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Careers in STEM Begin with Elementary Student Interest in Mathematics

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Walden University
2017

Abstract

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MA, Walden University, 2003

BS, University of South Florida, 1982

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

I investigated why math capable students are not entering science, technology, engineering, and math (STEM) careers. To research the problem, I explored how highly effective math teachers (HEMT) create student interest in mathematics using the self-efficacy (SE) theory and information and communication technology (ICT). The purpose of the study was to discover if teacher training and instructional strategies could influence student interest in mathematics to improve STEM career entry. The theoretical framework adopted for this study was the SE theory, and the 4-phase model of interest development was the conceptual framework. Participants in this multi-case qualitative study included 5 HEMT who work in a southern ICT-based urban school. The data gathered were individual teacher observations, interviews, and discussions about student artifacts, which were then analyzed for themes and patterns using NVivo software. The results indicated that the teacher participants use vertical curriculum experiences to improve student SE in 4th and 5th-grade students to fill-in curriculum gaps. Also, problem-solving math equations based on real-world simulations are used to stimulate and sustain a perceived student interest in mathematics. Additionally, ICT was used to augment math lessons and to personalize learning. Society will benefit from this information when educational stakeholders implement instructional strategies that improve student interest through the use of real life scenarios. Real-world math applications can influence elementary student interest in taking higher levels of math education that lead to STEM careers.

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Dedication

For my father and students.

Acknowledgments

Thank you to my committee and the Walden University staff for providing me with the opportunity to expand myself in a way I never thought possible. To all the researchers who came before me, thank you for providing me with the platform to study the art of education, and to those researchers who follow in the future, I trust my investigation will be a platform for your research. A special appreciation to my family, friends, students, and colleagues for their support through this transformative journey. Finally, to the teachers who made a difference in my life, gratitude for teaching me to care about my students and improve myself.

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Chapter 1: Introduction to the Study

Introduction

In a quest to raise the rate of students entering science, technology, engineering, and math (STEM) careers, U.S. education systems have taken the leap of providing teacher training in STEM education. The initiative's goal is to improve student entrance into postsecondary STEM education through teacher knowledge and self-efficacy (SE) for teaching STEM, thereby increasing student knowledge in STEM; however, student content knowledge in STEM does not lead directly to higher levels of STEM career entry (Ruthven et al., 2011). Educational stakeholders need additional information to make informed decisions regarding STEM teacher training, specifically about teacher SE and how it is communicated to students.

In this study, I explored teacher instructional strategies that were intended to improve student SE and math interest as a potential influence on STEM career choice. In qualitative studies, researchers have found how elementary level teaching practices enhance math students' SE led to a reciprocal effect of strengthening sustained student interest in math education (Brown, 2012; Piotrowski & Hemasinha, 2012; Stevens, Harris, Aguirre-Munoz, & Cobbs, 2009). There is little research about elementary level instructional strategies used by teachers to enhance student interest in math though (Brown, 2012; Piotrowski & Hemasinha, 2012). Brown (2012) argued that mathematics is a precursor to postsecondary STEM entrance and posited that understanding how elementary level instructional strategies influence student SE and sustained interest in mathematics provides educational stakeholders with needed information to improve a student's foundation in mathematics. Consequently, this discovery can lead to positive social change in elementary math instruction.

For improved student SE, some researchers have also supported the use of technology (Arslan, 2012; Herrington, Reeves, & Oliver, 2010). The International Society for Technology in Education (ISTE) publishes widely adopted standards to aid in teaching K–12 teachers and students in Information and Communication Technology (ICT). These standards include pedagogical practices that are used to enhance SE in ICT (ISTE, 2013). Combining the role of teacher influences on student SE in elementary STEM education with the role technology can play in student SE, a research gap existed in determining how elementary teachers use ICT instructional strategies to influence students' SE and to improve sustained student interest in mathematics.

In this chapter, I will present the rationale for this study on how the theoretical framework of SE and instructional strategies using ICT are applied. In this study, I discovered effective elementary math teachers' instructional strategies for building student SE and student interest in mathematics at the primary level of education. The theoretical framework of the study was based on Bandura's (1977) SE theory and Hidi and Renninger's (2006) four-phase model of interest development (FPMID) as the conceptual framework. Also, Hattie's (2013) synthesis of meta-analyses provided principles of classroom management that support highly effective teacher strategies.

Hidi and Renninger's (2006) FPMID demonstrates how the deepening of learner interest leads to a well-developed individual interest. Elementary students who possess a personal SE belief for mathematics may cultivate a sustained individual interest in mathematics. Through an understanding of how elementary level teaching practices influence student interest in mathematics, educational stakeholders may strengthen student interest in STEM education (Brown, 2012; Piotrowski & Hemasinha, 2012; Stevens et al., 2009).

Informal interviews permitted me to gather the teacher participants' thoughts and feelings about instructional strategies and teaching mathematics at the elementary level. Additionally, teacher participants brought student work samples to their interviews with me. The artifacts are results of class math instruction that demonstrate student interest in a lesson. Reporting of student comments added to the qualitative context of teacher instruction. Conducting open-ended teacher interviews about instructional strategies allowed me to explore answers to the research questions about SE, sustained interest, and ICT.

My use of the multiple-case study approach (see Lancy, 1993; Yin, 2009) gave the teacher participants an opportunity to discuss the instructional strategies they use in class, including ICT approaches. I asked questions about the student work samples to elicit information designed to address the research questions. Patterns and themes emerged from the teacher conversations, which led to evidence of a link between ICT instructional strategies and a sustained student interest in mathematics.

The SE model (Bandura, 1977) supported exploration of the gap I found between how elementary teaching methods improve student interest in math and STEM career interest. Fisher, Doctoroff, Dobbs-Oates, and Arnold (2012) suggested the impact of a teacher's ability to improve student interest in mathematics may affect student math experiences through how teachers approach teaching mathematics. Some recent studies have shown that student opinions about mathematics formed during their elementary years influenced their STEM career interest (Brown, 2012; Burton, 2012, Marshall, Horton, Igo, & Switzer, 2009; Piotrowski & Hemasinha, 2012).

Background

Research was needed to understand how teachers build interest in math among elementary students. Elementary students who possess a personal SE belief for mathematics may cultivate a sustained individual interest in math (Hidi & Renninger, 2006). Bandura (1997) stated that SE stems from the an individual's beliefs in their abilities, motivation factors, and familial and educational influences to succeed. Given the important role that SE plays in math interest at the elementary level, it was important to address the research gap in highly effective math teachers' (HEMT) instructional strategies that included ICT and sustained student interest in mathematics.

Well-developed individual interest in mathematics occurs when students with emerging individual interest persevere through challenging math assignments (Hidi & Renninger, 2006). Drawing on encouraging words from their teacher, a student develops coping behavior mechanisms that minimize anxiety during the challenging lesson or assignment. Through perseverance, student confidence improves their SE (Bandura, 1977).

Burton (2012) suggested that teachers, even at the primary level, demonstrate mathematics anxiety stemming from low SE in teaching mathematics. This anxiety carries over to their students, which leads to students feeling inept at understanding math and its application. Since many college teacher programs require few math classes for preservice elementary teachers, future educators may not feel confident about teaching mathematics, even at the elementary level (Brown, 2012; Madden, Beyers, & O'Brien, 2016).

Using SE judgments from Bandura's (1977) unifying theory of behavioral change for personal efficacy, I explored the influence of SE as a principle of change. Many teachers are unaware of the concept of SE and how to build achievement in students as Stevens et al. (2009) reported that SE is not a well-known term in public school K–12 settings. Stevens et al., (2009) demonstrated that public school classroom teachers do not usually reflect on the student's SE to improve content knowledge. Stevens et al. suggested that mathematics teachers need professional development (PD), so they may learn how to improve on content knowledge, analyze teaching methods, improve interprofessional skills, and exercise classroom management to improve student SE for math.

The construct of SE was drawn from Bandura (1986). I addressed teacher math content knowledge in this study because pedagogical development was found to improve student engagement (see Ruthven et al., 2012). Their findings led to teacher PD for incorporating STEM into subject areas. However, Ruthven et al. (2012) measured improved student math content knowledge. That does not necessarily lead to STEM career entrance, thus, the need for this study.

Current math and science experiences in school are not resulting in sustained student interest in STEM careers at a time when more STEM-trained workers are needed.

Hattie (2013) suggested that teachers who provide good classroom climate experiences and build positive student-teacher relationships are more likely to have students achieve success. Therefore, student math interest may develop for students who have classroom teachers that provide experiences which include positive classroom climates, successful teacher-student relationships, and who use instructional strategies as a means for improved student SE in mathematics.

Providing elementary teachers with instructional strategies for improving student SE and interest in math may lead to greater sustained student interest in mathematics by the time students begin secondary education. My additional data gathering goals in this study were needed to determine what teachers do in the classroom to stimulate sustained student interest in mathematics and improve student math SE. Hidi and Renninger's (2006) FPMID authenticates learner interest as an area of exploration regarding SE. I investigated whether the verbal persuasion of HEMTs has a reciprocal effect on student SE and math interest in this study. Through observations, teacher interviews, and teacher-student feedback, instructional strategies that produce math interest in elementary students were discovered. The model helped me extend existing research on ways interest affects SE, goal setting, and the ability to self-regulate behavior.

As suggested by the National Educational Computing Conference's 2013 report, elementary school (ES) teachers who successfully teach mathematics to their students may improve STEM awareness and interest in STEM careers. Ultimately, this interest in STEM careers could fill projected job needs in the United States. I was not able to find any empirical research that described what highly effective teachers do to generate sustained math interest among their elementary age students. Consequently, this study was needed to discover how teacher instructional strategies influence student SE judgments and sustained interest in mathematics.

Problem Statement

Inadequate SE and interest for mathematics propagate the belief that U.S. students do not have the math foundation needed to enter STEM careers (Bandura, 2001; Ruthven et al. (2011). It is not clear how elementary teachers improve student interest in math because few studies exist on this topic at the elementary level. Heightened student SE for mathematics appears to improve mathematical content knowledge in students (Bandura, 1977). Mathematic trends are showing possible student improvement when taught by teachers who have graduated from programs of study (POS) or PD classes with a focus on ICT-based instructional strategies in math education (Brown, 2012; National Center on Education and the Economy, 2013; National Center for Women & Information Technology, 2013). However, improved content knowledge in mathematics does not equate to student entry in STEM careers (Piotrowski & Hemasinha, 2012).

A research gap existed in determining whether instructional strategies can influence student interest in mathematics, criteria for STEM entry, and if that interest improves when students use ICT when learning math. Hidi and Renninger's (2006) FPMID explains how intrinsic interest develops, and the paradigm demonstrates how teachers can engage individual math interest in young students. Therefore, it was important to study the impact of an HEMT instructional strategies and their effect on student math interest.

Purpose of the Study

The purpose of the study was to explore how HEMT use ICT to teach mathematics to their students. I used a multicase study to examine this topic and Bandura's (1977) SE judgments provided the foundation of the theoretical framework for this dissertation. Brown (2012) stated elementary level teaching practices enhance a math student's SE. Sustained student interest in math during the elementary years may improve student entry into secondary education classes that lead to STEM careers (Fisher, Dobbs-Oates, Doctoroff, and Arnold,2012) .

In this study, I also explored and described the relationship that exists between SE and interest in mathematics as perceived by HEMT. The exploration supported previous research on the reciprocal effect of SE judgments and sustained student interest in elementary math (Piotrowski & Hemasinha, 2012; Stevens et al., 2009). I also attempted to discover if verbal persuasion of HEMT had a reciprocal effect on student SE and math interest required exploration and asked HEMT how they felt about how teaching mathematics correlates to the physiological feedback in Bandura's SE judgments. As I expected, the reciprocal effects between student SE and sustained interest in mathematics were revealed by the teachers and reported in the research study.

Research Questions

I addressed the following case study questions in this study:

1. What experiences of HEMT affect their ability to teach mathematics to elementary students?

2. What instructional strategies do HEMT model to stimulate and sustain a perceived student interest and SE in mathematics?
3. How do HEMT facilitate their use of ICT to enhance student SE and interest in math?
4. How do HEMT feel about a perceived reciprocal effect in student SE and math interest due to the use of instructional strategies?

Conceptual Framework for the Study

The contextual lens that I used in this multicase study approach was formed from Bandura's (1977) SE judgments, Hidi and Renninger's (2006) FPMID in mathematics, and Hattie's (2013) classroom management meta-analyses. The framework, conceptualized through the literature, connects to the research questions. Bandura stated SE judgments influence individual efficacy beliefs and that experience of mastery arises from effective performance; in other words, that success leads to interest. Hidi and Renninger's model describes four phases in the development and deepening of learner interest that leads to a well-developed individual interest. While Hattie's meta-analyses suggest classroom teachers that provide positive classroom climates, successful teacher-student relationships, and who use instructional strategies as a means for improved student SE in mathematics lead to student success.

Bandura's SE theory was demonstrated in the participants' responses through judgments of experiences, emotions, feedback, and teacher modeling (see Redmond, 2010). The theory informed Research Question 1 on teacher feelings about their personal math ability and the more likely classroom teachers are to make an effort in preparing to teach math (see Piotrowski & Hemasinha, 2012). Hidi and Renniger's (2006) belief that elementary students who possess a personal SE for mathematics may cultivate a sustained individual interest in mathematics informed Research Questions 2 and 3. These questions also included the instructional strategies of ICT used by HEMT. Hattie (2013) revealed that good classroom climates build a positive student-teacher relationship that leads to students who achieve success, which informed Research Question 4 on the reciprocal effects of student SE and interest due to the use of instructional strategies of HEMT. A more detailed analysis of the conceptual framework and the logical connections among the key elements can be found in Chapter 2.

Nature of the Study

The nature of this qualitative multicase study included interviewing highly effective elementary teachers who teach math. Yin (2009) and Lancy (1993) suggested a qualitative approach as an appropriate method to provide teachers the opportunity to discuss their thoughts in depth. A qualitative approach permitted the HEMTs to self-report in this study. My triangulation of a class climate observation, a 40-minute interview with the HEMT participant, and a discussion about student math interest with each teacher participant gave a snapshot of the math classroom. Through an interview process, the teachers shared some of their perceived ideas on how they use instructional strategies to teach elementary math with me.

I began this study using a quantitative approach; however, quantitative research strategies were inadequate to explore and describe how student math interest leads to a career in math. I determined a qualitative study was necessary to gather observatory and descriptive data. Using qualitative interview techniques to collect data helped me find patterns and themes of how students become interested in careers, which require higher-level mathematics.

During the interview sessions, I prompted the five highly effective teacher participants to elaborate on the interactions they experience when teaching math. Their perceived thoughts linked to the purpose of the study and the research questions on student interest in mathematics. Additionally, I gathered data on teacher perceptions and educators' use of ICT when teaching math to their students. This process allowed for the discovery of student SE and sustained interest in mathematics as a reciprocal effect.

Using SE judgments from Bandura's (1977) framework, I explored how teacher instructional strategies can lead to a reciprocal effect on student SE and interest in mathematics. SE judgments include a person's past performance and vicarious experiences, physiological and emotional states, and verbal persuasion (Bandura, 1977). Interest is a psychological state where the last stage of development applies to in-school and out-of-school learning (Hidi & Renninger, 2006).

Essential to the study were HEMT perceptions and their self-reporting on student experiences, emotions, and feedback during math lessons, assignments, and projects. Asking questions about teacher perceptions during the interview process allowed me to collect rich data for the study. My goal of discovering how to create a principle of change that leads to a sustained student interest in math can direct more students into STEM careers.

The research questions I developed focused on teacher instructional strategies, how teachers incorporate ICT into the math lessons, how teachers feel about math themselves, and how teacher instructional strategies affect student interest in math. My use of an interview approach allowed teachers the opportunity to describe overheard comments as students worked on their assignments or student work samples. Teacher self-reports are a constructive type of data to collect because rigor is improved (see Patton, 2002).

I invited five highly effective elementary math teachers to participate in the study based on their exemplary teacher effectiveness system (TES) rating. The teachers had a broad range of experiences and came from a large, diverse, southern public school district. Participants were interviewed in their classroom, which allowed for a comfortable atmosphere (see Patton, 2002). Additionally, student work samples were readily available to add to my data collection. During the interview sessions, I asked teachers to provide student work samples that reflected student interest in the math assignment. The artifacts allowed the teachers to explain the process that took place as students worked on their assignments. Talking about the work sample allowed me to gather student comments on their feelings and interest. I audio recorded the individual teachers in their classroom during the open-ended interview sessions to provide an accurate data collection.

I used NVivo software to analyze the collected data and to a priori code the data collection. The codes served as a way to tag, compile, and organize the data. This process allowed me to summarize and synthesize the data collection.

Definition of Terms

Classroom climates: Expert teachers create classrooms in which errors are welcome (Hattie, 2013).

Effective teacher: The state superintendent states that effective teachers promote student learning by using research-based instructional strategies relevant to the content to engage in active learning and to facilitate the students' acquisition of key knowledge and skills.

Experience of mastery: Cognitive events are induced and altered by experience of mastery from effective performance (Bandura, 1977).

High expectations: The teacher finding out what the student's expectations are and pushing the learner to exceed these expectations (Hattie, 2013).

Highly effective elementary teacher who teaches mathematics: A teacher who scores exemplary under the TES Review headings of Planning, Instructional Delivery, and Learning Environment (TES, 2013–2014).

Information and communication technology (ICT): Content standards and related digital curriculum resources that are aligned with and support digital age learning and work (ISTE, 2014).

Instructional strategies: The teacher continually facilitates students' engagement in metacognitive learning, higher-order thinking skills, and application of learning in current and relevant ways (TES, 2013–2014).

ISTE standards: ISTE standards for evaluating the skills and knowledge educators need to teach, work, and learn in an increasingly connected global and digital society (ISTE, 2014).

Passion for math: The teacher allows students to enjoy their learning challenges and to overcome their learning frustrations (Hattie, 2009).

Positive classroom climates: The teacher continually engages students in a collaborative and self-directed learning environment where students are encouraged to take risks and ownership of their own learning behavior (TES, 2013–2014).

Self- efficacy (SE): beliefs among mathematics majors: A person's ability to perform at an optimal level in their chosen career. (Piotrowski & Hemasinha, 2012)

Self- efficacy (SE) judgments: Variations in behavioral change (Bandura, 1977).

Student (SE): A person's belief in their self-regulatory efficacy, which promotes cognitive growth (Bandura, 1997).

Sustained interest: This interest leads to increased persistence, positive affective engagement, and the tendency to direct attention to the object/event of interest over and above other choices (Hidi & Renninger, 2006).

Teacher self-efficacy (SE): A teacher's ability to perform at an optimal level in their career (Piotrowski & Hemasinha, 2012).

Teacher Effectiveness System (TES): Evaluation system used by a large, diverse, southern public school district (TES, 2013–2014).

Understanding: A teacher's deep conceptual understanding of elementary mathematics (Stevens et al., 2009).

Vertical curriculum: Knowledge and skills of information management. What is learned and evaluated in one course prepares students for the next course, which are used and further developed across a whole program of study (POS) (McGowan et al, 1998).

Well-developed individual interest: The student values the opportunity to reengage tasks for which they have a well-developed individual interest and will opt to pursue these if given a choice (Renninger et al.2004).

