mathematics classroom. Using interviews and portfolios the overall perception of the teachers was that DT did help students to master Common Core State Standards. Mastery in this study was defined as "complex, worthy, and valid tasks on which students must demonstrate high-level ability" (Wiggins, 2014, p. 11) and teachers reported that when they focused on creating units and lesson using design thinking (DT) students did in fact raise to the challenge of mastery. Using the key words of the definition of mastery as an analysis tool and guide to overall themes, it is clear to see that the teachers' perspective did show what the study was looking at.

Chapter 5: Discussion and Conclusion

Introduction

Two overarching themes emerged in this study from the six smaller themes provided in detail in chapter 5: (a) the use of design thinking (DT) within the middle school classroom was perceived as helping students master the Common Core State Standards and, (b) design thinking (DT) brought about a mindset change including the concept of failure and grit. The discussion of the theoretical and practical implications of the research findings are discussed, and limitations of the study are noted in this chapter.

This study utilized a case study approach using two middle schools that currently use design thinking in their classrooms as an instructional strategy in mathematics. Within each case, 10 teachers were chosen to be interviewed in a semi-structured interview. Following the interview each teacher provided artifacts in a digital portfolio that consisted of 2 lesson plans with a pre-lesson and post-lesson reflection. The data from the interviews as well as the portfolios were then analyzed looking for key terminology from both the design thinking (DT) process and the definition of Mastery that was used for the study. The terminology from DT was then combined into the definition of Mastery to allow for connections.

Summary of the Results

Design thinking (DT) has been identified as a viable problem-solving method in business and has started to show its presence in the classroom (Kelley & Kelley, 2013). This study aimed to provide the perspective to teachers who have ventured into using DT in their classroom as an instructional strategy in meeting the needs of students for the Common Core State Standards (CCSS). Using the definition of mastery in connect with the key elements of DT did in fact show the teachers' positive perspective of DT for meeting the needs of students in mastering

CCSS in mathematics. The study showed that students were better equipped with skills when design thinking (DT) was used in the classroom and when lessons or units were designed with DT in mind. The themes that emerged from the teachers' perspective were the themes of real-world problems, creativity, critical thinking, communication, collaboration, and failure.

The six themes that emerged from the teacher interviews correlate with the definition of mastery used for this study to show that teachers perceived that design thinking (DT) does help students master the CCSS standards in mathematics. Many of the teachers also reported that they started to see students transferring the strategy to other aspects of their lives and learning. Overall the results of the case study showed positive connection and perception in students learning. The six themes included communication, collaboration, critical thinking, failure, and real-world connections.

In this study, a connection was made between key vocabulary found in the design thinking process and definition of mastery used in the study. Using both interviews and online portfolios, the perceptions through word count and quotes shows the positivity of using DT in the classroom.

Discussion of the Results

Participants found that by focusing their planning or learning experiences for their students using the DT process as the learning strategy, real-world problems naturally became part of lessons and units as real-world problems become the tool to show mastery. This allows the learning to be relevant to the students and for students to see the value in what they were learning. Teachers attributed trying to gain empathy as the main DT element that brought about the real-world problems. The definition of mastery used for the study used the term complex and

most problems we see in the real world are complex as they take on many option without a right or wrong answer.

Teachers gave specific examples of real-world learning including units such as buying a car for a specific client, blowing up pumpkins or watermelons through formulas, creating a house fit for all biomes assigned to groups, developing plans to help combat global warming, and even developing devices that release the perfect amount of ketchup for kids. These real-world problems allow students to explore and develop solutions to the problems presented while learning the math needed for solutions. The real-world problems used in the classroom through DT was reported to eliminate the need for students to ask why they need to know the math.

The second main theme that was seen through the analyzation of the data was communication. The participants noted that students struggle to communicate the processes that they had to go through to develop a mathematical answer. The DT process provided the platform for students to communicate not only with one another but to share the solution of their real-world problem they were solving to others. Communication in life is a skill that many people struggle with and in a math classroom many teachers do not have the time to develop in their students. The process of DT was seen as a way to allow time for students to talk with one another, talk with adults and people outside the classroom, and most importantly present their findings and solutions. Communication is embedded throughout the entire DT process and teachers reported an increase in students' communication abilities.

The third theme was collaboration. Teachers in the study noted that middle school students often struggle working with others to develop solutions or even in learning. The DT process developed the culture in which students had to work together to develop and solve problems. Teachers provided multiple lesson plans and examples in which students had to work

in teams with assigned roles in order to successfully solve problems. Those examples included working as a team to successfully create housing adapted to different biomes, develop accurate weather devices, and provide websites for student use. Participants noted that collaboration provided a platform for students to learn from each other as well as develop multiple solutions to mathematical problems.