Assumptions

I held the following assumptions in this study:

- HEMT in this study have exemplary skills for teaching elementary level mathematics based on the school district's TES rating. The district's TES is based on the Georgia Teacher Evaluation System, which used the federal Race to the Top executive summary to support teaching and learning.
- TES administrator analysis was a valued measure of highly effective teachers. District use of the TES by the local school administration was assumed a valid measure of exemplary teacher ability to teach mathematics. District administrators were specifically trained to complete the TES.
- Teacher self-reports were perceived to be an accurate account of the instructional strategies used by the teacher due to the exemplary status on the district TES.
- Teachers were honest with their answers.

Scope and Delimitations

Content knowledge is often a key focus in STEM career entry studies; however, my review of the extant literature revealed interest as a influence in career choice. Ruthven et al. (2011) supported the particular focus of intrinsic interest instead of content knowledge in STEM career choice. Therefore, I excluded content knowledge from the framework in this study. An aspect of the research problem explored teacher instructional strategies, including ICT methods to improve student interest in mathematics.

In this 2-month study, participants were comprised of elementary grade level teachers located in two local schools in the district. I chose the schools based on their technology usage in daily lesson plans. The ISTE standards provided a framework for teachers to describe their perceived use of ICT instructional strategies in digital content and technology. Digital audio recordings were used to help manage researcher bias. Patton (2002) suggested the use of audio recordings to capture accurate quotations and the interviewee's words during interviews used in fieldwork. During interviews, the discussion of learner work samples allowed the teachers to convey comments about student interest in math during class assignments.

Limitations

The findings in this multicase study cannot be generalized but may contribute to the knowledge of developing student interest in STEM careers. My triangulation of a class climate observation, a 40-minute interview, and a discussion about student math interest with each teacher participant provided a snapshot of the math classroom. The triangulation did not allow for a measurement of student sustained interest though. Future studies need to focus on additional populations to generalize to a larger sample.

Sample participants who held advanced degrees were able to articulate what they do and how it affects student SE and interest during the interview session quite easily. However, I used probing questions during one interview to clarify participant answers to the questions. Also, participant follow-up questions were used to address concerns for the clarity of student remarks overheard by the teachers.

Significance of the Study

In this study, I looked into instructional strategies as an approach to influencing student interest in mathematics. STEM occupations are considered by employers to be an area of need, but not enough elementary age children are interested in math or other STEM careers (DeJarnette, 2012; Pajares, 1997). The trend continues through secondary school and college, resulting in a shortage of trained people to fill STEM jobs (NRC, 2011).

Improved student SE for mathematics leads to increased interest in math education, a foundation for STEM careers (Bandura, 1997). A strong math foundation allows for future STEM career opportunities in ICT and other areas of STEM where job needs continue to grow. The results of this study may lead to changes in teacher education programs to improve student interest in mathematics. Exploring how ICT was used as an instructional strategy for math interest allowed me to provide recommendations to educational stakeholders for the improvement of teaching elementary level mathematics. This exploration of the reciprocal effects between student

SE and sustained math interest may provide more students with the needed math foundation to enter STEM careers.

Summary

Several explanations exist as to why a higher percentage of college students do not enter and graduate from STEM majors. Evidence points to the factors that influence student entrance and success in the area of STEM career awareness; two specific factors are weak math knowledge and interest (Fisher et al., 2012; Hidi & Renninger, 2010). Elementary student SE, interest in mathematics, and teacher ICT instruction-based strategies were areas for exploration in this study. My focus on the areas in this study provided information needed to improve student entrance into STEM careers. Through the improvement of student efficacy in math, intrinsic interest in mathematics develops.

In this study, I explored how the SE theoretical framework can be interpreted to show what affects student interest in mathematics. A reciprocal effect between SE and student interest in math led to understanding how elementary level instructional strategies influence student SE and interest in mathematics. This knowledge can provide educational stakeholders with needed information to improve a student's foundation in mathematics.

Bandura (1997) stated that SE stems from an individual's beliefs in their abilities, motivation factors, and familial and educational influences to succeed. Bandura argued that personal and challenging standards encourage the building of competencies, allowing for the achievement of student goals. Hence, student SE in mathematics develops when teachers promote student learning using relevant mathematics to engage students in active learning. Given the important role that SE plays in math interest at the elementary level, it was important for me to address the research gap between HEMT usage of ICT and students' SE and intrinsic interest in math in this study.

The SE model supported my exploration of the gap found between how elementary teaching methods improve student interest in math and STEM career interest. My exploration of how a highly effective math teacher acts to promote student interest in mathematics led to an understanding of how teachers approach teaching mathematics to affect student experiences. Teacher actions using ICT were of particular relevance. By discovering how elementary level teaching practices influence student interest in mathematics, educational stakeholders can strengthen student interest in STEM education (Brown, 2012; Piotrowski & Hemasinha, 2012; Stevens et al., 2009).

Hidi and Renninger's (2006) FPMID described four phases of learner interest that lead to a well-developed individual interest. The model authenticates learner interest as an area of exploration regarding SE (Bandura, 1977). Elementary students who possess a personal SE belief for mathematics cultivate a individual interest in math (Hidi & Renninger, 2006).

My primary focus in this study was HEMT instructional strategies, which included ICT-based strategies for generating student interest and improvement of SE in mathematics. Grasping how elementary level teaching practices enhance math student's SE may lead to a reciprocal effect of strengthening student interest in math education (Brown, 2012; Piotrowski & Hemasinha, 2012; Stevens et al., 2009). Student intrinsic interest in math during the elementary years improves student entry into secondary education classes that lead to STEM careers (Fisher et al., 2012; Hidi & Renninger, 2010).

In Chapter 2, the literature review will contain an exploration of SE as a framework for increasing interest in math among elementary students. SE judgments provided the foundation of the theoretical framework for this study, and the FPMID explained how attraction to math develops. The model extended existing research on ways interest affects SE, goal setting, and the ability to self-regulate behavior (Hidi & Renninger, 2010). Additionally, the model provided an explanation of how interest is a powerful influence on learning. I will describe the methodology of this study in Chapter 2.

Chapter 2: Literature Review

Introduction

Inadequate SE and interest for mathematics propagate the belief that U.S. students do not have the math foundation needed to enter STEM careers. Mathematic trends are showing possible student improvement in math when taught by teachers who have graduated from POS or PD classes with a focus on ICT-based instructional strategies in math education (Brown, 2012; National Center on Education and the Economy, 2013; National Center for Women & Information Technology, 2013). However, improved content knowledge in mathematics does not equate to student entry in STEM careers (Piotrowski & Hemasinha, 2012).

I used a multicase study and explored how HEMT use ICT to teach mathematics to their students. Bandura's (1977) SE judgments provided the foundation of the theoretical framework for this dissertation. Brown (2012) stated elementary level teaching practices enhanced a math student's SE. Sustained student interest in math during the elementary years may improve student entry into secondary education classes that lead to STEM careers (Fisher, Dobbs-Oates, Doctoroff, and Arnold,2012).

The relationship that exists between SE and interest in mathematics as perceived by HEMT showed that a reciprocal effect on SE judgments and individual interest led to a perceived student interest in elementary math (see Piotrowski & Hemasinha, 2012; Stevens et al., 2009). As I expected, the reciprocal effects between student SE and interest in math were revealed by the teachers and reported in the research study.

The major sections in this chapter will include SE, SE judgments, and intrinsic interest development. I will also discuss Hidi and Renninger's (2006) FPMID explains how intrinsic interest develops and how the paradigm demonstrates how teachers can engage individual math interest in young students. This literature review will also include teacher instructional strategies and the reciprocal effects in SE and interest.

Literature Search Strategy

The databases I used to locate the literature for this review included Academic Search Complete, Dissertations & Theses, Ed/ITLib Digital Library, Education Research Complete, ERIC, ProQuest Computing, and PsycARTICLES. The following keywords were used: *elementary math, highly effective teacher, Information and Communication Technology, instructional strategies, interest, math teachers, primary math, and self-efficacy*.

I reviewed over 200 abstracts on SE content specific to interest in elementary math or instructional teaching strategies. The information I obtained resulted in fewer than 50 studies relevant to the research problem. I found seven peer-reviewed journal articles on the reciprocal effects of SE and student interest in mathematics at the elementary level. Adding ICT to the search lowered the number of studies to three. Furthermore, much of the literature measured SE for improved content knowledge and not student interest. Additionally, 32 studies I found focused on secondary education math and not elementary level mathematics. The small number of studies found confirmed the need for further evidence to explore the process for improving elementary student interest in mathematics.

Theoretical Foundation

The major theoretical propositions that I used to create the theoretical foundation for this study included Bandura's (1977) SE framework and Hidi and Renningers' (2006) FPMID. I explored the thinking process as a principle of change. Many teachers are unaware of the concept of SE because it is not taught to them, and they do not know how to build SE in students (Stevens et al., 2009.) It was important for me to determine if teacher awareness of SE during the learning process helps students improve interest in mathematics.

SE judgments provided part of the foundation of this dissertation. Bandura's (1977) SE theory listed four SE judgments necessary to influence individual efficacy beliefs: performance accomplishments, vicarious experiences, verbal persuasion, and physiological feedback. I will explain these four SE judgments in greater detail in the following section.

Hidi and Renningers' (2006) FPMID explained how interest in math develops. Their model extends existing research on ways interest affects SE, goal setting, and the ability to self-regulate behavior. The FPMID provided an explanation of how interest is a powerful influence on learning, although I did not measure mathematics or career aspirations in this study. Instead, I explored teacher instructional strategies that included the use of ICT that improve student interest in mathematics.

Building on the previous work on the model of domain learning, person-object theory, and the psychology of constructive capriciousness, the FPMID strengthens the purpose for sustained interest (Renniger &Hidi, 2011). The model demonstrates how interest develops as a motivational variable in learning (Renniger &Hidi, 2011). In a review of the FPMID, Harackiewicz, Durik, Barron, Linnenbrink-Garcia, and Tauer (2008) offered strong support for the model and supportive rationale of the chosen theories for this study. The paradigm demonstrates how teachers can engage individual math interest in young students (Hidi & Renninger, 2006).

Harackiewicz, Barron, Tauer, Carter, and Elliot (2002) determined factors that maintained college students continuing interest were better predictors of interest than triggered interest. Duplicated results from Harackiewicz, Barron, Tauer, and Elliot (2002) added to the validity that the FPMID model justifies the need for SE and interest to create a sustained interest throughout education levels. The longitudinal study conducted by Harackiewicz et al. (2008) also supported the findings on achievement goals and ability measures of college student interests. However, the listed studies cannot be generalized to elementary mathematics.

Conceptual Framework

I used Bandura's (1977) SE judgments, Hidi and Renninger's (2006) FPMID, and Hattie's (2013) classroom management meta-analyses as the conceptual framework in this study. Student SE judgments in mathematics can change student interest in mathematics. Bandura (1986) stated that personal, behavioral, and environmental influences woven together result in altered behavior through self-reflection; these self-regulatory mechanisms present the potential for changes in behavior. In this study, I used Hidi and Renninger's (2006) FPMID to explain how interest in math develops. Hidi and Renninger built on existing research to create their model, in which they described the four phases in the development and deepening of learner interest. Phase 1 of interest development triggers situational interest, and curiosity, spurred by the environment externally supports interest. Phase 2 maintains situational interest, where continued interest occurs. In Phase 3, the beginning phases of individual interest emerge, and long-term interest over time continues to develop. The final phase of development is Phase 4, which Hidi and Renninger labeled as a well-developed individual interest. In Phase 4, a person chooses to pursue an area of interest as a choice. For purposes of this study, I called Phase 4 by the commonly known title of sustained interest.

In their study of 40 elementary students, Bandura and Schunk (1981) found that a person's judgments of their capabilities can affect the rate of math skill acquisition and performance mastery by boosting SE in a mutually enhancing process. Their findings revealed that mathematical performance and intrinsic interest in arithmetic activities relate to a student's perceived SE. The physiological state of children with higher efficacy levels demonstrated elevated levels of intrinsic interest in mathematics (Bandura, 1997). Students who demonstrated self-doubts concerning their capabilities showed little spontaneous interest in solving arithmetic problems (Bandura & Schunk, 1981).

Hattie's (2013) collection of meta-analysis on classroom management explained the teaching practices of HEMT, who teach math at the elementary education level. Researchers believe that SE is a result of the student's success in math (Brown, 2012; Stevens et al., 2009). The better a teacher feels about their personal math ability, the more likely they are to make an effort in preparing to teach math (Piotrowski & Hemasinha, 2012).

Teacher content knowledge, teaching methods, interprofessional skills, and classroom management are focal points during the teaching process. Hattie (2013) stated the importance of these areas for effective teaching to take place. In this study, I explored how HEMT used ICT-based instructional strategies to develop SE and interest in elementary math students.

Baya'a and Daher (2013) proposed that potentiality of ICT acts as a motivator for student learning and discovery of math concepts. They further stated that teachers who use ICT-based instructional strategies support independent student learning and development of math topics. Baya'a and Daher reported that independent learning and the discovery of math concepts leads to a deeper understanding of mathematical ideas.

This study benefitted from Baya'a and Daher's (2013) findings. Their results suggested that teacher attitudes and emotions towards the use of ICT in the mathematics classroom affected teachers' intentions to integrate ICT into their teaching. Additionally, they found that teacher's feelings of self-esteem and control in the presence of ICT also affected their teaching. Baya'a and Daher concluded that the result of ICT helps students achieve in mathematics.

SE, Judgments, and Intrinsic Interest Development as Key Variables

To improve SE for teaching mathematics, some education systems provide teacher PD in STEM. Polly, Neale, and Pugalee (2014) examined the influence of a 13-month PD program in mathematics on elementary teacher beliefs and practices. Their descriptive report centered on task-focused mathematics PD. Twenty-eight elementary teachers participated in their study, and all reported a positive effect in their mathematical knowledge, instructional practices, and positive beliefs in math as a subject area. The PD focused on helping teachers to improve their understanding of the mathematical concepts and pedagogies embedded in the districts' new standards-based mathematics curriculum. Using a multi-method approach, teacher-participants completed pre- and post measures of mathematical knowledge for teaching, teachers' beliefs about teaching and learning mathematics, and teachers' self-reports of enacted instructional practices.

Additionally, the Polly et al. (2014) study included observing three elementary math teachers. As the PD progressed, the observed teachers improved their high-level math problem tasks and math questions. In their study, Polly et al. called for further exploration into the topic using additional teacher interviews, observations, and data analysis of student work samples. Consistent with the scope of my study, the results of Polly et al.'s study relates to my interview questions and supports content validity as teachers describe student comments during class assignments. The results of the Polly et al. study provided information relevant to the interviews and observations that took place in my research. A more prescriptive approach to PD will provide policymakers with better guidance for teacher staff development in math teaching.

In Bailey's 3-year longitudinal study using 30 teacher participants, Bailey (2010) addressed changes in 13 elementary math teachers' content and pedagogical knowledge. The multivariate test analysis revealed that a strong effect size occurred in the areas of peer-to-peer interactions, peer-researcher interactions, and teacher immersion in the development of standards-based instruction, assessments, and homework. Bailey (2010) stated influencing teachers' subject area knowledge content, and pedagogical knowledge that uses research-based methods to integrate mathematics qualifies educators as highly effective to teach students.

A synthesis of the Polly et al.(2014) and Bailey (2010) studies suggests that: additional math classes improve a teacher's mathematics background, direct positive impact through teacher immersion improves mathematical knowledge, and instructional practices and SE beliefs improve a teacher's preparation for developing student content knowledge in mathematics. Interactive teaching is effective in developing content knowledge and skills in mathematics. Still, enhanced context, where teachers make strong links to student experiences and interests is under- investigated in mathematics (Ruthven et al., 2011).

In addition, the teachers who have taken classes in STEM improve their SE for teaching mathematics through task-focused mathematics. Exploring cognitive demanding mathematical tasks and high-level questions appear to be a critical influence on improved teacher pedagogy. Educators with enhanced SE in mathematics are better able to improve student SE in mathematics with elementary students (Brown, 2012; Ruthven et al., 2011; Howe, Mercer, Taber, Luthman, Hofmann, and Riga, 2012). Missing from the discussion is the role ICT plays in teacher pedagogical practices and developing student SE for improved interest in mathematics.

Still emerging as an explanation for sustained interest in mathematics, Hidi and Renningers' (2006) four-phase model of interest development (FPMID) may help answer the question of ICT-based instructional strategies and STEM career entry. Many knowledgeable math students do well in mathematics classes, but still do not pursue

STEM careers. STEM jobs usually require a foundation in math (National Educational Computing Conference, 2013). It could be that math knowledge is not the only factor in STEM career entry. I explored a well-developed individual interest or sustained interest in math, as it reciprocates with student SE in mathematics (Bandura, 1987). The reciprocal effect of mathematics is discussed later in the chapter.

Intrinsic Interest

In many cases, students develop math skills but continue to disengage themselves from math. Bandura (1997) reasoned the importance of cultivating intrinsic interest through the development of SE in Bandura's book: *The Exercise of Control* (p. 219). Through personal and challenging standards, students set goals for themselves, which upon completion, allow for the development of efficacy and intrinsic interest (Bandura, 1997).

Focusing on student interest in addition to knowledge may prove important in the classroom for continued postsecondary math interest. After all, engaging in a task for intrinsic interest helps to ensure long-term growth (Hofe, Lichtenfeld, Murayama, & Pekrun, 2013). Empirical studies abound regarding SE and content knowledge for student success in mathematics. Granted knowledge of mathematics is necessary, but the importance of the reciprocal effects of SE and interest require further investigation at the elementary grade level (Chatzistamatiou, Dermitzaki, Efklides, & Leondari, 2013).

Intrinsic motivation, enjoying what you do because it interests a person, is different from extrinsic motivation, which is completing a task for a reward. With extrinsic motivation, people involve themselves in the act because of outside motivation such as grades (Hofe et al. 2013). Extrinsic motivation causes students to earn high grades as a motivator for success, but the students do not necessarily have an interest in the subject or assignment.

Exploration of the effects of student SE continues to develop in education. Supportive evidence is unclear if SE and interest have a reciprocal effect similar to SE and knowledge. Lipstein and Renninger (2006) argued that teachers could influence academic interest in their students. Yet, some teachers believe they have no control of a student’s interest level. Hidi and Renniger (2012) stated interest is a psychological state that causes a person to reengage subject matter that leads to learning. Teachers who build student interest in mathematics help, even the youngest of children, enjoy learning math.

The FPMID accepts that young children have individual interest and differing conceptualizations from older children. Hidi and Renninger (2012) stated that emerging attention, goal-setting, and learning strategies, even in young children, leads to a predisposition for content learning in all ages. Fisher, Dobbs-Oates, Doctoroff, and Arnold (2012) argued that interest in learning could strengthen throughout childhood and lead to continued interest after post-secondary high school. Bridging the FPMID to SE and intrinsic interest in mathematics may help educators improve student math interest. Students, who have a well-developed individual interest in mathematics, phase four of the model, are more likely to enter STEM careers (Hidi & Renninger, 2010) because continued learning exists after the instruction has past.

Reciprocal Effects in SE and Interest

The ES years are critical for creating a sustained interest in mathematics. Thus, to improve career entrance in STEM more efficient math instruction should take place during the primary grades (Fisher et al., 2012; Hidi & Renninger, 2010). The National Council of Teachers of Mathematics (2002) has indicated its agreement by supporting early math instruction, and that math education should begin in preschool. By studying how highly effective elementary teachers who teach math implement mathematical instructional strategies, researchers can learn how to improve student SE and interest in math (Bandura & Schunk, 1981).