The fourth theme that developed from the data was the concept of failure. Participants stated that students learned that they do not have to have the right answer the first time they attempt a solution to a problem. Students developed grit as they tackled problems repeatedly instead of giving up. Teachers noted that the majority students struggled prior to learning and using the design thinking (DT) process and would give up after their first attempt thinking they were not smart or getting it, but after DT they would realize it is ok not to have it right the first or even second time you try, but if you continue to try you will develop the right solution or answer. Failure developed a growth mindset in students who regularly used the DT process. This growth mindset means more students would continue to work for the mastery of a math concept. Teachers noted that although a byproduct of DT, it is one of the greatest assets of DT for students.

The fifth theme that emerged from the study was creativity. This theme showed to be the highest in priority for teachers as they were transitioning to the CCSS. Creativity would naturally be the enemy for math teachers as there can be a lack of creativity in mathematics. By bringing in choice and voice into math learning creativity naturally followed. Teachers ensured that they provided choice in the outcome of learning. Teachers also reported that using the DT process forces them to be more creative in their teaching and the classroom experiences they provide for their students.

The sixth theme that was found in the study was critical thinking. Critical thinking can be defined in many ways. Teachers in the study used the words deep dive, complicated, choice, multiple, and complex to describe critical thinking. DT was seen by teachers to provide opportunities for this kind of critical thinking. The projects teachers provided to the students naturally made students analyze and critically think of solutions including the math needed. Teachers reported a greater success in student thinking and analyzing problems when they used DT than before they were using DT in their classrooms.

Discussion of the Results in Relation to the Literature

Education in the United States is in constant change. The most recent change came in the form of the Common Core State Standards (CCSS). These standards place an emphasis on four main areas of students learning: communication, critical thinking, creativity, and collaboration (Common Core State Standards Initiative, 2016). This shift required teachers to look for new instructional strategies, especially in the subject of mathematics. This study used research on how people learn to look at different strategies that could be used for the skill areas CCSS was focusing on.

In this study teachers reported an increase in the level of communication and the skills that students used to communicate when the design thinking (DT) process was used in their classroom. This correlates with the research that was conducted that showed people learn through interaction and could demonstrate mastery through proper communication skills (Russell, 2012). DT provides students with the skills and the requirement to communicate with other and to other their thoughts and solutions.

Communication was not the only skill in which teachers reported an increase in from their students. Teachers reported that students' ability to work in teams and groups became

easier and more constructive each time design thinking (DT) was used in the classroom. Research showed that the ability to collaborate and teamwork are skills business leaders and colleges are looking for in graduates (Kelley & Kelley, 2013) and students need to learn how to collaborate in a productive way. Teachers saw a natural increase in effective collaboration because of the process of DT. Teachers noted that they still had to teach how to properly collaborate with others, but as the process was used more and more, students developed and refined the skill.

After completing this study, it is clear that the results are similar to other studies that have been conducted on design thinking (DT). The first study by Cupps (2014) looked at DT and it's use in college undergraduate programs. In that study, they found success as an individual course and had limited success in the integration of students into other content areas. Unlike that study, design thinking was integrated as a teaching and learning strategy, not an independent course. This study was able to show that integrating it for students shows success of the strategy being used more often. The second study reveiwed in Chapter 2 by Campos (2011) looked at DT being used by a school district to bring about change in their school in regard to 21st century skills. In that study, the researchers found success in being able to transform learning and bring in the change needed. Similar to the above study, this investigation showed a similar transformation in the skills students need to show mastery of CCSS standards in mathematics.

The third study found in Chapter 2 for design thinking, Kweck (2011) focused on middle school learning and found that DT increased student motivation for learning. Unlike that study which focused on private schools, this public-school study focused on the teacher's perceptions of mastery but found that perseverance, grit, and overcoming failure for students were perceived as to increasing these areas which could be seen as motivation. Another study used in the

literature review was by Carrol, Goldman, Britos, Koh, Royalty, and Hornstein (2010) in which university professors developed interdisciplinary units through design thinking (DT). They found success in interdisciplinary units using DT as the basis for the unit, which is similar to the units that the teachers in this study developed for their students and perceived success in the mastery of the standards the units were created for.

Three more studies were noted in the literature review on the use of design thinking (DT) in educational settings. Watson (2015) studied the use of DT in a high school art class. The researcher in that study looked at his students and if they were transferring DT into other aspects of their life and learning. He found that students did transfer the strategy into other aspects. Teachers in this study were not specifically looking at or mentioned the transfer of the strategy to their students' lives. Purdy (2014) looked at the writing process and using DT through the writing process. They found that indeed DT helps with the writing process. In this study teachers notes multiple times the skills of communication and the increase they saw in their students in this area. Lastly Fontaine (2014) used the planning and creating of interactive museums with graphic design students using the DT process. They found success in helping students see differently elements of graphic design. This study matches the results of this study the most. This study found that students who used the process saw their learning different and were really able to apply knowledge for mastery.