Piotrowski and Hemasinha's (2012) looked into career entry in their study. The research was limited to undergraduate college math majors enrolled in an STEM-specific career aspiration. The results from the 40-participant study revealed that math majors have a career interest in teaching, engineering, and finance. Piotrowski and Hemasinha (2012) demonstrated through their results that 25% of math majors plan to teach. However, the study focused on entry-level job preference and referenced high school and college level mathematics, but no data collection of elementary education occurred in the study.

In addition, Fisher et al. (2012) conducted a correlational study investigating the relationship between math interest and skill. The researchers measured preschool sample relationships between interest and skill simultaneously and over time. The sample consisted of 118 students, in two different Head-Start centers. Measured in the study were standardized math tests, behavioral assessments, and teacher surveys on the children's math interest.

The results of their study concluded that early interest in mathematics predicts strong math skills and "A reciprocal relationship between math interest and math ability may be in place as soon as preschool" (p. 673, para. 1). Additionally, they found that math skills moderately to strongly correlated with all measures of interest. Student age did not significantly moderate any of the relations between math skills and interest, although older children appeared more interested in math. Fisher et al. (2012) demonstrated a correlation of early math development to improve interest in math development. Not all children are raised in a positive atmosphere for mathematics; therefore, it is important to discover if a teacher can improve student math interest.

Accordingly, a belief in a person's self-regulatory efficacy promotes cognitive growth (Bandura, 1997). Consequently, HEMT who engage ICT-based instructional strategies for challenging material produces a positive classroom climate. Students can persevere through challenging material. This process leads to a sustained interest in math (Hidi & Renninger, 2006). With this in mind, HEMT who use ICT-based instructional strategies to teach mathematics create a reciprocal effect between student SE and sustained interest. This action may lead to a sustained interest in math at the elementary level.

The model in Figure 1 proposed a way that ICT-based instructional strategies may produce a reciprocal effect on SE and sustained interest in elementary students. The model shows that HEMT, who use multiple instructional strategies including ICT, may improve student math SE through a successful understanding of math concepts.

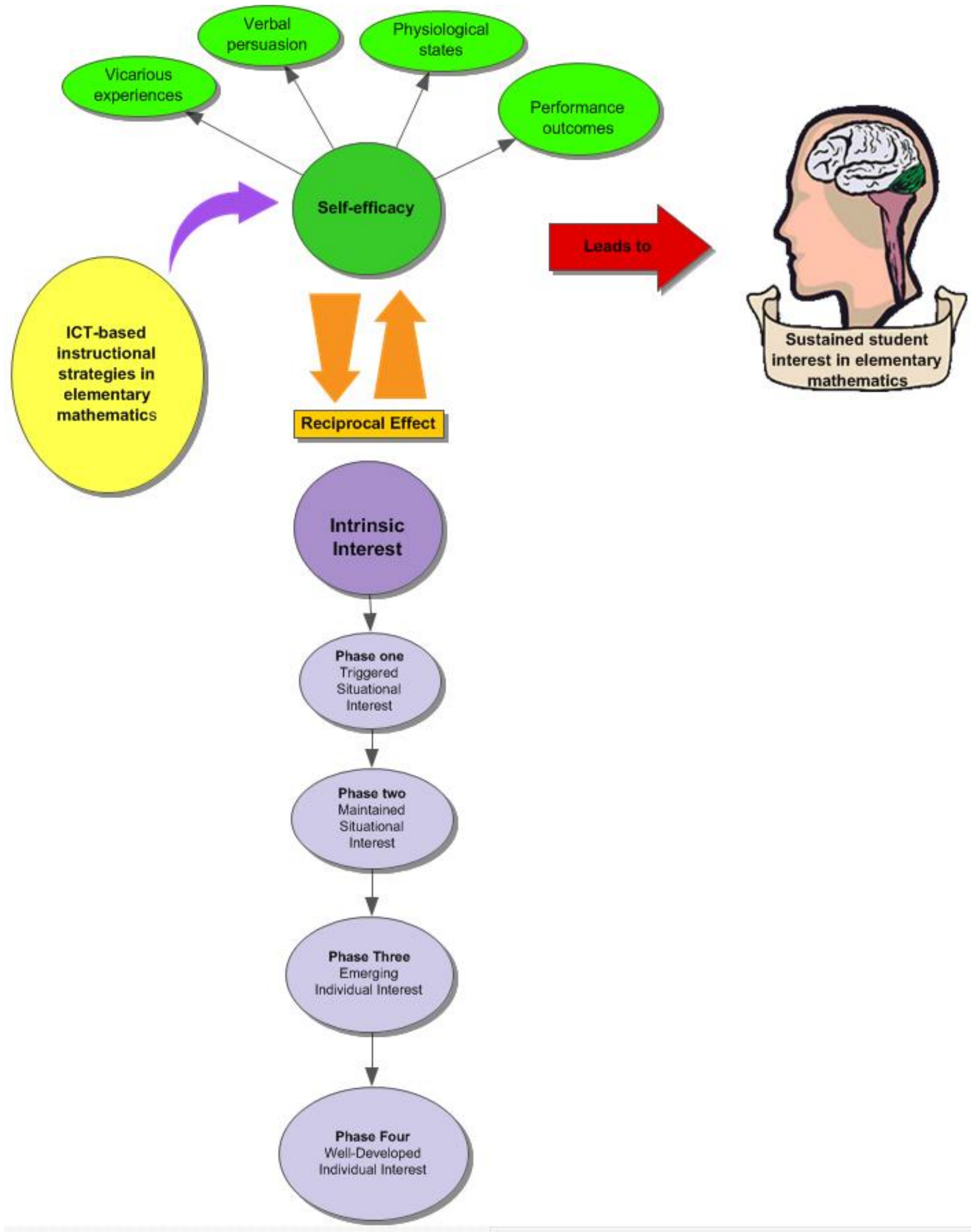

Figure 1. Model of ICT-based instructional strategy affect on self-efficacy and interest. By L. Brimmer, 2017

The model in Figure 1 suggests that developing math ICT-based instructional strategies may support student SE and sustained interest in mathematics for elementary level students. The reciprocal effects of SE and interest can lead to a sustained interest throughout post-secondary math education (Bandura, 1997; Hidi & Renninger, 2006). I found limited evidence on the claim at the elementary level in mathematics, so an exploratory study was conducted to add to the literature.

Summary

In summary, current literature establishes that heightened student SE for mathematics improves mathematical content knowledge in students (Bandura, 1977). However, improved content knowledge in mathematics does not equate to student entry in STEM careers (Piotrowski & Hemasinha, 2012). Discovering how highly effective math teachers use instructional strategies to create a reciprocal effect in SE and sustained interest occurred in the study.

The SE theory is demonstrated through judgments of experiences, emotions, feedback, and teacher modeling (Redmond, 2010). Elementary students who possess a personal SE belief for mathematics cultivate a well-developed individual interest in math (Bandura & Schunk, 1981). Exploration of ICT-based instructional strategies produced a reciprocal effect on SE and sustained interest in elementary students. The interest in mathematics may lead to a future STEM career choice.

Instructional Strategies

The US Department of Commerce (2011) predicts a 17% job growth through 2018 in STEM with not enough student interest to fill the available jobs. Of the studies I examined, none explored teacher instructional strategies as a measure in creating student math interest at the elementary level. Relatively few available studies suggest student interest in mathematics may lead to STEM careers (Fisher, Doctoroff, Dobbs-Oates, &Arnold, 2012, Hidi & Renninger, 2006, Piotrowski & Hemasinha (2012).

The National Council of Teachers of Mathematics (NCTM) and The National Association for the Education of Young Children (NAEYC) publish texts and resources to assist teachers developing instructional strategies in math content knowledge. NCTM offers principles and standards to describe features considered necessary in mathematics education. High-quality math principles describe components for mathematics education. NCTM (2015) standards describe the mathematical content and processes that children should learn. It is important to note that math content knowledge does not always lead to interest in mathematics. However, math knowledge does help lay the foundation for some STEM careers (Piotrowki & Hemasinha, 2012).

One factor for improved student math interest includes reducing anxiety in the classroom. Hattie (2013) stated positive classrooms environments are conducive to learning. Safe classrooms provide an environment for students to develop personal SE and a sustained student interest in mathematics. Burton (2012) suggested that teachers who teach at the elementary level demonstrate mathematics anxiety themselves stemming from low SE for teaching mathematics. The anxiety carries over to their students, which leads to students feeling inept at math content and application. The cycle leads to an unfavorable learning climate, which lessens interest in mathematics. Bailey's (2010) longitudinal study provided convincing evidence that components of teacher training should include ample focus in the following areas of study: (a) teachers' cognition, understanding and use of effective strategies for facilitating children's problem-solving; (b) teachers' knowledge about NCTM standards, NAEYC standards, and state mathematics standards; (c) teachers' understanding and use of NCTM principles relevant for developing an appropriate math curriculum (i.e., technology, and equity), and (d) mathematics content proven to impact teachers' ability to design and use authentic assessments.

College teacher programs require few math classes for preservice elementary teachers (Brown, 2012). The lower standard in math preparation leaves future educators with a lack of confidence in teaching mathematics, even at the elementary level (Brown, 2012, Madden, Beyers, & O'Brien, 2016). Brown's (2012) study suggests that teacher preparation for teaching mathematics at the elementary level may reduce teacher anxiety. Additionally, more math classes during preservice teacher education improve active teaching.

Adding to the teacher anxiety conversation for teaching math is a study conducted by Brown, Westenskow, and Moyer-Packenham (2011). Their study conclusion reveals that preservice teachers who participate in additional math methods courses utilize mathematic strategies and activities early in their teaching experiences to reduce math-teaching anxiety. Confirming researcher findings is a study by Piotrowski and Hemasinha (2012) which revealed that improved student SE occurs in math when teachers improve their self-efficacy for teaching mathematics. In conclusion, ample evidence exists to disclose that participation in STEM courses utilizing mathematic strategies and activities helps teachers alleviate math anxiety for teaching mathematics.

ICT-Based Instructional Strategies

Early exposure to computing activities leads to increased awareness and interest in STEM, a career area of need (Ashcraft, Eger, & Friend, 2012, Liston, Peterson, & Ragan 2008; NCEE, 2013). By discovering how elementary level instructional strategies influence student SE in mathematics, educational stakeholders may influence student interest in STEM education (Brown, 2012; Piotrowski & Hemasinha, 2012; Stevens et al., 2009). As student math skills improve, interest in mathematics grows (Fisher et al., 2012). Training teachers to use specific instructional strategies for teaching mathematics may support student math interest. Through PD in integrative teaching methods, educators become aware of their role in increasing student interest in math (Baya'a & Daher, 2013).

Teachers who take PD classes learn how to infuse ICT-based instructional strategies into elementary math lessons, which may help promote sustained student interest in mathematics. A teacher's use of ICT to improve student motivation and understanding of mathematics provides students with a deeper understanding of math concepts. Math knowledge gained improves student SE that can lead to a sustained student interest in mathematics.

How teachers feel about implementing ICT in the classroom can affect student learning. Baya'a and Daher's (2013) case study concluded four factors are necessary for successful integration of ICT into class math lessons. The factors include teacher perceptions of their ability in ICT, attitudes toward contributions, teachers feeling of control, and intentions to use ICT in the classroom. The researchers showed that students who gain a deeper understanding of mathematics discovered math concepts. The study results also concluded that teachers who use appropriate ICT instructional strategies motivate student learning through active teaching

Equally significant is the impact of state-mandated ICT PD courses. Educators who take classes in STEM improve their teacher SE for teaching mathematics (Carney et al., 2014). Significant changes occurred in SE and teacher PD in the Carney et al. study. The large-scale survey determined that PD influences and improves self- efficacy of reform-oriented instructional practices.

Neither the Baya'a and Daher (2013) or Carney et al. (2014) studies referenced the ISTE standards. ISTE standards are widely adopted published standards to aid in teaching K-12 teachers and students in ICT. ISTE standards are pedagogical practices that are used to enhance SE in ICT. Researchers support the use of technology for improved student SE (Arslan, 2012; Herrington, Reeves, & Oliver, 2010). A research gap exists in determining how elementary teachers use ICT instructional strategies to influence math interest.

Teachers introduced to the standards published by ISTE learn to infuse technology into K-12 student lessons. Through comfortable math classroom environments and lessons that infuse ICT, students may develop a sustained interest in mathematics. Understanding how HEMT use ICT-based instructional strategies to sustain student interest in math may ultimately lead to a better understanding of how to stimulate more sustained interest in STEM careers.

Earlier in the chapter, the NCTM was discussed. NCTM offers principles and standards to describe features considered necessary in mathematics education. High-quality math principles define components for mathematics education. NCTM standards describe the mathematical content and processes that children should learn (2015).

The below chart provides evidence that using NCTM standards and ICT to teach mathematics to students can allow children to learn visually and with hands-on activities thus, motivating students to learn. The information delivers a comparative view between the study district strategies and NCTM math standards. Also included are SE judgments. The comparative chart helped me to review and synthesize strategies related to the research questions.

Table 1

Comparative Table: Elementary Math School Strategies

Study District Strategy	NCTM Standards for School Mathematics	NCTM: Reflection Self-Efficacy Judgments
Make sense of problems and persevere in solving them.	Number and Operations Standard	Vicarious experiences Verbal persuasion
Reason abstractly and quantitatively.	Algebra Standard	Vicarious experiences Verbal persuasion Performance outcomes Physiological feedback
Use appropriate tools strategically.	Geometry Standard	Vicarious experiences Performance outcomes
Model with mathematics	Measurement Standard	Vicarious experiences
Construct viable arguments and critique the reasoning of others.	Data Analysis and Probability Standard	Performance outcomes Physiological feedback
Attend to precision.	Problem Solving Standard	Vicarious experiences Performance outcomes
Look for and make use of structure.	Reasoning and Proof Standard	Vicarious experiences
Look for and express regularity in repeated reasoning.	Communication Standard Connections Standard Representation Standard	Vicarious experiences Performance outcomes

Note: Study district strategies for teaching math compared to NCTM standards and SE judgments.

Defined in the study district's TES (2013-2014), an instructional strategy is demonstrated when a teacher continually facilitates student engagement in metacognitive learning, higher-order thinking skills, and application of learning in current and relevant ways. Teachers who raise awareness of knowledge and skills needed for future career paths provide students with the opportunity to bridge classroom learning to a real-world application. An instructional strategy such as engaging elementary students in conversations and lessons on future career opportunities can then bridge learning to their future reality. Thus, understanding how educators improve student SE and math interest can lead to a future in STEM careers, and by extension, provide educators with successful instructional strategies for teaching elementary mathematics. Exploration of this process may improve the foundation needed for entry into STEM education.

Goldhaber, Walch, and Gabele (2013) stated in their published report that measuring teacher performance against student achievement is not possible due to many reasons. So, I used the district definition of a highly effective teacher in this study. Ten headings are included in the district TES to describe highly effective teachers. The entries include- Professional Knowledge, Instructional Planning, Instructional Strategies, Differentiated Instruction, Assessment Strategies, Assessment Uses, Positive Learning Environment, Academically Challenging Environment, Professionalism, Communication. Two of the headings used apply to my study; they include Instructional Delivery and Learning Environment. Based on the 2014-2015 on-line brochure in the district where this study will take place the listed standards in the table support the literature review on HEMT.

Table 2

|*Study District Definition for Highly Effective Teachers*

Heading	**Sub-heading**
Instructional Delivery	***Instructional Strategies***: The teacher promotes student learning by using research-based instructional strategies relevant to the content area to engage students in active learning and to facilitate the students' acquisition of key knowledge and skills.
	Differentiated Instruction: The teacher challenges and supports each student's learning by providing appropriate content and developing skills which address individual learning differences.
Learning Environment	***Positive Learning Environment:*** The teacher provides a well-managed, safe, and orderly environment that is conducive to learning and encourages respect for all.
	Academically Challenging Environment: The teacher creates a student-centered, academic environment in which teaching and learning occur at high levels and students are self-directed learners.

Note. HET information appeared in an on-line brochure from the district under study.

As stated in the district study brochure in the above definition, HEMT use research-based instructional strategies to teach challenging standards and engage students in a strong math foundation during ES grades. Bandura (1997) argued that personal and challenging standards build competencies allowing for the achievement of student goals. Hence, student SE in mathematics develops when teachers promote student learning using relevant mathematics to engage students in active learning. The district definition coincides with Bandura's SE framework. Providing educational opportunities at an early age, personal SE in mathematics affords students the ability to reach their math goals (Piotrowski & Hemasinha, 2012). These actions can lead to a well-developed student SE in math throughout the secondary level of education.

Classroom Climate

Highly effective classroom teachers provide student motivation and evidence for educational growth and accountability. Motivation and strategy variables are critical to academic achievement and are predictors of educational growth (Hofe et al., 2013). Teachers that use multiple instruction strategies keep students engaged in the assignments. Sanden (2012) concluded that highly effective classrooms demonstrate student educational growth and accountability for learning. Sanden argues for the need of extensive use in scaffolding (teachers model or demonstrate the problem-solving process, then step back and offer support as needed), strategies that encourage self-regulation, and high expectations to improve achievement and growth.

The study district has met the requirements for the AdvancEd accreditation by the Southern Association of Colleges and Schools (SACS). Earning and maintaining system accreditation through SACS allows for the use of timely and effective instructional strategies. Following scientifically based research on schools that experience high levels of student achievement, including those with challenging populations of students, provides the district with strategies used by teachers and school leaders. Results from the studies guide the district with Quality-Plus Mathematical strategies and practices. Delivery of the strategies and practices to the classroom teachers through PD opportunities improves teacher instruction in elementary mathematics.

In the United States, some districts are infusing technology into class lessons through Bring Your Own Device (BYOD) lessons and interactive digital textbooks. Baya'a and Daher (2013) conducted research in teacher readiness for integrating ICT into

Israeli classrooms. Six research constructs measured in the study investigated teacher feelings and emotions for ICT in the mathematics classroom. Their small study sample concluded that teachers felt ICT methods implemented by the teachers provide students with a deeper understanding of mathematics.

Baya'a and Daher (2013) report some negative teacher perceptions of ICT use. They stated that teachers who perceive their ICT ability as low did not always feel in control. PD can combat the negative feelings of educators frustrated with ICT. Baya'a and Daher suggested that teachers require continually effective PD in existing and developing technologies to keep up with ICT. Furthermore, sometimes teachers are tired and exhausted after teaching a lesson using ICT, which can lead to teacher frustration or anger. For these reasons, teachers may give-up using ICT-based lessons in the classroom.

Despite the challenges of ICT and technical issues, many teachers feel they have the technical ability to use ICT to teach mathematics successfully. Exploring the instructional strategies of highly effective teachers will provide information to educational stakeholders on the need to incorporate ICT teaching and learning strategies into the curriculum. Conclusions from this study may find that HEMT includes ICT-based instructional strategies in class math content and that the use of ICT can improve student SE and interest in mathematics.

To develop student math perceptions, the teacher can integrate technology into their teaching. Teachers who implement ICT-based instructional strategies into their teaching practices may improve a student's view of mathematics. Instructional strategies that include ICT may help engage learners in mathematics. Through ICT education activities, the teacher can personalize student lessons. Teachers who provide ICT and other teaching strategies that focus on mathematics knowledge help to build student SE (Stevens et al., 2009). Additionally, educational stakeholders work together to engage diverse learners with the challenging curriculum (Schleicher & Stewart, 2008). Personalizing student learning contributes to improving student efficacy in math, which may lead to a sustained interest in mathematics.

Schmidt et al. (2009) created an assessment survey instrument for preservice and in-service teachers to measure teacher's self-assessment of their Technological Pedagogical Content Knowledge (TPACK). The intent of the instrument is to determine what teachers need to know to integrate technology into their daily lessons for improved student knowledge. The survey instrument uses a triad of content, pedagogy, and technology to measure a teacher's feelings toward the implementation of technology as a teaching strategy. The longitudinal study survey shows promise to be reliable and valid in determining a teacher's ability to integrate technology in the classroom.

However, the TPACK survey is not the correct instrument for this study. Teacher-researcher interviews with some observations are the focus of this multi-case study. Therefore, a longitudinal measure is not appropriate for the study. Also, many teachers in the target district feel competent in incorporating technology in the classroom. Through their daily use of countywide tools found in teaching, learning, and organizational practices technological content knowledge is strong among the faculty and staff.

Academically Challenging Environment

ES math curriculum should challenge students to improve growth of knowledge. Bandura (1986) stated that personal, behavioral, and environmental influences are woven together resulted in altered behavior through self-reflection; these self-regulatory mechanisms present the potential for changes in behavior. Academically challenging standards push students beyond their comfort level allowing for student growth in knowledge and skills. Hattie (2013) stated that effective teachers teach students how to interpret and analyze math solutions. Successful thinking and strategizing about challenging curricula improves student learning.

To summarize, programs of study need to incorporate the instructional strategies of HET. Sanden (2012) concluded that teacher education classes should model HET methods to improve classroom instruction. She makes a case for student goal setting as a means to motivate growth. Sanden (2012) argued that HET provide self-directed classroom climates that produce teacher feedback conducive to learning and student growth. Through highly effective instructional strategies, student accountability and self-regulation strengthen student learning.

The ability of a student to learn is conducive to their SE. Hattie (2013) synthesized over 800 empirical meta-analyses, in his book, related to achievement. Through 15 years of research and synthesis, Hattie explains the effect of how feedback from teachers to their students can improve learning and understanding by using positive talk techniques. Hattie stated through knowledge, empathy, and verbal ability, and teachers use their interpersonal skills to be effective teachers. His data reveals a student's perception of their ability for success is the most substantial of all effects (Hattie, 2013).

Positive Learning Environment

The study district defines a positive learning environment as providing a safe, well-managed, and orderly learning environment. This type of environment provides students with an atmosphere for learning. In Hattie's book on *Visible Learning*, Hattie (2013) included the need for students to make mistakes without fear to associate good problem-solving environments. Although not specifically defined in the district definition, it is important to note that a positive learning environment allows for student error without fear of retribution during the study. Hattie's research on meta-analysis supports effective classroom management and interpersonal skills in teachers to create a classroom climate where students learn. Teachers and students who respect each other create an atmosphere for the importance of education.

Summary and Conclusion

In the quest to raise the rate of students entering science, technology, engineering, and math (STEM) careers, US education systems have taken the leap of providing teacher training in STEM education. The initiative's goal is to improve student entrance into postsecondary STEM education through teacher knowledge and SE for teaching STEM, thereby increasing student knowledge in STEM. However, student content knowledge in STEM does not lead directly to higher levels of STEM career entry (Ruthven et al., Howe et al., 2011). As an alternative, improving an interest in mathematics especially during elementary level education may lead to a sustained student interest in STEM.

An exhaustive search of literature demonstrated the lack of studies found on the reciprocal effect of SE and an increase in math interest at the elementary education level. To fill the literature gap, an exploration of HEMT was needed to determine if teacher ICT-instructional strategies promote math interest in students. A reciprocal effect of student SE judgments and intrinsic interest for learning mathematics may be critical factors for students' entrance in STEM. These factors may create a strong foundation in mathematics for the student. With a strong foundation in math, HEMT can lead students to future STEM career choice (Hidi & Renninger, 2006).

The research questions proposed in Chapter 3 explored methods teachers use to build SE judgments and intrinsic interest in math among elementary students. Using a multicase research approach, a triangulation of observations, interviews, and discussions about student math artifacts occurs. Five teacher participants helped to discover how HEMT use ICT-instructional strategies to improve math interest in elementary students.

Chapter 3: Research Method

Introduction

The purpose of this qualitative study was to explore how HEMT use ICT instructional strategies to teach mathematics to their students. The major sections of the chapter will focus on my research methodology and design usage to explore ICT instructional strategies. Relatively few colleges and universities offer elementary teacher programs in STEM education (Brown, 2012). Trends show possible student improvement in mathematics when taught by teachers who have graduated from STEM POS or PD classes (Brown, 2012; National Center on Education and the Economy, 2013; National Center for Women & Information Technology, 2013).

In this study, I explored and described any relationship that may exist between student SE and interest in mathematics as perceived by HEMT including the reciprocal effects between student SE and sustained interest in math. As I previously discussed in Chapter 2, one method I used to investigate this research problem was through gathering teacher perceptions and self-reports. Teacher comments allowed me to collect their use of ICT instruction-based strategies that affect student SE judgments and interest in mathematics.

Bandura's (1977) SE judgments provided the foundation of the theoretical framework for this dissertation. I used a multicase inquiry to explore how HEMT use instructional strategies to teach elementary mathematics. Brown (2012) stated elementary level teaching practices enhance a math student's SE. Improving SE may lead to a reciprocal effect of strengthening sustained student interest in math education (Piotrowski

& Hemasinha, 2012; Stevens et al., 2009). Continued student interest in math during the elementary years may improve student entry into secondary education classes that lead to STEM careers (Piotrowski & Hemasinha, 2012).The contents of this chapter include research design and rationale, my role as the researcher, methodology, data instruments, data analysis plan, and trustworthiness.

Research Design and Rationale

I developed the following research questions to guide this study:

1. What experiences of HEMT affect their ability to teach mathematics to elementary students?
2. What instructional strategies do HEMT model to stimulate and sustain a perceived student interest and SE in mathematics?
3. How do HEMT facilitate their use of ICT to enhance student SE and interest in math?
4. How do HEMT feel about a perceived reciprocal effect between student SE and interest in mathematics due to the use of instructional strategies?

The central concepts I focused on in this study included SE judgments, intrinsic interest, and teacher instructional strategies that include ICT. A method that can be used to study these concepts is the multiple-case study research tradition (Lancy, 1993; Yin, 2009). Using an interview process, I anticipated the teachers would reveal their thoughts on how well prepared they felt to teach math to their students. A one-time interview session with each participant provided a snapshot of the teachers' perceptions of teaching elementary mathematics.

Yin (2009) stated that conducting open-ended participant interviews allows for exploration of the research questions. In the interviews I conducted, the teacher participants discussed the instructional strategies they used in class including ICT strategies. Their perceptions and self-reports enabled my discovery of ICT instruction-based strategies that affect student SE judgments and interest in mathematics. During the interview sessions, teacher participants also discussed student work samples created during math lessons. The learner artifacts allowed the teachers to convey perceived comments about student math interest during class assignments to me.

Role of the Researcher

My role in this study was that of an observer and interviewer. Given the state of education and constraints of feasibility, I observed classroom climate during one mathematics lesson delivered by each of the teachers in the sample (see Appendix A). Observing HEMT teacher-student relationships revealed how judgments influence individual student efficacy beliefs in learning mathematics.

As an observer and interviewer, I remained unbiased and objective. To help manage researcher bias, Patton (2002) suggested the use of audio recordings to capture accurate quotations and the interviewee's words during interviews used in fieldwork. Although I have been teaching for 34 years at all levels of education, from preschool to adults and feel comfortable in the classroom setting, I practiced the interview process during three mock interviews to improve reflexivity. As a secondary school Career and Technical Education teacher, I did not work with the elementary teacher participants in this study. I did not know the participants beforehand, nor did I hold a supervisory or instructor relationship involving power over the participants.

Methodology

Participants in this qualitative study included five elementary HEMTs who worked in recognized ICT-based schools. The sample size of five teacher participants showed consistent patterns and themes, and validation transpired during the interviews. Data saturation occurred when this simple multicase design replicated conditions from case-to-case (Yin, 2009).

I chose intermediate teachers (fourth and fifth grades) before primary teachers. HEMT participants provided me with information about perceived student SE and interest in mathematics through relaxed interview conversations. The classroom teachers met the district-wide TES requirements defined by the state for HEMT. Teams of local administrators or colleagues identified the HEMT, who have been evaluated based on school district TES standard.

I recruited study participants through an introductory protocol. Following administrator directives, the teacher participants learned of the research purpose and why they were selected. My initial contact with the participants occurred through the school district e-mail service.

During the introductory protocol, participants learned what I did and did not aim to do with the study and the time requirements needed for the interview process. Additionally, teachers understood that I would use the results of the study to inform future policy decisions in education. Forty-minute teacher interviews were recorded, transcribed, and coded using electronic software. I provided teachers with appropriate paperwork describing the research, and the participant was asked to sign a release form before the interview took place in their classroom.

To establish sufficiency of the data collected in answering the research questions I used an observation sheet, interview questions (see Appendix H), and teacher self-reports in the study. The observation form is a published data collection instrument, but I developed the interview questions based on the interview protocol. I will discuss the instruments further later in this chapter. Digital recordings of the interviews and artifact conversations about perceived student interest in creating the math assignment artifacts were also used in this study. Replicating the same procedures should allow future researchers to arrive at similar results (Yin, 2009).

Observations

I used an observation sheet created by professors at the Idaho University education program to witness class management (Appendix A). Used by faculty members for observations during student tutoring sessions (Appendix B), the Idaho form is consistent with the teacher standards for the state where the study took place and correlated well with the school district's teacher evaluation form. The observation form was appropriate for this study because it lists specific areas of teacher actions that establish classroom climate of highly effective teachers (HET), the same areas as the study districts evaluation system description for HET.

Under the Classroom Observation review section of the form was space for note taking. I established content validity when observed teacher actions were revealed on safe climates for student error, teacher math anxiety, and preparation of instructional strategies used in the lesson by the teacher. For instance, the document has a section for writing descriptions and comments about safe classroom climates that encourage respect, participation, and a proactive learning environment. Additionally, the observation form headings mirror the interview questions I used in this study. For example, under the Subject Matter Content section of the form, an interview question asks the teacher to describe how their knowledge of mathematics affects the student's ability and interest in math.

I did not use all areas of the observation document during the elementary math lesson. Since I did not measure the teacher actions in the study, the last three opinion questions listed on the form were not answered. No mention of teacher strengths, suggestions for improvement, or overall impression of teaching effectiveness was used. These opinion questions were deleted from the published document before the observations took place.

While searching for a published data collection instrument, I was careful to find a tool that observed teacher behavior and not student behavior. Finding an observation form with a focus on the classroom climate and not on improving teacher skills was necessary. Since HEMT are the focus of this study, use of an observation form that provided me with a focus on observing teacher effectiveness was required.

Interviews

The basis of this researcher-developed instrument was to collect descriptive data from HEMT regarding ICT-based instructional strategies. The open-ended interview question format explores the participants' perspective of their words and meaning (Patton, 2002). According to Lancy (1993), "the researcher has three principal data sources: observations, interviews, and artifacts" (p. 17). Participants had the opportunity to review the standardized, open-ended interview questions before the session. To establish content validity, having the list of interview questions ensured that I asked the same questions to each participant and used the same wording (see Patton, 2002). This process allowed me to collect data systematically as identical questions were asked in the same order to each teacher. The data I collected through asking the interview questions sufficiently answered the research questions.

I developed the interview protocol from the central concepts of the study and the conceptual framework (see Appendix C). The interview questions expressed expectations of HEMT. An expert panel of secondary and elementary math teachers edited the questions before the research commenced. The expert panel ensured the accuracy of my design, the clarity of the questions for ease of understanding, and their relevance to the central research question. The panel also examined the questions for vocabulary accuracy, clarity in voice, and appropriate questioning to achieve the study purpose. I substantiated the revisions by using the question matrix from the literature review and Patton's (2002) question types. Additionally, I referred to the panel for their advice on changes to the question revisions.

The interview questions supported the purpose of this study by exploring teacher perceptions about SE judgments and using ICT instructional strategies to promote student interest in mathematics. Patton (2002) recommended the use of open-ended questions to stay organized and promote timely responses, rather than scattered questions. I developed the questions based on information gathered from the literature review findings.

Focusing on the study's purpose, I applied a matrix of the literature review resulting in four high-quality research questions that have a basis in the literature (Appendix D). The 12 interview questions and two follow-up questions connected to the study research questions. Distinguishing between the types of questions I asked during the interview was important for interviewee clarity. Patton (2002) posited that there are six different types of interview questions. I used all six types of questions to varying degrees in this study. Many of the interview questions fell under Patton's' heading of experience and behavior questions. Rich data from the interviews made it possible for me to uncover the reciprocal effects of student SE and interest.

Additional questions asked during the interview were made-up of opinion and value and feeling questions. These type of questions aim to understand the thinking process (opinion and value) and feeling process (emotions) rather than actions and behaviors received from experience and behavior questions previously mentioned. Opinion and value questions asked the teacher to think about their experience. It was expected that the educator would provide their opinion, value, and judgment during the interview session.

Employing open-ended interview questions that encouraged detailed responses was expected to reveal valuable information about student interest in mathematics. Participant's responses required follow-up questions and prompts. For example, Question 11 asked teachers to provide their opinion about the types of learning experiences they believe build math interest in the students. Question 12 asked teachers to provide work samples they believe demonstrates math interest or the ability to complete a math task. Concerning ICT instructional strategies, Question 5 asked teachers how they feel about using technology to help their students' complete assignments or to enhance their interest in math. Question 9 asked, "If I followed you during a typical math lesson where you use technology, what would I see you doing?" The purpose of qualitative research is to explore and describe phenomena that are not well understood. HEMT answers revealed the unexpected, which is the nature of the research.

Artifacts

Polly et al. (2014) suggested that future studies include student work samples. The artifacts collected allowed the teachers to explain the process that took place when students worked on their assignments. The discussions that took place about the assignments allowed for a discovery of student feelings and interest based on teacher perceptions. During the interview process, teachers had the opportunity to provide perceived student statements or comments. This process helped me explore the SE process that takes place in learning math.

Teacher participants selected student math artifacts to bring to the interview that they feel demonstrates student interest during a math lesson. During the process, teachers shared student comments that described the student's feelings and interest while creating the artifact. This dialog provided rich data that was coded for student SE and interest as perceived by the teacher.

Digital recordings were used to track the interview comments and reporting of student math lesson artifacts. Patton (2002) recommends the use of recordings to establish accuracy and data credibility to answer the research questions. Only teacher comments about student interest in the assignment was collected. Because no analysis and coding of the student work take place, the IRB did not require parent approval. However, the study district did request that I obtain parent permission. Included is a sample letter I created requesting parental consent for a student to be observed during the teacher observation (Appendix E).

There were several steps to the data collection plan. The first step was the classroom climate observations. Next were the teacher interviews that were held in the classroom. Lastly, a discussion between the teacher and me about student-created artifact samples produced during a math lesson occurred. During the final interview inquiry, participants added anything else that they felt was relevant to the interview process.

Two locations were used in this multicase study; therefore, it was necessary to utilize precise wording of the interview questions to improve data accuracy. Patton (2002) described standardized open-ended questioning to have a set order and specific wording. Open-ended questions increase the ability to compare the responses of the interviewees. It also allows for easier organization and analysis of the results.

Triangulation of the data was used in this study. Collecting data from various sources helped me to triangulate data collection, thus increasing objectivity and removing research bias (Frankfort-Nachmias & Nachmias, 2008). The process allowed rich data to be collected and disaggregated into patterns and themes about instructional strategies used by HEMT.

Individual teacher observations took place in each teacher participant's elementary level math classroom when informed consent was received and before the start of the interview. Student comments or actions were not field recorded during the observation. Global observations of student behavior occurred but were attributed to individual students. Students remain anonymous throughout the observation with no record of their comments or actions. Each teacher observation lasted through one mathematic lesson, which is approximately 40 minutes in duration.

I used initial observations of HEMT to discover classroom environments in the elementary math classes. Through this experience, I observed the classroom climate employing teacher expectations, policies, and procedures. The use of an observation sheet to record field notes about the classroom climate occurred. To inform the students of my presence, the teacher introduced me and explained that I am in the classroom to observe the teacher teach a math lesson to the class. Information learned from the observation process, led to an adjustment of open-ended interview questions to improve data collection accuracy.

Asking interview-feeling questions helped to discover if HEMT have anxiety toward teaching math or using ICT to teach elementary mathematics. Data obtained from this type of question explores the teacher's thoughts. For example, Interview Question 2 and 3 respectively asked, "Describe for me how your knowledge of mathematics affects your student's interest and engagement in math." and "What is your opinion of how your mathematical knowledge helps you to create a math interest in your students?" Discovering patterns and themes from the questions was significant to promote student SE and sustained student interest in elementary mathematics. Asking the teacher at the end of the interview session if there was anything else they would like to add to the interview rounds out the interview question options suggested by Patton (2002).

Observations

To establish the atmosphere found in HEMT classrooms, I conducted a 1 day, single math lesson observation per teacher participant. A published observation template from Idaho State University (Appendix A) was used to gather data. Only the teacher's behavior was recorded in the field notes. Understanding classroom climate helped me collect data regarding safe atmosphere of student error, teacher math anxiety, and preparation of instructional strategies used in the lesson by the teacher. I sat in the back of the classroom with the students' back toward the wall. This process allowed for minimal disruption of student instructional time.

Interviews

To provide content validity, the interview questions were based on the literature review. The questions required teacher reflection about the instructional strategies they use to teach elementary-level mathematic concepts. The questioning protocol was found in the Instrumentation Development section of this chapter (Appendix C). Patterns and themes developed from the interview questions were not always as predicted, so discovered information about vertical curriculum can help policymakers improve teacher PD education for enhancing student interest in mathematics.

To create a conversation with a casual atmosphere and conversational tone, data collection occurred in the teacher's classroom using an audio recorder. This procedure captured interview questions asked in a logical, natural sequence (Appendix H). The interviews lasted about 60 minutes per participant. This time allowed for rich data collection without creating a sense of a long interview process.

Teacher participants were provided with the list of interview questions before the interview session to help develop a connection between the faculty and me and to introduce the study. This action allowed the teachers an opportunity to verify their understanding of the interview questions before the data was collected. It also provided time for the teachers to assemble student work samples for the data collection. Data collection from the participants took place during a one-time interview process and was expected to take 2 months to complete. Recorded conversations allowed for a plethora of data to be collected.

The final stage of triangulation occurs through artifacts of student work. The teacher presented the work samples after the interview took place. Eliciting from the teacher's-descriptions and insights of student work samples provided rich data for coding the overheard comments as the students worked on the assignment. Student work samples are anonymous and are not collected or identified for the study.

Data Analysis Plan

The classroom observation form obtained from Idaho University educator's program provided data that establishes classroom climate (Appendix A). The data collection was used to connect classroom management data to the first research question referencing experiences of HEMT and their ability to teach mathematics to elementary students. The observation data focused on subject matter content, organization, and rapport of HEMT. Other areas of consideration include teaching methods, presentation, and management.

Also, digital audio recordings were used to analyze teacher comments obtained through the interview process and student artifact perceived comment descriptions. Interview questions reflect Research Questions 2, 3, 4 on perceived student SE and interest in a math lesson. Comments about ICT-instructional strategies and non-ICT strategies were collected for analysis. Audio-recording usage for artifact analysis, focused on Research Questions 3 and 4. HEMT were asked about their perceived use of ICT instructional strategies to enhance student SE and interest in mathematics.