Limitations

With this research design, the limitations will include transferability to other content areas, grades, and schools. In addition, the nature of qualitative research excludes the hard-quantitative data that many administrators and school districts look for in studies to make significant changes in pedagogy. The goal of this research is to explain the teachers' perspective

of design thinking (DT) in middle schools to meet the needs of the Common Core State Standards in mathematics. The themes and generalizations that occur from the study may prove of interest and use for school administrators who are looking at a similar change in pedagogy.

Implication of the Results for Practice, Policy, and Theory

From year-to-year standards, practices, and requirements asked of students and teachers change within the classroom. The Common Core State Standards (CCSS) have brought about changes when looking at the skills students are being asked to use and for teachers to develop. These skills include creativity, critical thinking, communication, and collaboration which became four of the themes and skills of this study. This study demonstrated the teachers' perspective on using the developed business model called design thinking (DT) within the classroom. This model has proven successful in helping businesses develop new plans, be creative, and problem solve (Kelley & Kelley, 2013).

Practice. Using design thinking (DT) as a tool and problem-solving strategy which includes empathy, ideation, prototype, test, and reflect; students have a platform and method for working through hard problems using the skills CCSS requires. This study has provided the insight from the teachers using DT as an instructional strategy in the mathematics classroom for mastery. As teachers and school district start to look for ways to help students learn and refine the skills needed to meet and master the CCSS and prepare for college and careers, this study will provide feedback and insight into DT needed for others to consider using the process in their own classroom. Overall, this study demonstrated that teachers favored using the DT process and could see many of their students reach mastery in mathematics.

Policy. Educational policies exist to protect student, provide structure for teachers and staff, and for accountability to stakeholders. Policies on how content is taught are not the norm

for most districts and public schools. This study looked at individual teacher's perception as a case study not the policies behind the teaching strategies used in classrooms. What this study provides is a view into personal policies that teachers can make within their own classrooms that help to provide students with a new way to master content. This study is not intended to make new policies in education but instead to provide theories for learning as well as educational practices.

Theory. The theoretical implications of this study reach into education beyond the everyday teaching. Bringing new and innovative learning tools like DT help students and teachers stay current with the needs of the world. DT was brought in from the business world and made to work and fit into education. Looking for these opportunities theoretically pushes education to new heights. If it is possible to bring strategies like this into education them so can so many other strategies and concepts. Theoretically this study shows that when given a little bit of time and creativity anything is possible and can be used to benefit the learning of students.

Recommendations for Further Research

This research provided a starting point for the use of design thinking (DT) in the classroom. The researcher developed three research questions for recommendation for further research including Does design thinking (DT) improve students' performances on high stakes standardized tests? What are the experiences of the students who are using the design thinking (DT) process in their learning? Does the design thinking Process transfer to other areas of learning beyond mathematics?

Quantitative data validation. This study looked only at the qualitative aspect of design thinking in the classroom. For many educators, they are searching for more than qualitative data and would like to see quantitative data to prove the instructional strategy. Looking at high stakes

standardized tests such as the PAR or CAASPP tests for students prior to implementing the strategy into their everyday learning and after could show the success many educators are looking for.

Student's perspective. This study looked at design thinking from the perspective of the teacher however student buy-in has to play a factor. Looking at the strategy and learning from the student's point of view and perception can help complete the picture. Using a similar method used here but only using students as the subject could show their perception of mastery and use.

This study focused specifically on mathematics. For a complete view of design thinking in K–12 education including all other subject areas would be needed. The holistic view allows more buy-in from stakeholders as they can see the value of taking time to teach and use the strategy.

Conclusion

Education continues to change as are the demands placed on students leaving school and entering the workplace. For these changes to be successful, education should be looking for alternative strategies that can be used the classroom. Design thinking (DT) is one of the strategies that has started to take hold in education. This study aimed at providing the perspective of middle school teachers using DT in their classroom to help students master the Common Core State Standards in mathematics. Teachers showed that they had passion and saw real merit in the strategy. They saw an increase in the skills of communication, collaboration, critical thinking, failure, real-world connection, and creativity because they focused on using elements of DT in their lesson and units. As teachers and schools look for new ways to approach learning to meet the changes that education takes and the new skills being asked of students, this

study can help them see the benefits of DT and hopefully dive deeper into the process on their own.