After data collection, NVivo digital software was used to code the data using a priori categories. The codes serve as a way to tag, compile, and organize the data. This process allowed for summarization and synthesis of teacher thoughts and opinions. The relationship of the data collection and interpreting the data coding became the basis for developing the analysis. No discrepant findings occurred, so the three additional teachers planned for were not needed to discover patterns and theme.

Issues of Trustworthiness

Elements of trustworthiness in a study coalesce from credibility, transferability, dependability, and confirmability. Credibility was established through a trust of accuracy in the classroom climate observation, teacher interviews, and the data collection (Patton, 2002). Factual interpretation was systematically documented and reported with the use of an observation form used during all teacher observations. Digital recordings were used for comment accuracy during the interview questions and the artifact discussion. Confirmability occurs through interview follow-up questions and member checks of the data collection.

Creswell (2007) confirmed that triangulation of multiple types of data validates a rich data collection. Complete description transcribed from interviews provides for the emergence of patterns and themes, and variation in participant selection improves transferability. Additionally, attitudes and practices of HEMT instructional strategies are disclosed from observations and student work samples.

Patton (2002) recommends starting the study process with more than the needed sample size. Starting with eight teachers in the sample when only five teachers are necessary in a multicase study allowed participants to drop out without affecting the information richness of the cases. The expectation was that the data collection occurred from interviewing five HEMT teachers. The sample size was large enough in this multicase study for transferability of patterns and themes, which were revealed about student SE and sustained math interest. Onsite visits, digital audio recordings of the interviews, and student artifacts helped to improve dependability in the study.

Ethical Procedures

Specific procedures were used to avoid any ethical issues. A math K-5 grant was awarded to the district that was similar to my study framework; the district director was pleased to learn of my research. She suggested I contact the District Research and

Evaluation (RE) Department to address ethical issues. Following district protocols, my application to the RE Department staff was accepted.

In addition to following school district policies, ethical issues related to the use of sensitive personal data. I possessed a valid certificate from the National Institutes of Health (Appendix G). I reported the study conclusions with a truthful and unbiased approach. As a researcher, I am responsible for honest, candid, and forthright communication with the findings of my study and I followed all of the Walden University IRB policies and procedures before conducting any research or contacting any participants.

To maintain the highest level of confidentiality, anonymous coding was used to hide the identity of the study district, personnel, observations, and research assignment artifacts. Teacher participants were provided with documentation that included an invitation (Appendix F) and a confidentiality and anonymity of comments statement, which they signed in agreement prior to study participation. Upon approval of participation, a parent letter went home in the student's Friday folder. The purpose of the letter was to notify the parent or guardian of the study and the need for my classroom presence during the observation process. The letter established a mutual understanding between the teacher, parent, and me that an observation of the mathematics classroom climate allowed me to establish class protocols. Student learning time was not missed or disrupted. Moreover, student observations and data were not recorded.

A parent permission form was sent home upon the school district's request because students were in the math classroom during the teacher observation. Students, who did not return the permission form, were seated out of the observer's view. The teacher presented the following statement to the classroom students who are present, "Class, I want to introduce Mrs. Brimmer to you. She is in our classroom today to observe how I teach you mathematics. Unfortunately, she won't be able to talk to you because she will be busy taking notes." The statement and university permission documentation including the IRB application and permissions are located in the appendix section.

I will use the study's District RE website to follow protocols for committee approval of my study. Permissions from the school administrator(s), consent forms, teacher participation letter, and interview questions are in the Appendices B, D-H. The interviews took place at each teacher's school, so the setting was familiar and casual. The participants were informed in writing and verbally that the volunteers could abandon from the study at any time and with no ramifications. All data were collected and placed in a locked safe in my home where I alone hold the key. All confidential and anonymous material will be shredded after 5 years, and the audio files will be destroyed. No students are involved in the study.

Upon approval of my proposal by the University Research Review process, I submitted to the local school district the required IRB application. When my application was accepted, I met with the school district director of mathematics to choose elementary schools for the study. Four elementary schools that are recognized as ICT-driven by the director were considered for used in the study. After gaining approval from two principals and six teachers, I completed the necessary paperwork, and began the data collection.

Summary

The purpose of this study was to conduct exploratory research in the realm of elementary mathematics. Sustained student interest in math during the elementary years may improve student entry into secondary education classes that lead to STEM careers. To investigate the research problem, I explored how the SE theory and ICT instruction-based strategies are used by HEMT to build student SE and interest in mathematics. SE judgments provide the foundation of the theoretical framework for this dissertation. Bandura's (1977) theory listed four SE judgments necessary to influence individual efficacy beliefs: performance accomplishments, vicarious experiences, verbal persuasion, and physiological feedback. The research questions reflect the SE judgments.

Conducting open-ended teacher interviews allowed for exploration of the research questions about SE, sustained interest, and ICT. During the multiple-case study approach (see Lancy, 1993; Yin, 2009), teachers had an opportunity to discuss the instructional strategies they use in class, including ICT strategies. Teachers brought student work samples to the interview

Three instruments were used in the data collection, which includes an observation sheet interview protocol, and teacher comments about student's interest in creating the assignment artifact. Participants included five elementary mathematics teachers who work in recognized ICT schools. The teacher collected samples from student math assignments and shared student interest about the assignment during the teacher interview.

I used an interview process to investigate current trends and HEMT attitudes and practices of instructional strategies. Complete description transcribed from interviews provided for the emergence of patterns and themes, and variation in participant selection assured transferability. Analysis of the data included pattern and themes that emerge from the study using NVivo priori coding. Chapter 4 will contain a comprehensive analysis of each teacher participant's interview comments, which manifested from the research questions.

Chapter 4: Results

Introduction

The purpose of this study was to explore how HEMT at the fourth and fifth-grade levels of ES use ICT to teach mathematics to their students. I used a multicase study to explore how five classroom teachers use instructional strategies to teach elementary math, and explore relationships that exist between student SE and interest in mathematics as perceived by HEMT. I also explored whether teacher verbal persuasion has a reciprocal effect on student SE and math interest. The chapter is organized into the following sections: Setting, Demographics, Data Collection, Data Analysis, Evidence of Trustworthiness, Results by Research Question, and a Summary of the Data.

Research Questions

I used the following research questions to guide this study:

1. What experiences of HEMT affect their ability to teach mathematics to elementary students?
2. What instructional strategies do HEMT model to stimulate and sustain a perceived student interest and SE in mathematics?
3. How do HEMT facilitate their use of ICT to enhance student SE and interest in math?
4. How do HEMT feel about a perceived reciprocal effect in student SE and math interest due to the use of instructional strategies?

Setting

The two schools selected for this study are located in the suburbs. I chose them for their diverse student population and depth of ICT usage. Pseudonyms are used for the participants and study sites to protect their confidentiality. The participants of this study were five HEMT who work at the two selected schools. The observations and interviews took place in each teacher's classroom, so the setting was familiar and casual to the participants. The venue worked especially well for Interview Question 12, which requested a discussion about student work samples (see Appendix H). Due to the familiar location, the teachers had easy access to assignment artifacts to demonstrate the math interest in their students.

Through the interview process, I learned that Ms. Kirk was hired to work at Beams ES by the principal so that she would instruct a few of the math department teachers on the use of the workshop methodology. Ms. Kirk taught the mini-lesson methodology to two of the study participants and team-taught with a third participant. During the observation process, I became concerned about research bias due to the modeling of teaching styles among the HEMT from Beams ES. Therefore, I found it necessary to choose a sample participant from a similar district school to strengthen the research. Mr. Gary from McAuliffe ES agreed to participate in the study, which helped to improve transferability. I discovered that he instructs similarly to the workshop mathematics methodology used at Beams ES even though he has no training in the approach.

Demographics

All five elementary teachers in the sample have taught at the middle school level and received an exemplary TES rating while teaching at the ES. Although all teachers had a minimum of 11 years of teaching service, this was not a requirement of the study. The teachers have diverse teaching backgrounds, levels of education, and teacher certifications.

Ms. Ruth earned an undergraduate degree in business, marketing, and a Master's degree in education. Additionally, she earned a middle school certification before teaching at the elementary level. She said her knowledge of middle school mathematics helped her understand what to teach to fourth and fifth graders because she knew the foundational skills the students needed to learn for future math classes.

Ms. Murray holds a BS in elementary K–5 education. She also holds a middle school math certification and had experience teaching at the middle school grade level. She had the least amount of teaching experience with 11 years and no other degrees. Ms. Buckley earned a BS in early childhood education (ECE), and she taught mathematics at the intermediate level as a substitute teacher. She felt her elementary math classes and gifted endorsement had helped acknowledge her as an exemplary teacher. Ms. Buckley and Ms. Ruth had planned together this year with a county math coach to analyze the curriculum standards, create pacing guides, and writing assessments. Both teachers credited the experience as highly valuable.

Ms. Kirk had been teaching for 21 years and had the longest amount of years as an instructor. She graduated from an Elementary Math Keystone Cohort with an education specialist degree. The Keystone Cohort POS gave her experience in teaching algebra, statistics and analysis, numbers and operations, geometry, data and probability, and fractions. The teacher credited the Keystone Cohort education for her ability to teach mathematics well. Also, Ms. Kirk earned her BA degree in reading, language, and literacy in elementary education and worked with Ms. Buckley coteaching.

Mr. Gary taught a variety of classes at McAuliffe ES. He had taught kindergarten and fourth through sixth grades. He taught accelerated seventh-grade students at a local university to help prepare the learners for college level mathematics. He credited his father's occupation as a calculus teacher for his preparation to teach math. All the educators commented about the importance of modeling math foundations and breaking down mathematics for student understanding and teaching at least one level of higher mathematic curriculum, so they knew what the students need to know in future math classes.

Table 3

Demographic of Sample Participants' Degrees and Educational Experiences

Pseudonym	**Years Taught**	**Preparation/Degree**	**Experience**
Kirk	21	Elementary education degree, reading, language, and literacy in elementary education, elementary math keystone cohort education specialist degree based on math strands	Specialist degree cohort included algebra, statistics, and analysis, numbers and operations, geometry, statistics, data and probability, fractions; six strands that correlate to the elementary curriculum.
Murray	11	Bachelor of Science (BS) in elementary K-5, middle school math certification through state test.	Sub experience in middle school math. This year departmentalized in ES math, followed principal from middle school and ES. Took math institute during summer, but that is not a math endorsement.
Ruth	12	Degree in business and marketing, Masters in Education.	One course in ES and high school mathematics strategies, certification in middle school math helped to know where kids are going. Worked with a co-teacher and district math coach.
Buckley	19	BS in ECE	Took some ES math classes certified Pre K-4, gifted endorsement. Worked with a co-teacher and district math coach.
Gary	12	BS in Elem Ed.	Taught at 6-7 grade level math, working on teacher math endorsement. Credits his father's occupation as a calculus teacher for his preparation to teach math.

Data Collection

I collected data from the Governor's Office of Student Achievement to demonstrate the diversity of the student populations in the teacher's classrooms and the school performance. Beams ES had been rated in their state report card grade as an A school at 94.3%, and McAuliffe ES was rated as an A school with 90.4%. McAuliffe ES was similar to Beams ES in attendance of most subgroups except for limited English proficient students and students with disabilities. McAuliffe rates were higher at 5.7% and 9.6% respectively than Beams ES. Mobility rate at Beams ES was at 7.8%, while McAuliffe holds a 10.1% movement percentage. The free and reduced lunch rates were also higher at McAuliffe by twice as much; 36% versus 18% at Beams ES.

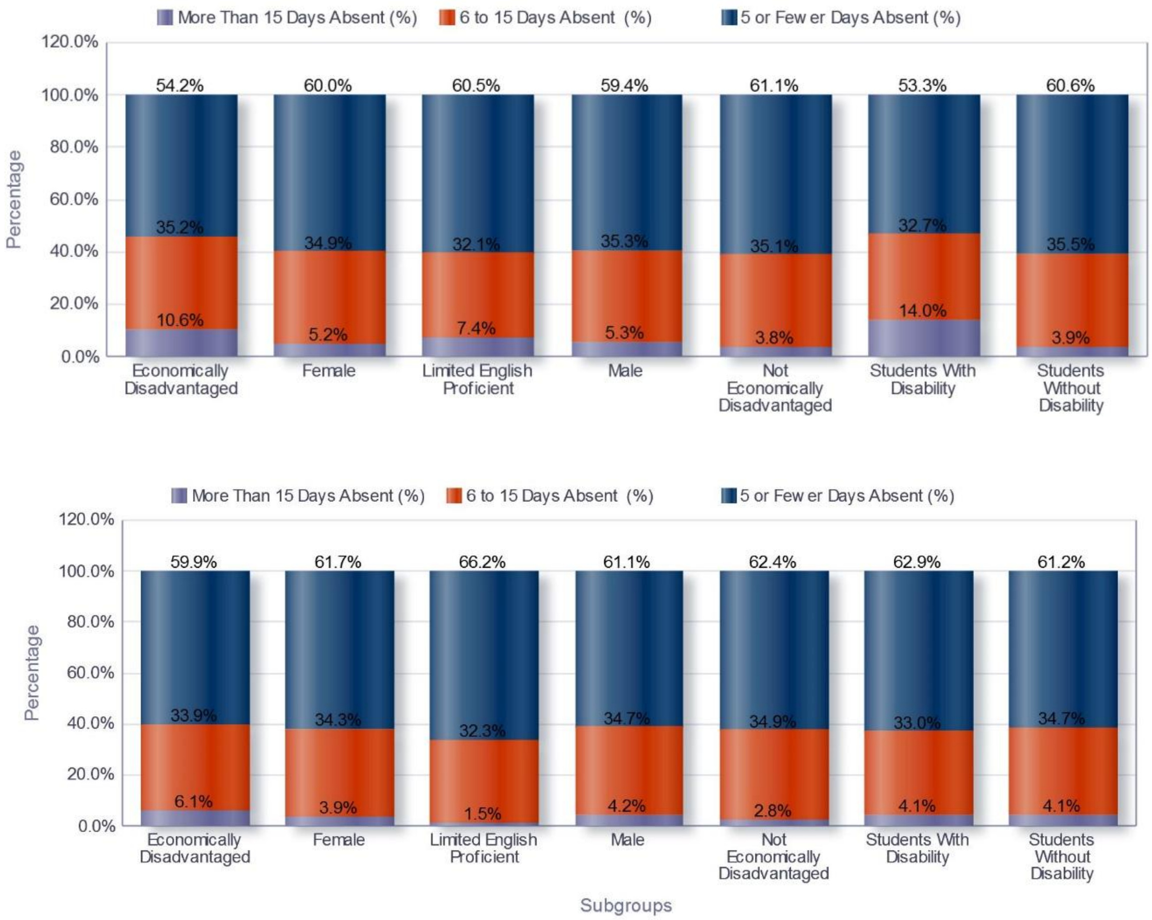

Figure 2. Participant demographics relevant to the study.

Data Collection Description

Originally slated for a 2-month period, my data collection process ended up taking 3 months due to scheduling issues. Mr. Gary's observation and interview were scheduled about one month after the completion of the other interviews. The delay had no bearing on the information collected.

The data I recorded were in the form of separate observations (see Appendix A), interviews, and artifacts. Data were collected as a composite after receiving acceptance from the district RE department and school principal (Appendix I). I submitted a teacher introductory letter (Appendix F) and obtained written consent from each educator before the observations. For each teacher participant, I sent an e-mail distributed through the district system with attachments of an Invitation to Participate letter, the Consent Form, and the Classroom Observation form. Responding to my e-mail, the teachers and I arranged observation times. The same e-mail process took place for educators from both schools.

Observation Data Collection Instrument

I recorded field notes describing the climate using the Classroom Observation Form (Appendix A). The teacher and not the students were the focus of my observation, so the IRB did not require a student permission form. Each observation lasted an hour per teacher and transpired over a week for Beams ES and one day at McAuliffe ES.

All the teachers I observed demonstrated an organized classroom setting with good student rapport and stress-free learning as defined in the Observation Form. For example, a student in Ms. Buckley's class had a book on his head. Continuing to teach, the teacher calmly took the book and handed it to the student getting him back on the task of learning. She never stopped teaching.

The educators gave students clear goals in their teaching and emphasized main points. All of the teachers used different types of technical hardware appliances to deliver instruction to their students. When discussing her iPad, Ms. Ruth stated, “I put everything in there and then I can just page through, and I don’t miss anything.” Further discussion about ICT usage will occur in the Data Analysis section.

The teachers taught content using examples that were clear, precise, and appropriate. Mr. Gary used a speaker and microphone system to teach his students who were sitting on the floor in a semicircle. The children watched the Mimeo interactive whiteboard from a projected display. Teachers at Beams ES had students sit at their group tables and view instruction through ceiling projectors, interactive boards, iPads, and Ladibug Document Cameras.

Ms. Kirk, Ms. Ruth, and Ms. Buckley walked around their classrooms as students completed the problem-solving activities and assisted groups of four or five students. Ms. Murray and Mr. Gary each sat at a fixed station in their respective classrooms and worked problems with their students. The teachers answered questions in a non threatening manner and observed work habits as they moved around their classrooms. The five teachers showed good command and knowledge of the mathematics content and demonstrated breadth and depth of math mastery. Mr. Gary guided his students with questions like, “Explain the Munster Munch strategy used at the station.” Each lesson began with a review and followed the math workshop methodology. Ms. Kirk explains the process in the following manner:

> We pick out a concept that has to be taught. I try to teach it in about a 15-to-20-minute time period. Then, I let them have about 20 minutes for independent work. During that time I'm facilitating. I'm either walking around helping kids that have questions or my role kind of changes.

At one point, a student in Ms. Buckley's room was called to the front office. When the child returned 20 minutes later, he put his head down on the table and did not focus on the teacher instruction. Several minutes later, he raised his head and just sat in his seat. Ms. Buckley then taught him the information he missed, while the rest of the students worked at different stations. As an observer, the teacher demonstrated an understanding of her student's needs. She gave him time to recover from what appeared to be an uncomfortable circumstance before she brought him back into a learning situation.

Upon completion of the observations, I thanked the educators for their participation in the study. A copy of the interview questions were handed to the teacher for their review and a time was fixed for discussions to take place. The interviews took place with-in a week of the observation, and in the teachers' classroom, where the artifacts could easily be retrieved.

Interview Data Collection Instrument

To establish sufficiency of the data collection in answering the research questions, I read from the interview document in the order the statements appeared on the paper.

Additionally, I took field notes and used a digital recording of the interviews as the prime focus for the data collection. Using the VRP 7 phone app to record our conversations, I then typed the individual files onto separate word processing documents that were kept in a password-protected computer.

I transcribed three audio interviews, but to save time I used a professional transcription service to write the final two interviews. Once I had the transcripts, I reviewed each file against the recording to ensure that the text file was accurate. Choosing to transcribe the interviews myself allowed me to know in detail what was said about each inquiry and the teacher that made the statement. However, due to time constraints, two conversations were transcribed by Copytalk, a password protected transcription service. The service offers a 24-hour turnaround period, which was faster than I transcribed. Using this service was not part of my initial Chapter 3 plan, but was necessary due to time constraints caused by my surgery. The company sent password-protected links to my e-mail when the transcriptions were complete. I then reviewed the transcriptions against the recording for accuracy.

Next, I copied the entries onto word processing documents and deleted the e-mail from the server. Proposing I send a copy of the interview transcripts for correctness, all five teachers declined my offer. The educators felt that the recordings provided the accuracy needed for the study. Using the district e-mail server, I contacted the educators from Beam ES for additional information when questions arose. The process added validity to my interpretations. Lastly, I loaded the files into NVivo Pro and began the initial coding process.

I coded the interview questions for the development of patterns and discovered similar teaching vocabulary and instructional methods among the teachers. Also, the educators broke down the curriculum content into mini-lessons; they try to think like the students. ICT is used by each teacher participant as a teaching tool, and I learned they all are passionate about mathematics. The teachers in the study have similar teaching styles and demonstrated strong class management skills.

Data Analysis

Transcribing the interviews allowed me to listen to the digital recordings and read the word collection of the teacher participants. By reading the transcripts and listening to the digital recordings, I obtained the context of the interviews. The dictations were uploaded into NVivo Pro data collection software and labeled as resources. Working in NVivo, I highlighted each whole thought that were related to the research questions. This procedure allowed me to organize patterns and identify subcategories as I worked through the conversations several times.

The software facilitated the analysis to move inductively from coded units to larger representations. Text searches and word frequency queries were used to tag, compile, and organize the data. This technique allowed for the discovery of patterns that included *experience, vocabulary, instructional methods, mini lessons, ICT as a teaching tool, hands-on, passion for math*, and *strong class management skills.*

Next, I created nodes for each interview question. Data from the teacher remarks were captured and used to deepen my analysis of the conversations. By summarizing and synthesizing the collected interview data, the themes identified by HEMT employed in instructional strategies to teach elementary mathematics are vertical curriculum, modeling, ICT instructional delivery, and interactive learning.

The results of the study are organized by the research questions. Patterns and themes quickly developed to make me wonder if the teachers from Beams ES had discussed the interview questions with each other before my interviewing them. I learned that the entire school uses a standard vocabulary and teaching method to teach students. For example, Ms. Kirk referred to the process as a workshop school, “What we do, we're a workshop school.”

Categories formed showing common teaching strategies and the use of ICT. For that reason, I subsequently observed and interviewed a teacher from McAuliffe ES to see if the premise continued to be the same. Although teacher verbiage was sometimes different, the practice of teaching was almost identical between schools; review, explore, introduce, practice, and show.

While compiling the data, I contacted Ms. Kirk from Beams ES to get clarification about the Workshop methodology. She explained the Math Workshop in the following manner.

> Readers and writers workshop is a teaching method rather than a framework. It is something that is known about nationally - Fountas and Pinnell, and Lucy Calkins both promote it through their work with teachers. Ms. Buckley also mentioned that "workshop" is an instructional methodology, and is something promoted by the district as a strategic way to present instruction for maximum learning. It is

not a district requirement, but many elementary principals expect their teachers to use the model for reading and writing. More recently, it has been used in math.

Since the four teacher participants from Beams ES follow the Workshop methodology, I explored whether Mr. Gary from McAuliffe ES also used that method. I learned he did not. However, his approach is like that of the Workshop methodology. Mr. Gary provided the following description in these words:

> Typically, when I first introduce something, I have them work with their tables, and they're usually with about three or four other people, and they try to solve the problem on their own, using any strategy they want. Then, I would have two or three groups share their answer and the strategy that they used. Then, I would introduce, this is actually the way you would do it. A lot of times (hesitates) we have so many rules in math that they really don't always understand; they can't memorize everything, so I just try to see what strategy I think would be best to use. I guess the other thing (hesitates) I mean, this sounds simplistic, but when they got their answer, I'd always say does their answer even make logical sense? Because sometimes I think they get so bogged down with how do I get to the answer, that they never stop to think is it even possible, or does it make remote sense. I encourage them to model it, do it with numbers; just any strategy to solve the problem that would be best for you.

In summary, the instructors in the study used similar instructional strategies, although vocabulary differed in the delivery. NVivo Pro software was used to examine the data and an analysis pursued. Patterns and themes emerged into the categories of vertical curriculum, modeling, ICT instructional delivery, and interactive learning.

Evidence of Trustworthiness

I exhaustively explored the data from each observation and interview to discover the attitudes and practices of HEMT instructional strategies. I used the words and experiences of the participants to identify these themes and to strengthen the credibility of my interpretation. Complete descriptions transcribed from digital recordings were used to track the interview comments and reporting of student math lesson artifacts. The use of recordings and field notes established accuracy and data credibility to answer the research questions.

The sample size is large enough in this multicase study for transferability of patterns and themes, which are revealed about student SE and sustained math interest. Onsite visits, digital audio recordings of the interviews, and student's artifacts helped to improve dependability in the study through triangulation. Two schools were used in the study to add variation in participant selection assured transferability. Confirmability occurred through follow-up questions asked during the interviews. Additionally, I contacted the teachers via district e-mail to clarify answers that were not clearly established during the conversations.

A logical argument, backed up by data, allowed themes to emerge that respond to the research questions. NVivo software allowed me to collect text-based data from interviews and organize the qualitative data for thematic analysis. Using the software, I could build trends, patterns, and themes. Once the data were loaded into the software, I identified trends using the *tech search* and *word frequency* tools. Word-trees provided an exploration of key words or phrases through a text-word query. Code mappings were used to create a hierarchy of words, allowing me to learn more about the data collection and communicate the findings. Creating nodes for each interview question allowed me to scrutinize the teacher conversations, which improved credibility and dependability of the data collection analysis.

Results by Research Questions

Patterns and themes emerged during the data analysis. I identified common characteristics among the experiences of the educators, which included Vertical Curriculum, Modeling, ICT Instructional Delivery, and Interactive Learning. Divisions of the classifications were organized by research questions in the following section.

Research Question 1

Research Question 1 asked, “What experiences of highly effective elementary math teachers (HEMT) affect their ability to teach mathematics to elementary students?”

It appears that educators who have experience teaching higher grade levels than their present level of teaching are more familiar with future math curriculums.

> **Ruth.** I feel like I have a pretty deep knowledge of math; I love math. I know the curriculum through ninth grade and have taught a lot up through ninth-grade, so I think that helps me sort of peak their interest. It’s like, okay, this is what you are going to be doing next, so you need to make sure you understand the concept. Like, we talk a lot about negative numbers even though it’s not in the curriculum for fifth grade. They’ll like say, so what’s four tenths minus six-tenths and we

can't do that. Well, actually you can. So, I think because I like math and I'm excited about it, and the main reason I ended up going to middle school before this is because I felt like I wanted to teach just (emphasis) math.

Vertical Curriculum. The theme formed under the educator background category is *vertical curriculum*. Each study participant has experienced teaching at a higher-level math curriculum than the grade level they are presently schooling. The breath of educator experience in vertical curriculum improves a teacher's ability to deliver to their students a solid math foundation for future grade levels. Familiarity with the standards spans beyond the intermediate grade level, affording student awareness of middle school math content and principles.

Gary. I think for PD, we need to do more as a county of increasing our teachers' knowledge of math vertically. Teachers need to take a district assessment two years above where you teach to see what students learn two years at a time. So, a 1^{st}-grade teacher should just take the 3^{rd}-grade test just to see. I think there's some teachers that just don't have a great grasp of math and how what they say is not really factually true, even though it's true in their grade. I've taught so many different grades for math; I have a pretty good understanding-- I don't say multiplying gives you a bigger answer, because that's not true when you do fractions, and it's not true when you have positives and negatives. Just stuff like that, where sometimes I think the things we teach the kids confuse them later on because they're not really correct.

Educators who fill the curriculum gap for their students, stretch student content knowledge, and critical thinking. Additionally, they teach problem-solving skills further than grade level curriculum standards. The teachers exhibit vicarious experiences and verbal persuasion; both are SE judgments. Student successes in mathematics lead to critical thinking and problem-solving accomplishments. A teacher who has a clear understanding of present and future curriculums creates a developmental depth of knowledge for student math foundations, which leads to improved student SE and interest in mathematics.

Discrepant Cases. Based on the elementary teacher demographics collected, the interview process informed that Math Endorsements, Professional Learning classes that do not focus on content specific lessons, and degree level did not emerge into patterns or themes of HEMT. Yet, teachers new to the school district have been encouraged to earn a math endorsement to add to their teaching certificate even though this study does not support the certification. The collected HEMT comments suggest that vertical curriculum experience may be more effective at creating SE and math interest in students than some PD opportunities and endorsements that are advertised through the district.

Modeling. The SE judgment of verbal persuasion (Bandura, 1977), is also known as modeling. Piotrowski and Hemasinha (2012), revealed that improved student SE occurs in math when teachers improve their SE for teaching mathematics. Their finding is supported by this study when Ms. Kirk commented:

> the teacher across the hallway is new to our school. And I just inherited seven more AC [Accelerated Curriculum] math kids, and we're playing catch up. And

> the kids were worried. And this one little girl was worried. The teacher across the hallway told her, Mrs. Kirk is gonna take care of you. She knows what she's doing; she's going to get you through math class, and I thought that is a really big compliment. I appreciate her saying that. So, the kids totally trust me because they see me, I think, as an expert. They know how much I love it, and so I think they tend to trust me. They get all fired up about stuff because I do, too.

During the interviews, all participants explained the need for breaking down mathematics to create student understanding of math concepts and principles. Several teachers suggested that PD classes should focus on teacher comprehension of the math standards. Also, there is a need to teach the math educators how to teach the curriculum standard. Mr. Gary stated, “I don't think a lot of ES teachers have a real great understanding of math. Some of the questions they asked me, if I was being honest, are somewhat surprising.”

> **Buckley** A lot of times what we will do when something is new we will pull out the manipulatives, let’s play a little bit. I ask the students, *what does it look like, what do you notice about it?* Then, give them some time just to explore, especially with fractions, because the fraction pieces are very enticing to children. So, we just had some free time to play for a minute. That brings up questions like *what do* or *how do you know this? What do you notice about the manipulatives? What can you do? How do you do that? Can you replace it with a different kind of piece?* You know, just trying to get them thinking about what they're doing. I want to model and go to some sort of guided activity where they're doing it

alongside me. Then, an independent activity. Sometimes independent will be something where they're working with a partner; sometimes independent will be completely on your own.

Research Question 2

Research question 2 asked, “What instructional strategies do HEMT model to stimulate and sustain a perceived student interest and SE in mathematics?

Teachers who model a cognitive thought process for their students, break down mathematics to teach students how to critically think through math problems. This action improves the physiological state of the student to support learning. Ms. Kirk explained:

> look at things from a student perspective. So now when I plan anything, I'm thinking about my experience with it; where kids get hung up on things. And I try to look at it from, if I was a fourth grader. How would I work this, and what would be most beneficial for me to know? I try to think about my thinking, like as a master, as a model for these kids, what is it that I'm doing that could help them? And I try to break it down for them that way.
>
> **Ruth.** I think PD needs to be more grade specific. I think about the math class I took in grad class and it was fun, but I don’t necessarily apply here what I learned there. I think it needs to be grade level-curriculum specific because the way that common core teaches math is so vastly different than we even taught it ten years ago. I think everybody is doing the best that they can, but if you're not math minded, it’s a challenge to understand a lot of the models and the way it is being taught.

> **Buckley.** responded about her comfort in teaching mathematics as, "I do love math; I've been writing frameworks for a couple of years. We have some new teachers that didn't get the foundation I learned. They learned the trick but didn't really get the foundation. Like with rounding the five or more, raise the score. So, they know the trick, but they didn't get the lessons that help them understand why that works, you know? Maybe some vertical planning. Or I think too, for the past year we've had a math coach who has come, she comes occasionally, and she has been helping us with our frameworks, which I think is huge. Because we could go and say this is something we're seeing, this is the gap we're seeing in fourth graders, and she's able to address that and help solidify instruction.

Present under the modeling theme is SE judgments of verbal persuasion, vicarious experiences, and physiological (emotional) states. Teachers who make use of instructional strategies that express regularity in repeated reasoning, improve performance outcomes in their students. Modeling precise steps when teaching mathematics to students, allows students to *see* the math, explained Ms. Murray. Creating a solid math foundation improves student SE and interest in math.

> Ms. Kirk explained, "I did take a group of kids from third grade to fifth grade through common core math, and those were some mathematically powerful kids when they left me." When she saw them a year later, she stated, "When they left me, they were ... I was like, "You all are good." And they've come back to me, and they're like, "Yeah, sixth grade was awesome."

ICT Instructional Delivery

ICT is content standards and related digital curriculum resources that are aligned with and support digital age learning and work (ISTE, 2014). During the observations, I discovered that the participants were very organized in their delivery of math lessons. Although ICT is not routinely used to introduce math content, the teachers used technology to present instruction daily and to review or extend learning. Whether walking around the classroom with a tablet, using an interactive white board, or the preferred document camera delivery, all the teacher participants modeled how to work a problem using some type of technology apparatus.

Research Question 3

Research question 3 asked, "How do HEMT facilitate their use of Information and Communication Technology (ICT) to enhance student SE and interest in math?"

> **Ruth**. I am using the tablet to teach; I've sort of become tied to that. It's difficult for me to not teach with that because that's how I plan my lessons. I put everything in there and then I can just page through, and I don't miss anything.
>
> **Buckley.** I feel like my technology for math right now for me is more a tool. Like using the Ladybug, I can't teach without it, that freedom of being able to do, show them exactly what it looks like, I can't live without it. Kids like it too because sometimes I'll say come do your work under there (points to the Ladibug), so that people can see what you did or how you solve the problem.

Teacher participants access technology on several levels. Some teachers say they have all the appliances they need, such as tablets and computers, others do not. Some say the equipment is available to them on a needed basis. No teacher stated that a lack of equipment caused concern. Figure 3 shows how the educator participants use technology during math sessions.

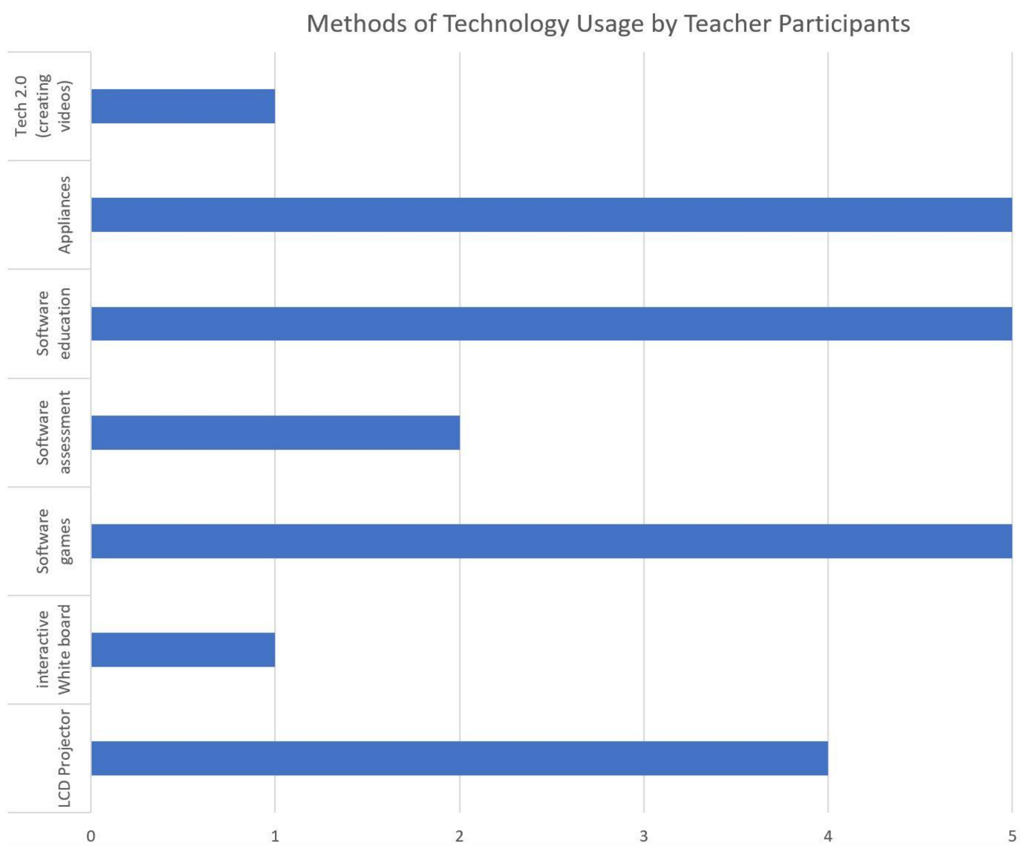

Figure 3. Types of technology usage by teachers during practice, and review of mathematic content.

Uncovering information that provides educational stakeholders with a direction for improving student interest in mathematics can lead to more people entering STEM careers. The answers given in research question 3 shows that the HEMT sample uses ICT as a tool for delivery of math lessons, also, reviewing and extending math content knowledge. However, it is the solid foundation of content knowledge and real life problem-solving scenarios, which create student SE and interest in mathematics.

Often, the use of ICT is hands-on learning that goes beyond the classroom setting. Computer use offers students the ability to participate in life skills. Real-world situations challenge students, which can lead to motivation and interest. Sustained student interest in math during the elementary years improves student entry into secondary education classes. The high school courses set-up students for postsecondary education classes that can lead to careers involving STEM.

Interactive Learning

The informal interviews used in this dissertation permit for the discovery of a teacher's thoughts and feelings about instructional strategies and teaching mathematics at the elementary level. Participants brought artifacts to the interview to discuss the instructional strategies they use in class, including ICT approaches. The work samples are results of class math instruction that demonstrate student interest in a lesson. The reporting of student comments adds to the qualitative context of the analysis. Conducting open-ended teacher interviews about instructional strategies allowed for exploration of the research questions on SE, sustained interest, and the use of ICT. Interview Question 12 asked about student work samples to elicit information designed to address the research questions. Interactive learning is a theme that emerged from the teacher conversations.

Artifacts. The workshop methodology provides learning strategies for different types of learners. Practice situations and practical applications found in real world settings help students to discover math concepts. Also, competition stimulates student interest and SE for mathematics. When students witness classmates successfully complete an assignment, they want to complete the task too. Students learn to persevere through teacher verbal persuasion. They feel that they can *do the math*.

> **Murray**. The first thing is how do I break it down to teach it to an elementary student? And I think of what can they relate to first? What piece of this do they know that I can then build upon, and I think that makes a big difference for them, if I have to, if I can make a connection, but that's the biggest thing is how do I connect it to what they already know and then break it down into pieces they can understand? And sometimes that involves manipulatives, and sometimes it involves you know, okay let's look at, and sometimes it starts with their hands-on it, and then they end up with the abstract or organic, we try to do that and up with the algorithm at the end.

Research Question 4

Research Question 4 asked, “How do HEMT feel about a perceived reciprocal effect in SE and math interest due to the use of instructional strategies?”

Since the schools in the study are STEM certified, I expected to discover clear evidence of a link between ICT and mathematic teaching strategies to increase SE and interest in mathematics. Instead, a discrepant case emerged within the study. I discovered that the HEMT use real world problem solving scenarios to raise student SE and interest in mathematics. Educators employ guiding questions to motivate student interest. For instance, when given the volume, of five different suitcases Mr. Gary asked his students, "Would it fit in your trunk?" Using a huge box brought in by the teacher to simulate a car's rear storage, the students calculated the volume of the suitcases and trunk. The highly-motivated students learned that although they thought the problem would be easy, because of all the dimensions involved the equation was difficult.

The theme of interactive learning emerged for improving SE and math interest. Hands-on learning and activities were mentioned through-out the interviews. Ms. Ruth described how the students enjoy cutting and pasting, "It keeps them engaged." In fact, the phrase "hands-on" was referenced by four of the five teachers as a method for fostering student interest. During Interview Question 2 that asked, "What type of learning experiences do you believe build interest in your students?" Ms. Kirk exclaimed, "So anything kind of hands on is going to be good, anything that's going to get them moving, and problem- solving." Answering the same question Ms. Murray described a district Three Act activity that required the students to decipher the materials needed for a medical pick-line.