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Appendix A: Design Thinking Digital Portfolio

Design Thinking Digital Portfolio

Student Name: _____

CATEGORY	1 point	2 points
Use of Empathy	Lesson Plan/Unit Plan contained only 1 use of empathy	Lesson Plan/Unit Plan contained only 2 use of empathy including use in designing the unit
Use of Defining the Focus	Lesson Plan/Unit Plan contained only 1 use of empathy	Lesson Plan/Unit Plan contained only 2 use of empathy including use in designing the unit
Use of Ideation	Lesson Plan/Unit Plan contained only 1 use of empathy	Lesson Plan/Unit Plan contained only 2 use of empathy including use in designing the unit
Use of Prototype	Lesson Plan/Unit Plan contained only 1 use of empathy	Lesson Plan/Unit Plan contained only 2 use of empathy including use in designing the unit
Use of Test/Reflect/Refine	Lesson Plan/Unit Plan contained only 1 use of empathy	Lesson Plan/Unit Plan contained only 2 use of empathy including use in designing the unit
Reflection of Successes	Teacher reflected on only the student successes or lesson/unit successes	Teacher reflected on both the student successes and lesson/unit successes

Appendix B: Semi-Structured Interview Questions

1. What is your name, grade level you teach, subject you teach, years teaching?
2. What school and district do you teach at?
3. How would you define Design thinking?
4. How long have you been using Design thinking in your instruction?
5. How do you integrate Design thinking into your content area?
6. What training in Design thinking have you had?
7. What successes have you had in integrating Design thinking? Can you give me an example?
8. What failures have you experienced in integrating Design thinking? Can you give me an example?
9. What changes do you hope to make in integrating Design thinking?
10. What advice do you have for other teachers who are looking at integrating Design thinking into their content area instruction?
11. How have students responded to Design thinking?
12. How do you see Design thinking meeting the needs of the Common Core State Standards?
13. Describe the essence of integrating Design thinking into Math
14. Looking at the provided definition of Mastery, how well do you feel Design thinking helps student master the Common Core State Standards?

Appendix C: Design Thinking Portfolio Checklist

☐	Lesson plan #1 Pre-lesson Reflection
☐	Lesson plan #1 showing Design thinking Elements
☐	Lesson plan #1 Post-lesson Reflection
☐	Lesson plan #2 Pre-lesson Reflection
☐	Lesson plan #2 showing Design thinking Elements
☐	Lesson plan #2 Post-lesson Reflection
☐	Lesson plan #3 Pre-lesson Reflection
☐	Lesson plan #3 showing Design thinking Elements
☐	Lesson plan #3 Post-lesson Reflection

Pre-Lesson Reflection: Please focus on why you choose the resources you did, what part of design thinking is being used and why? What are your expected outcomes? How are you hoping to see mastery?

Post-Lesson Reflection: Please reflect upon the lesson's success, failures, changes and how did Design thinking help students master or not master the concept based on the study's definition of mastery.

Appendix D: Statement of Original Work

The Concordia University Doctorate of Education Program is a collaborative community of scholar-practitioners, who seek to transform society by pursuing ethically-informed, rigorously- researched, inquiry-based projects that benefit professional, institutional, and local educational contexts. Each member of the community affirms throughout their program of study, adherence to the principles and standards outlined in the Concordia University Academic Integrity Policy. This policy states the following:

Statement of academic integrity.

As a member of the Concordia University community, I will neither engage in fraudulent or unauthorized behaviors in the presentation and completion of my work, nor will I provide unauthorized assistance to others.

Explanations:

What does "fraudulent" mean?

"Fraudulent" work is any material submitted for evaluation that is falsely or improperly presented as one's own. This includes, but is not limited to texts, graphics and other multi-media files appropriated from any source, including another individual, that are intentionally presented as all or part of a candidate's final work without full and complete documentation.

What is "unauthorized" assistance?

"Unauthorized assistance" refers to any support candidates solicit in the completion of their work, that has not been either explicitly specified as appropriate by the instructor, or any assistance that is understood in the class context as inappropriate. This can include, but is not limited to:

- Use of unauthorized notes or another's work during an online test
- Use of unauthorized notes or personal assistance in an online exam setting
- Inappropriate collaboration in preparation and/or completion of a project
- Unauthorized solicitation of professional resources for the completion of the work.

Statement of Original Work (Continued)

I attest that:

1. I have read, understood, and complied with all aspects of the Concordia University-Portland Academic Integrity Policy during the development and writing of this dissertation.
2. Where information and/or materials from outside sources has been used in the production of this dissertation, all information and/or materials from outside sources has been properly referenced and all permissions required for use of the information and/or materials have been obtained, in accordance with research standards outlined in the *Publication Manual of The American Psychological Association*

Darlene Painter

Digital Signature Name (Typed)

June 13, 2018

Date