> **Murray.** They love hands-on, and Three Act tasks. They're very challenging! Basically, it gives the kids a scenario about how they have to plan. They had a list of intravenous supplies, and they were talking about treating a person with a pick-line. These were all of the things that you needed in order to treat a person's disease for two weeks. The kids had to figure out what would you need, and how much would you need if you had to treat ten people for two weeks. The fun part was everything came in different size packages. So, they had to think how many alcohol wipes for this one person will they need for the two weeks, and then they

were multiplying everything--- it was really good. But, oh my gosh, it was so funny! As a teacher, it was really hard to teach. I had to walk them through it. It turned into a guided more than an independent lesson, but that was okay. At the end, I told them they all had a medical degree. It was kind of funny because they were good-natured about it. They [the students] felt success because at first they, [sic] you can tell, you can see the expressions on their face. Once they actually figured out what the question was asking them and they had a context for it, then they said okay. It kinda opened their eyes, but any kind of inquiry like that they like.

Buckley. explained different ways the teachers use ICT to support hands-on problem-solving activities. [Geometry is rolling around], I would really like to do something with the 3D printers where they have to create [a shape]. Like, give them some parameters where they have to use geometric shapes or polygons or something they have to follow, and find out how to incorporate and create a 3D structure.

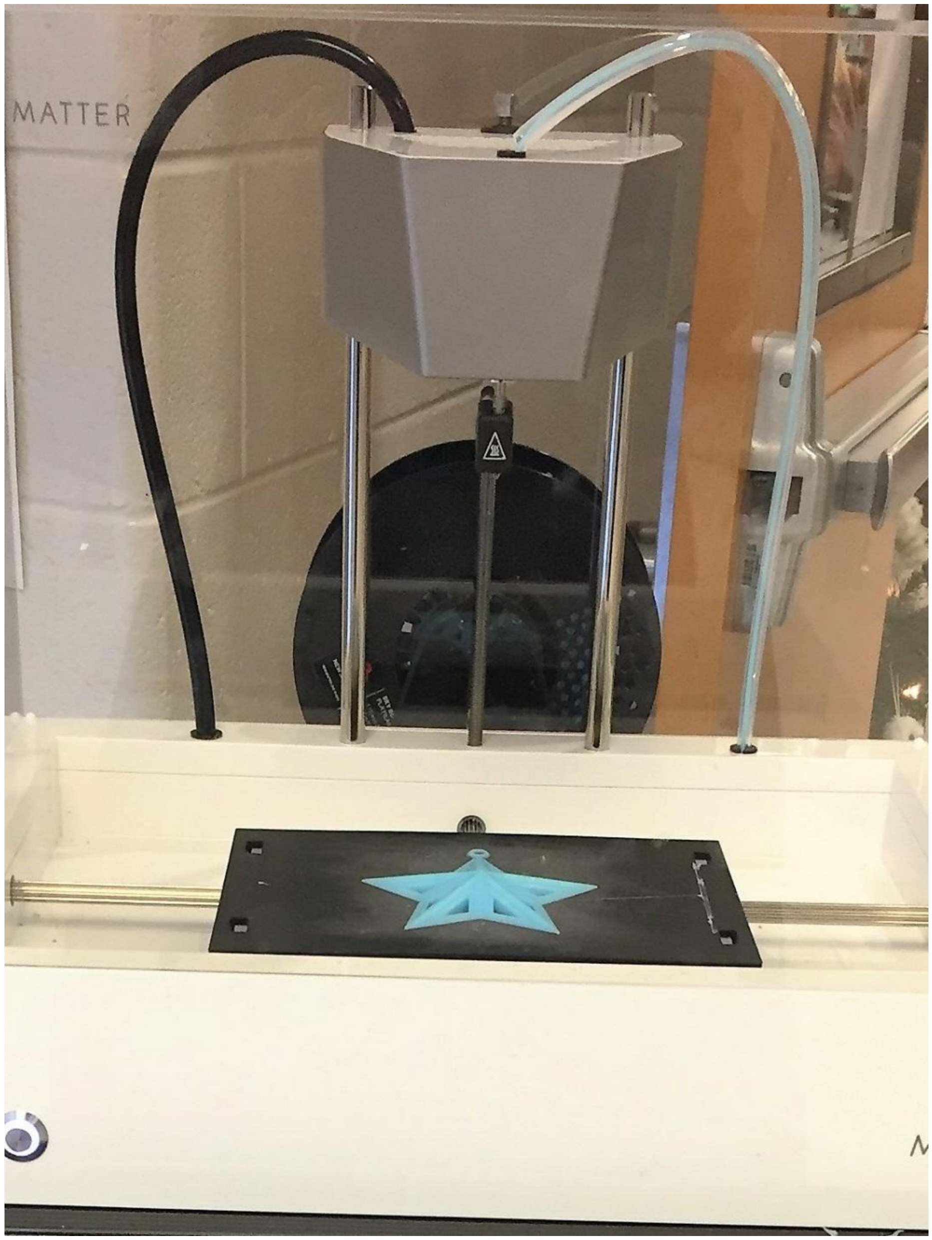

Figure 4. 3D Printer used at McCullife ES to create geometric shapes.

She went on to say, just giving them cameras, digital cameras and having them go around take pictures of different types of angles or different, you know, things like that and they can put it in a video, make a video or that type of thing.

> We used the *Explain Everything* app and not the whiteboard. Students can use pictures of different things, and it almost turns it into a video, and we talk about it. They can solve problems on there, or solve problems using the iPad. We used *Chatter Pics*, another app, that they took the shape and then make it talk. She took a trapezoid, the sofa in the media center, and it talks and then it was telling things, characteristics of the trapezoid."
>
> **Kirk.** They have to know characteristics of a two-dimensional shape, quadrilaterals, triangles, things like that. Using the application *Chatter Pix*, the student group demonstrates that they know the vocabulary. The following geometric shape descriptions were provided by the group, (student description) *This is a trapezoid. It has four vertices. This is an irregular polygon because it doesn't have all equal sides, and it doesn't have all equal angles. This polygon has two obtuse angles.* This was another one. And not all of them are fantastic. (student description) *Hi. I'm a square. I have two sets of parallel sides and four vertices. I also have four right angles and four sides of perpendicular sides. I'm also a quadrilateral. And that's just some of the characteristics that a square has.*

Not all discussed artifacts were ICT related. Ms. Murray explains the purpose of a *Where's the Math?*, an interactive poster that hangs in the fifth-grade hall.

Murray. We have an interactive poster out, we're gonna be hanging up photographs of different things and they have to write how does this relate to math? Like tomorrow we are hanging photos to see what they come up with, and then broaden it to the outside world. Get the students to realize that math is everywhere. Does that apply to you at the grocery store or to start them to understand why it's part of our lives.

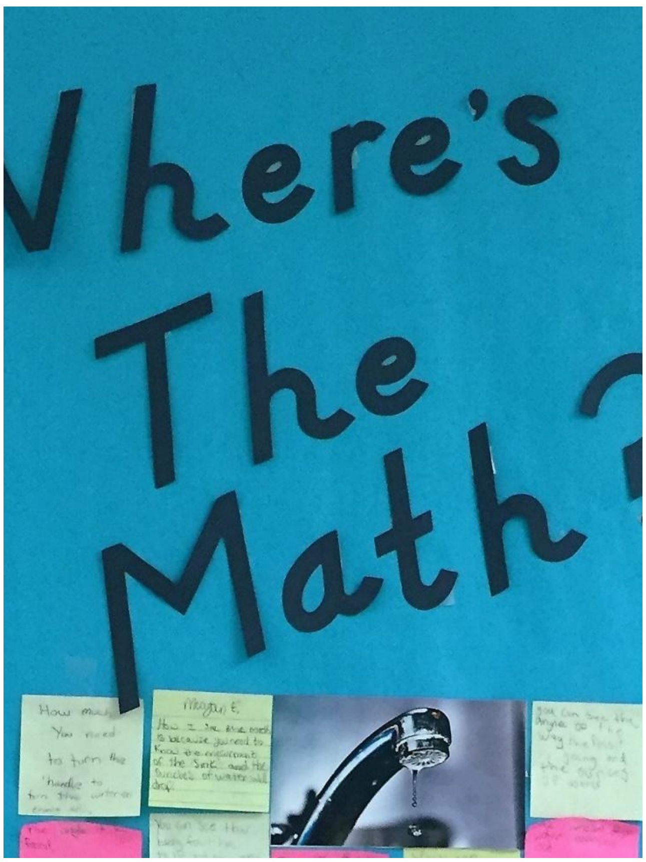

Figure 5. Interactive poster from Beams ES.

Interviewing the teachers in their classroom helped with the artifact collection. Teachers could easily access the math assignments where students showed interest and demonstrated SE for mathematics. I feel this was an important variable in the research.

Summary

I used a multicase study to explore how five classroom teachers use instructional strategies to teach elementary math. Secondly, I explored relationships that exist between SE and interest in mathematics as perceived by HEMT. Discovering if teacher verbal persuasion has a reciprocal effect on student SE and math interest was explored. In this chapter, I presented coded and analyzed data of HEMT perceptions about student SE and interest in mathematic relationships. Also, I recorded teacher observations and interviews that took place in each educator's classroom along with discussions about student assignment artifacts.

The two schools selected for this study are in the suburbs. They were chosen for their diverse student population and depth of ICT usage. Also, five HEMT who work at the two selected schools were used in the study. The observations and interviews took place in each teacher's classroom, so the setting was familiar and casual to the participants.

I exhaustively explored the data from each observation and interview to discover the attitudes and practices of HEMT instructional strategies. I used the words and experiences of the participants to identify these themes and to strengthen the credibility of my interpretation. Complete descriptions transcribed from digital recordings were used to track the interview comments and reporting of student math lesson artifacts. The use of recordings and field notes established accuracy and data credibility to answer the research questions. The sample size was large enough in this multicase study for transferability of patterns and themes, which are revealed about student SE and sustained math interest. Onsite visits, digital audio recordings of the interviews, and student's artifacts helped to improve dependability in the study through triangulation.

I learned that all the teachers had vertical curriculum experience with the middle school standards and none held math endorsements. Themes emerged into the categories of vertical curriculum, modeling, ICT instructional delivery, and interactive learning. The HEMT participants used ICT as a tool for delivery of math lessons plus reviewing and extending math content knowledge. Data indicated that teachers perceived a reciprocal effect between SE and math interest due to the use of interactive learning, and problem-solving of real world situations.

In Chapter 5, the purpose and nature of the study will be discussed. Interpretations of the findings were organized within the peer-reviewed literature described in Chapter 2. Analysis and interpretation of the conceptual framework occur. Recommendations for further research and the implications for social change are provided for dissemination among educational stakeholders.

Chapter 5: Discussion, Conclusions, and Recommendation

Introduction

The purpose of this study was to explore how HEMT use ICT to teach mathematics to their students. The multicase study design allowed me to explore how HEMT use instructional strategies to teach elementary mathematics and to explore and describe relationships that existed between students' SE and interest in mathematics as perceived by HEMT. The qualitative research approach that I employed helped me to discover that the verbal persuasion of HEMT has a reciprocal effect on student SE and math interest in elementary mathematics.

My triangulation between a class climate observation (Appendix A), a 30-minute interview (Appendix H), and a discussion about student math interest with five teacher participants gave me a snapshot of their math classrooms. The HEMT participants were prompted to elaborate on the interactions they experienced when teaching mathematics. Through interviews, the teachers expressed how they felt about teaching mathematics, which related to the physiological feedback in Bandura's (1977) SE judgments. As expected, the HEMT participants revealed self-reported insights on student experiences, emotions, and feedback during math lessons, assignments, and projects. Through the interviews, I discovered that reciprocal effects between student SE and sustained interest in mathematics exist.

Brown (2012) argued that mathematics is a precursor to postsecondary STEM entrance. Brown posited that understanding how elementary level instructional strategies influenced student SE and sustained interest in mathematics can provide educational stakeholders with needed information to improve a student's foundation in mathematics, which was significant to my study as Research Questions 2 and 3 focused on SE and sustained student interest at the elementary level. Teacher perceptions led to the belief that students with a strong math foundation can take higher-level math classes during secondary school. With a sound aptitude and interest in mathematics, an opportunity exists for students to enter college level classes and majors that require a strong math foundation.

Through the interview process where teachers shared their perceived ideas on how they use instructional strategies to teach elementary math, I discovered an unexpected result. Teacher participants in the sample revealed that they all had knowledge and experience with a vertical curriculum, or experience teaching at least one grade level higher than their present teaching level. The teachers felt that their experience in teaching higher-grade levels allowed them to compensate for gaps that exist from one grade level to another within the state math standards. This discovery requires further investigation to determine if vertical curriculum teaching experience leads to highly effective teachers. Areas discussed in this chapter include interpretation of the findings, limitations, recommendations, and implications of the study.

Interpretation of the Findings

I viewed the effective elementary math teachers' instructional strategies for building student SE and interest in mathematics at the primary level of education through the lens of Bandura's (1977) SE theoretical framework. Additionally, Hidi and Renninger's (2006) FPMID and Hattie's (2013) synthesis of meta-analyses about effective teachers were used as the conceptual framework that provided principles of HET strategies and classroom management. Piotrowski and Hemasinha (2012) and Stevens et al. (2009) concluded that at the postsecondary level a relationship exists between SE and interest in mathematics and that the connection exhibits a reciprocal effect on SE judgments.

The triangulation methods I used in this study confirmed that HEMT at the elementary level also reported a reciprocal link between SE and sustained student interest in mathematics. I discovered that teachers believed students develop a personal SE for mathematics along with a sustained individual interest in mathematics when problem-solving and critical thinking skills are applied to real-world scenarios. Further, the teacher participants believed that challenging mathematic tasks that involve hands-on learning create a sustained interest for math. They believed that ICT involves active learning that leads to interest. Hands-on instructional strategies, including ICT, engaged fourth and fifth grade students during mathematic lessons, assignments, and projects. The HEMT participants reported using teaching strategies that engage their elementary learners through active learning and ICT instructional strategies, and I witnessed this during the class climate observations.

Research Question 1

Polly et al. (2014) and Bailey (2010) reported on task-focused mathematic PD. Consistent findings among the studies concluded that curriculum specific teacher PD is needed to improve student interest and SE for mathematics. Also, they found that PD helped teachers improve their understanding of the mathematical concepts and pedagogies embedded in the districts' standards-based mathematics curriculum. Using teacher interviews, my research showed that the participant HEMTs exhibited a substantial knowledge of the state curriculum standards.

The participants commentary suggested their belief for their colleagues to participate in curriculum specific PD for improved comprehension of the standards. Their statements were consistent with the findings of the Polly et al. and Bailey studies. Some teacher participants in my study indicated that it was not enough to offer teachers PD in mathematical content knowledge. Rather, instructors needed to learn how to teach the curriculum standards so teachers can model the math content for their students. This more prescriptive approach to PD will provide policymakers with better guidance for teacher staff development in math teaching.

Bailey (2010) revealed that a strong effect size occurred in the areas of peer-to-peer interactions and teacher immersion in the development of standards-based instruction. My interview data disclosed that the school district math coach worked with two of the HEMT to analyze the math standards, create pacing guides, and assessments before lessons were written. The teachers then redelivered the information to their colleagues. The peer-to-peer interaction confirms Bailey's suggestion of developing standards-based PD instruction.

Missing from my literature review was information about vertical curriculum knowledge. All the teachers in the sample had experienced teaching grade levels higher than their current elementary grade level. The instructors believed that their experience with vertical curriculum knowledge helped them fill-in gaps with-in the state curricula.

They stated their background knowledge of higher levels of mathematics allows them to be more effective teachers because they know how to bridge gaps in the state math standards. The teachers believed that PD needs to focus specifically on the math content taught on grade-level through 1-to-2 years above grade-level. This discovery merits future investigation.

Research Question 2

In the book titled, *Visible Learning*, Hattie (2013) stated the importance of teacher content knowledge, teaching methods, interprofessional skills, and classroom management. Teacher participants in this study demonstrated strong classroom management as recorded through the observation form (Appendix A). Their lessons were organized using technology appliances of different types. Two of the teachers used Mimeo tools with an overhead projector, which makes a white board interactive. Two teachers used a Ladibug, which is a document camera that sits on a desk and projects information captured through the lens. One teacher, who prided herself on technology usage, organized every lesson through a Mobi View tablet. She liked the ease of organization with the device. All the teachers have students problem solve with the listed appliances. The children are encouraged to work out math problems as displayed on the screen. During my observations, I witnessed the students presenting information to their classmates with no hesitation. They looked comfortable as they performed tasks using the technical equipment.

Bailey's (2010) longitudinal study provided convincing evidence that components of teacher training should include ample focus in areas that I previously highlighted in the literature review. Pertinent information uncovered from my review of the literature included the principles relevant for developing an appropriate math curriculum (i.e., technology and equity) and math content proven to impact teachers' ability to design and use authentic assessments (Bailey, 2010). My discussion in Chapter 4 related to this aspect indicated how participant teachers used software programs to monitor student homework and practice math concepts. This practice allowed for authentic assessment of student time spent on homework and review. Using digital math games for student practice sessions engaged student interest in mathematics. Technology is used as an instructional strategy tool that allows the student to review and extend intrinsic interest in learning math concepts. Through the games, students become aware of how math is used in daily living and activities. Disconfirmed is Baya'a and Daher's (2013) belief that technology acts as a motivator. The schools in this study were certified in STEM education, and teachers and students used ICT as a tool or an instructional strategy. The teacher participants did not view ICT as a motivator for completing assignments or learning new material.

As I described in the literature review, the district's accepted use of the TES (2013–2014) explained that an instructional strategy demonstrates how a teacher continually facilitates student engagement in metacognitive learning, higher-order thinking skills, and application of learning in current and relevant ways. Educators who raise awareness of knowledge and skills needed for future career paths provide students with the opportunity to bridge classroom learning to a real-world application (Fisher et al, 2012). An instructional strategy such as engaging elementary students in conversations and lessons on future career opportunities can then bridge learning to their future reality and improve the foundation needed for entry into STEM education.

Sanden (2012) concluded that highly effective classrooms demonstrate student educational growth and accountability for learning. Sanden argued for the need for extensive use of scaffolding (teachers model or demonstrate the problem-solving process, then step back and offer support as needed), strategies that encourage self-regulation, and elevated expectations to improve achievement and growth. Consistent with Sanden's (2012) finding and the school district's definition for exemplary teachers, the study participants demonstrated exemplary instructional strategies during the classroom observation.

All teachers in the study sample used a math workshop approach that included exploring, learning, practicing, and reviewing in their math classes. Although the teacher from McAuliffe ES was not familiar with the phrase math workshop, Mr. Gary's teaching strategy was the same as used by the teachers from Beams ES. The math workshop approach provides for academically challenging standards that push students beyond their comfort, affording for student growth in knowledge and skills. This strategy is also consistent with Hattie (2013), who argued that effective teachers teach students how to interpret and analyze math solutions. Successful thinking and strategizing about challenging curricula improved student learning and was found in the data collection and analysis.

Research Question 3

As I previously discussed in the literature review, Stevens et al. (2009) concluded that teachers who provide ICT and other teaching strategies that focus on mathematics knowledge help to build student SE. Confirming Stevens et al.'s findings, the teachers in this study personalized student lessons by implementing ICT education activities to advance knowledge and interest. Personalizing student learning contributes to improving student efficacy in math, which leads to a sustained student interest in mathematics (Bandura, 1997).

Baya'a and Daher (2013) proposed that teachers who use ICT-based instructional strategies support independent student learning and development of math topics. The participant teachers' comments from this investigation were consistent with the Baya'a and Daher's conclusions, which reported that independent learning and the discovery of math concepts leads to a deeper understanding of mathematical ideas. The study participants used ICT as an instructional strategy to extend knowledge to students who learn more quickly than other classroom students do. The advanced depth of knowledge personalizes student education and acknowledges that a sustained interest in mathematics develops (Bandura, 1997). Students quiz themselves to use math in everyday situations and are engaged to solve daily challenges.

As I discussed in Chapter 2, personal challenges lead to a sustained interest in mathematics (Bandura, 1977). The elementary students were tested with a real-world scenario when they had to determine the materials needed for a pick-line. Defining what a pick-line is was the first part of the challenging assignment. Described as a difficult lesson that was released by the district, the students derived the costs of materials needed for the pick-line by breaking down the supply list and determining the medical needs for the mock patient. Although the assignment was challenging, and the students required teacher guidance, the children were proud of their accomplishment. They learned to persevere through the task and reach a conclusion. This example demonstrates how SE and interest create a reciprocal effect on learning.

Research Question

The Polly et al. (2014) study suggested the use of artifacts to uncover reciprocal effects in SE and interest in mathematics. Exploring math instructional strategies and assignment samples allowed me to take field notes on a teacher's perceived reciprocal effect in SE and math interest. The model proposed from the Literature Review in Chapter 2 illustrated how ICT-based instructional strategies produced a reciprocal effect on SE, and sustained interest in elementary students. Figure 1 of the ICT-based Instructional Strategy Effect on Self-efficacy and Interest Model is consistent with my findings that highly effective math teachers, who use multiple hands-on instructional strategies including ICT, improve student math SE through a real-world understanding of math concepts.

Hidi and Renninger (2011) stated that emerging attention, goal-setting, and learning strategies, even in young children, leads to a predisposition for content learning in all ages. Sustained interest continues throughout the grade levels if students remain with HEMT. Fisher et al. (2012) demonstrated a correlation between early math development is needed because not all children are raised in a positive atmosphere for mathematics. Consistent with the study results from Hidi and Renninger and Fisher et al. (2012) the participants in this study believe that HEMT can improve student math interest. HEMT that use real-world scenarios to teach hands-on problem-solving activities promote SE and interest in their students.

The ability of a student to learn is conducive to their SE. Through 15 years of research and synthesis, Hattie (2013) explained how feedback from teachers to their students can improve learning and understanding by using positive talk techniques. Hattie stated that through knowledge, empathy, and verbal ability, an educator uses their interpersonal skills to be effective teachers. Hattie’s data reveals a student’s perception of their capacity for success is the most substantial of all effects (Hattie, 2013).

Hattie’s (2013) research on meta-analysis is confirmed when he states that effective classroom management and interpersonal skills is used by effective teachers. Faculty and students who respect each other create a climate for the importance of education. Hattie included the need for students to make mistakes without fear, allowing for student error without fear of retribution. Hattie’s theory is consistent with my results. Classroom observations of all study participants were laid back, and organized, as the children focused on their education. Students who were off-task were quickly redirected to the class assignment. No escalation for improper behavior occurred as teachers ignored minor distractions. Transition times were effective as instructors continued to teach, while students made efforts to keep up with the instruction.

Consistent with Hidi and Renninger (2011) and Fisher et al. (2012), teacher presentation of materials was interactive and paced for the class to follow along without difficulty. Multiple workstations made it possible to individualize for student needs. Teachers suggested students talk to their *shoulder partner* to discuss math content that included solving mixed-fractions. Consistent with Bandura's (1977) SE theory, use of positive words by the teachers occurred improved student effort as they problem-solved math problems. Helping when needed, the students assisted each other assess and construct their learning. Use of the math workshop approach, as described by Sanden (2011) was evident.

Major Conclusions

In summary, Research Question 1 discovered that the study participants perceive vertical curriculum experiences of HEMT improve student SE in fourth and fifth-grade students. Since teachers know the curriculum standards for one or two grades above their present teaching level, they can fill the gaps of knowledge needed for student success in upcoming math classes. Uncovering this information was unexpected and not part of the literature review.

Research Question 2 explored instructional strategies and SE. I discovered that real-world problem-solving math equations are used by HEMT to stimulate and sustain a perceived student interest in mathematics. This type of hands-on learning is consistent with Hidi and Renninger's (2011) theory of the FPMID. Also, Bandura's SE theory is consistent with an HEMT's use of modeling mathematics. Educators need to model for students how to persevere during challenging math assignments. Teachers should use words that support learning and student efforts and use math exemplars to work through challenging problems.

Brown's (2012) study, which suggests that more math classes during preservice teacher education improve active teaching is inconsistent with my study findings. Instead, I discovered the need for all math teachers, not just preservice, to take classes that model how to teach specific mathematic curriculum standards. As state curriculums change, so must the PD classes, which target and model lessons specific to math content.

Research Question 3 asks about ICT and how it enhances student SE and interest in math. Inconsistent with the literature by Baya'a and Daher (2013) who propose that the potentiality of ICT acts as a motivator for student learning and discovery of math concepts. Instead, I discovered that HEMT participants use ICT to present student's lessons and to support or extend learning. The teachers use ICT to personalize education, grade homework, organize lessons in addition to the educators' daily productivity usage.

Lastly, in Research Question 4, I learned that consistent with the literature HEMT feel a reciprocal effect exists between SE and math interest due to the use of instructional strategies. Consistent with Bandura's theory on SE, HEMT demonstrate SE judgments in their instructional strategies.

Limitations of the Study

The findings in this multicase approach cannot be generalized but contribute to the knowledge of developing student interest in STEM careers. Triangulation of what takes place during a class climate observation, a 45to 60minute interview, and a work sample discussion about student math interest per teacher participant was a snapshot of the math classroom. The triangulation did not allow for student sustained interest measurement. Larger populations are needed in future studies to generalize to a larger sample.

Recommendations

Further research on ineffective elementary math teachers is needed to see if the backgrounds of those educators include vertical curriculum knowledge. Having one or two years of experience teaching in grade levels higher than the level a teacher is currently teaching appears to be a factor contributing to HEMT. Additionally, a study should look at the instructional strategies of ineffective teachers. A comparative analysis is needed to determine if HEMT who use hands-on approaches toward learning and real-life scenarios to add interest to the course work differs from other teachers. Analyzing the differences in these areas could lead to teacher effectiveness measures and ultimately to improved student interest in elementary mathematics.

The need for teachers to have experience in teaching one or two years higher than the present grade level they are teaching is an unexpected discovery of the study. This experience is known as a vertical curriculum. It was omitted in the Chapter 2 literature review. It appears to be an area to investigate because the HEMT in this study use their vertical curriculum knowledge to close the gaps that occur in state curricula.

Conclusion and Implications

Positive social change will occur as educational stakeholders learn how instructional strategies influence student interest in mathematics. STEM occupations are considered by employers to be an area of need, but not enough elementary age children are interested in math or other STEM careers (DeJarnette, 2012; Pajares, 1997). The trend continues through secondary school and college, resulting in a shortage of trained people to fill STEM jobs.

Empirical evidence shows that student SE for mathematics leads to improved content knowledge. However, math knowledge plus increased interest in math education creates a foundation for STEM careers. A strong math foundation allows for future STEM career opportunities in ICT and other areas of STEM where job needs continue to grow. This study may lead to changes in teacher education and PD programs to improve student interest in mathematics.

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Appendix A: Classroom Observation Form

Instructor: ____

Course: ____

Peer/Observer: ____________________________________

Date and Time ______________________________

Use criteria that apply to format of course observed.

Review Section	Description/Comments
1. **SUBJECT MATTER CONTENT** (shows good command and knowledge of subject matter; demonstrates breadth and depth of mastery)	
2. **ORGANIZATION** (organizes subject matter; evidences preparation; is thorough; states clear objectives; emphasizes and summarizes main points, meets class at scheduled time, regularly monitors on-line course)	
3. **RAPPORT** (holds interest of students; is respectful, fair, and impartial; provides feedback, encourages participation; interacts with students, shows enthusiasm)	
4. **TEACHING METHODS** (uses relevant teaching methods, aids, materials, techniques, and technology; includes variety, balance, imagination, group involvement; uses examples that are simple, clear, precise, and appropriate; stays focused on and meets stated objectives)	
5. PRESENTATION (establishes online course or classroom environment conducive to learning; maintains eye contact; uses a clear voice, strong projection, proper enunciation, and standard English)	

Review Section	Description/Comments
6. **MANAGEMENT** (uses time wisely; attends to course interaction; demonstrates leadership ability; maintains discipline and control; maintains effective e-platform management)	
7. **SENSITIVITY** (exhibits sensitivity to students' personal culture, gender differences and disabilities, responds appropriately in a non-threatening, pro-active learning environment)	
8. **ASSISTANCE TO STUDENTS** (assists students with academic problems)	
9. **PERSONAL** (evidences self-confidence; maintains professional comportment and appearance)	
10. PHYSICAL ASPECTS OF CLASSROOM (optional) (state location and physical attributes of classroom, number of students in attendance, layout of room, distractions if any; list any observations of how physical aspects affected content delivery)	

Appendix B: Copy of the Observation Permission E-mail

Coulter, Matthew (mattcoulter@uidaho.edu) <mattcoulter@uidaho.edu> Feb 24
to me

Hi Linda,

You are welcome to use the form you attached.
I am not sure of the history behind it. This is my first year in this position.
We have various forms we use, I attached another form many of our supervisors use.
Again I'm not sure exactly the history behind it but I know we establish certain dispositions that are consistent with teacher standards for the state of Idaho.
In recent years, we have worked to connect our evaluations with the Danielson Teacher Evaluation framework.

Dr. Matt Coulter
Director of Field Experiences
University of Idaho
(208) 885-0349

From: Linda Brimmer [mailto:linda.brimmer@waldenu.edu]
Sent: Tuesday, February 23, 2016 6:11 PM
To: teached
Subject: online Classroom observation Form

Hello,
Presently I am a doctoral candidate at Walden University and working on my study proposal. I would like to use an observation form that has been credited to your college and attached to this email fo your review.

Would you please tell me who developed the instrument and how the form has been used. Perhaps you can explain how you established validity for the content of the form. Any history about the development of the form or its use would be helpful to me.

Also, may I have permission to use the form in my study? I appreciate your timely assistance with my request and questions. Thank you for helping me move my proposal forward.

Sincerely,
Linda Brimmer

Appendix C: Interview Protocol- Matrix of Interview Questions

A. Introduction to the Multi Case Study and Protocol

1) Case study questions, hypotheses, and propositions

   a. How do highly effective elementary math teachers (HEEMT) feel about their ability to teach mathematics to elementary students?

      i) HEMT feel they are capable of teaching basic mathematical concepts to students.

      ii)HEMT feel they are well-able to teach basic mathematical concepts to students.

      b. What instructional strategies do highly-effective elementary math teachers use to generate sustained student interest in math and improve student self-efficacy ?

      i.Teachers use some, several, many teaching and learning styles to teach mathematics to improve student self-efficacy for mathematics.

      ii. Teachers demonstrate the need for students to be able to use mathematics.

      iii. Students learn to apply mathematics to complete common daily tasks.

   c. How do highly-effective elementary math teachers incorporate ICT to promote student self-efficacy and interest in mathematics?

      i. Using ICT, students are sometimes, always introduced to mathematic applications.

      ii. Using ICT, students sometimes, always practice mathematic skills.

      iii.Using ICT, students demonstrate daily math use for common daily tasks.

2) Theoretical framework for the case study

   a) Self-efficacy theory

   b) Well-developed individual interest model

3) Role of protocol

   a) keeps researcher focused on interview questions for proper data collection

B. Data Collection Procedures

1. Names of sites to be visited

2. Data collection plan

   a. direct classroom observations

   b. interviews

   c. student work samples- artifacts

3. Expected preparation prior to site visits

   a. district approval

   b. principal approval

   c. teacher approval

C. Outline of Case Study Report

1. A teacher's SE in teaching mathematics does or does not affects student self-efficacy

2. Sustained student interest in mathematics does or does not lead to further interest in mathematics

3. The reciprocal effect on self-efficacy and sustained student interest does or does not make a difference in student math achievement.

D. Case Study Questions

Appendix: D Case Study Questions

Different Fonts and Color Coding for Types of Questions

Theoretical framework for the case study	**Case Study Questions**	
	How do highly effective elementary math teachers (HEMT) feel about their ability to teach mathematics to elementary students?	**What instructional strategies do highly effective elementary math teachers use to generate sustained student interest in math and improve student self-efficacy in mathematics?**
Student Self- efficacy and sustained interest in math have a reciprocal effect. **Incorporating Information and Communication in teaching mathematics.** **Instructional strategies used by HEMT.**	**Please tell me about the preparation you received to become an elementary math teacher.** **How do you feel your knowledge of mathematics affects your student's math ability and interest in math?** **Please explain what goes through your mind when it is time to teach mathematical concepts to your students.** **Tell me your thoughts about taking professional development classes to improve student interest and ability in mathematics.** ***Major questions or prompts. Sequence question to prepare for the next question. Allows for more data. Color code how they are related to each other.***	***Instructional strategies determine the approach a teacher may take to achieve learning objectives.*** **Please describe what student behavior I would see in a typical math lesson that you teach.** **Tell me how you teach students to discover math concepts.** ***Can you describe the instructional strategies you use to peak your students interest in completing math assignments*.** **Please show me student work samples that you feel demonstrate math interest or student ability to reach a goal in math? Describe for me what the outcome of this sample shows.** ***Follow up—do you have any work samples that used technology?*** **Can you tell me how you discern if students are interested in a math lesson?**

Appendix E: Parent Permission Letter

April 15, 2016

Dear Parent/Guardian:

I am a doctoral candidate at Walden University in the department of educational technology. My study is examining highly effective elementary math teacher's instructional strategies to increase student interest in mathematics.

A step in this process is to observe the classroom climate during a math lesson. Interaction between the teacher and students will be identified and recorded. However, no names will be used to recognize the school district, school, teacher, or student. Students will be identified according to gender, but no names will be recorded or revealed in the course of the study. Your child's teacher will be interviewed about their math background, instructional strategies used to teach math, and how they feel about teaching mathematics. No communication will take place between your child and me except for a possible acknowledgement of my presence in the classroom. You will not be contacted for an interview regarding your child. Please indicate your permission by giving consent for me to proceed with my study.

If you have questions, please do not hesitate to contact me. Thank you in advance for taking the time to help me in my study.

Sincerely,

Linda Brimmer

____________ **I do give my consent** to the researcher to observe my child's mathematics classroom.

____________**I do not give my consent** to the researcher to observe my child's mathematics classroom.

Signed:____

Relationship to Child:______________________________

Student Name: ____

Classroom Teacher:________________________________

Appendix F: Teacher Invitation to Participate

Date:

Dear (Insert Teacher Participant Name):

Congratulations! You are recognized as a highly effective math teacher (HEMT) based on your teacher evaluation record, and I am asking for your help with my research. Presently, I am conducting a dissertation study regarding HEMT instructional strategies. As a XXXXX teacher, I know your time is limited; therefore, I am asking for a one-time 30-minute interview to get your opinion about teaching mathematics to your students.

Please accept my invitation and allow me to come into your classroom to first observe the classroom climate regarding your policies and procedures and then interview you about the instructional strategies you use to teach mathematics. We will set-up times and dates that are convenient to you; the interview will be held outside of class time. I am happy to answer any questions you may have.

Please respond to this e-mail to let me know if you can participate in my study. Thank you for your time and consideration in this matter.

Warm regards,

Linda Brimmer, Ph.D. candidate
Walden University

Appendix G: National Institute of Health Certification

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Linda Brimmer** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 06/08/2016.

Certification Number: 2091359.

Appendix H Interview Questions

Table 4

Interview Questions

Conceptual Framework	Question number	Type and Question
Self-efficacy judgments Sustained interest in mathematics ICT Instruction-based strategies	1	Experience Q: Please tell me about the preparation you received to become an elementary math teacher.
Self-efficacy judgments Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	2	Experience Q: Describe for me how your knowledge of mathematics affects your student's interest and engagement in math.
Self-efficacy judgments Sustained interest in mathematics	3	Feeling Q: What is your opinion of how your mathematical knowledge helps you to create a math interest in your students?
Self-efficacy judgments ICT Instruction-based strategies	4	Experience and Beh Q: What experiences would I observe you modeling to help your students discover a math concept?
Self-efficacy judgments Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	5	Knowledge Q: What math knowledge helps you to create a math interest in your students?
Self-efficacy judgments ICT Instruction-based strategies	6	Knowledge Q: What is your opinion of you taking PD classes to improve your student's interest in mathematics?

(table continues)

Conceptual Framework	Question number	Type and Question
Self-efficacy judgments Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	7	Sensory Q: Tell me what would I see students doing in a typical math lesson that you teach?
Self-efficacy judgments ICT Instruction-based strategies Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	8	Sensory Q: Tell me what would I see you doing to peak your students interest in a math assignment?
Self-efficacy judgments ICT Instruction-based strategies	9	Experience and Behavior Q: If I followed you during a typical math lesson where you use technology, what would I see you doing?
Self-efficacy judgments ICT Instruction-based strategies Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	10	Experiences and Behavior Q:What technology experiences would I observe you using to improve student interest and ability in math?
Self-efficacy judgments Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	11	Experiences and Behavior Q: What type of learning experiences a. do you believe build interest in your students? b. follow up: demonstrate ways that students feel successful in math?

(table continues)

Conceptual Framework	Question number	Type and Question
Self-efficacy judgments Sustained interest in mathematics ICT Instruction-based strategies Perceived reciprocal effect in SE and math interest due to the use of instructional strategies	12	Opinion and Value Q: Using the student work samples you've gathered, what is your perception of student interest with the assignment. a. Follow-up—Please explain how you feel this math assignment increased confidence in the student's mathematical ability.

Note. See the full interview protocol in Appendix A**.**

Appendix I: Letter to the School Principal

Date:

Dear (Insert Principal's Name):

Congratulations! County personnel have recognized your school as highly effective in mathematics education. I am asking for your help with my research. Presently, I am conducting a dissertation study regarding highly effective teachers' usage of instructional mathematic strategies. As a XXXX teacher, I am asking to conduct a one-time mathematics lesson teacher observation and a one-time 30-minute interview with highly effective mathematics teacher(s) who teach in your school.

A math lesson observation will take place by me to determine classroom climate, but no student information will be recorded. Field notes will be used to observe the teacher and climate in the classroom. Additionally, I will use an open-ended interview process to ask teacher participants questions about their use of instructional strategies to teach mathematics to students from your school. Teacher participates will choose a time convenient to them for the interview. The interview will take place during the teacher workday, but not during their class time. I have attached participation consent letters for your review.

At no time are students identified during the observation or interview. Although student math samples will be discussed during the interview session, only teacher comments about deindentified student artifacts are recorded. No class time will be used for the interview.

Please accept my invitation and allow me to come into your school to first observe the classroom climate regarding teacher participant policies and procedures and then interview the teacher about the instructional strategies used to teach mathematics. The teacher participant and I will set-up times and dates that are convenient for us and the interview will be held outside of class time. I am happy to answer any questions you may have.

Thank you for your time and consideration in this matter.

Warm regards,

Linda Brimmer, Ph.D. candidate
Walden University