An Exploratory Study of the Impact of Situated Professional Development for Integrating Technology in Mathematics Instruction on Pedagogical Beliefs and Teaching Practices of Secondary Mathematics Teachers in a School with a High African American, Low-Income Student Population

by

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A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

Auburn, Alabama
December 15, 2018

Key words: situated professional development, technology integration, African American students, low-income students, pedagogical beliefs and practices

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Abstract

The purpose of this study was to explore the impact of providing secondary mathematics teachers in a school with a high African American, low-income student population with situated professional development that focuses on integrating mathematical action technology within teaching practices. This study focused on how the professional development affected the teachers' pedagogical beliefs and integration of mathematical action technology. The multiple case studies examined the beliefs and practices of 6 secondary mathematics teachers (4 high school and 2 middle school). Analysis of data collected from departmental workshops, pre-and post-interviews, observations, observation debrief interviews, multiple planning sessions, lesson plan analysis, and department meetings revealed an increase in students' and participants' use of mathematical action technology to explore mathematics content increased during the study. Participants continued to implement mathematical action technology into their lessons after the study was completed. Additionally, participants decreased their overall use of low-level cognitive demand tasks during and after participating in the study.

Acknowledgements

I would like to thank my husband, Bryan Ellis, and my three amazing sons, Tyler, Jordan, and Brandon, for patiently supporting, loving, and encouraging me while pursuing this degree. Thank you also to my mother, Bonita Jones, and my best friend, M'Ericka Daniel for your daily motivational and positive affirmations. Thank you for understanding when I needed to "go off the grid".

I would also like to thank Dr. Marilyn Strutchens and Dr. W. Gary Martin for your guidance and mentorship during my graduate studies. Thank you for allowing me to teach with you, supervise teacher candidates, and further develop the skills necessary to become an effective mathematics teacher educator. Dr. Strutchens, thank you for supporting and encouraging me throughout this process. Your guidance throughout this program and dissertation process has had a huge, positive impact on my life. You are a gem to the field of mathematics education. Thank you for providing me with opportunities to lead professional development sessions and participate in influential national organizations. Dr. Martin, thank you for your "tough love" and introducing me to new mathematics technologies. I am honored to have studied under both of you.

Lastly, I would like to thank my Ph.D. buddies Misty and George. Thank you for encouraging me when I needed it, being there when I needed to vent my frustrations, and celebrating my successes.

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Chapter 1: Introduction

Technological innovations such as the internet, advanced computer technology, and mobile, sensor and location technology have had a large impact on the way members of society communicate, interact, and learn (Kinshuk, Huang, Sampson, & Nian-Shing, 2013). Moreover, for over three decades national organizations have called for teachers to integrate technology into their mathematics instruction in meaningful ways (National Council of Teachers of Mathematics [NCTM], 1980, 1989, 1991, 1995, 2000, 2009, 2014). However, research has shown that a large number of teachers struggle to effectively integrate technology into their teaching practices (Rebora, 2016; Cuban, Kirkpatrick, & Peck, 2001; United States Congress Office of Technology Assessment, 1995). As a result, current reform measures and mathematics organizations continue to call for effective technology use within the teaching and learning of mathematics (NCTM, 2014; Association of Mathematics Teacher Educators [AMTE], 2017; United States Department of Education; 2015). For example, the NCTM (2014) described an excellent mathematics program as one that "integrates the use of mathematical tools and technology as essential resources to help students learn and make sense of mathematical ideas, reason mathematically, and communicate their mathematical thinking" (p. 78). Additionally, the AMTE (2015, 2017) asserts that mathematics instruction which utilizes technology encourages and supports students' construction of mathematical ideas in multiple ways, encourages a growth mindset, improves mathematical communication and collaboration, and provides opportunities for mathematical exploration.

Current mathematics reform measures were influenced by previous education reform efforts aimed at closing the achievement gap between African American and white students and low-income and more advantaged students. The introduction of the No Child Left Behind Act of 2001 (NCLB) brought increased attention to the achievement gap that has long existed in the United States between African American and white students and low-income and more advantaged students (Darling-Hammond, Zielezinski, Goldman, 2014). Over a decade after the implementation of NCLB, the achievement gap is still present. In Alabama, for example, only 5% of eighth grade African American students compared to nearly 25% of white students scored at or above proficient on the NAEP 2015 Mathematics Exam (United States Chamber of Commerce Foundation, 2015; Nation's Report Card, 2017). Research has indicated that interactive learning and the use of technology to explore and create rather than "drill and kill" has been effective in increasing student achievement with at-risk students, including African American and low-income students (Darling-Hammond, Zielezinski, Goldman, 2014; Warschauer & Matuchniak, 2010). However, in some schools, particularly schools of poverty, "technology and other tools may not be available due to inequitable distribution of resources" (NCTM, 2014, p. 81). Furthermore, in many schools with a high percentage of African American and low-income students, effective technology implementation is not occurring because the technological resources are not present, technological resources may not be adequate, or teachers lack sufficient training and support (Forgasz, Vale, & Ursini, 2010; Reinhart, Thomas, & Toriskie, 2011). In some cases, potentially valuable technology and tools may sit unused in closets or on shelves, or used in unproductive ways (NCTM, 2014).

Additionally, the ineffective use of technology in some mathematics classrooms can be attributed to teachers' technology fluency and beliefs as well as their pedagogical beliefs and practices (NCTM, 2014). Effective technology implementation is an overwhelming task especially for teachers who possess conservative beliefs and teaching methods (Honey & Moeller, 1990). Overcoming personal barriers requires a change in teaching practices and beliefs about the role of technology (Honey & Moeller, 1990). Providing teachers with effective professional development has been shown to deepen participants' understanding, transform beliefs and assumptions, and create a stream of continuous actions that change habits and affect practice (Spark, 2003; Hirsh, 2005).

Professional development is grounded in current reform efforts and calls for technology use. Professional development is defined as "the process of improving staff skills and competencies needed to produce outstanding educational results for students" (Hassel, 1999). According to Guskey (2000), "one constant finding in the research literature is that notable improvements in education almost never take place in the absence of professional development" (p. 4). However, most professional development programs aimed at technology integration are teacher-focused, skill-based, application-driven workshops or summer institutes well removed from classroom practice (Holmes, Polhemus, & Jennings, 2005; Swan et al., 2002, Rebora, 2016). This type of professional development was rated by practicing teachers as one of the least effective activities impacting teachers' day-to- day integration of technology (Rebora, 2016; Holmes et al., 2005; Swan et al., 2002). Practicing teachers stated that professional development that allowed idea sharing with other teachers, collaborative planning time, and job-embedded training or coaching would be beneficial in helping them better effectively integrate technology into their instruction (Rebora, 2016). Situated professional development provides teachers with an opportunity to acquire skills in real-life contexts (Lave & Wenger, 1991). Situated professional development has been shown to be successful in fostering technology integration into teachers' instructional practice because it links learning about technology with authentic practice (Putnam & Borko, 2000; Holmes et al., 2005, Swan et al., 2002).

Statement of the Problem

Access to important instructional resources and professional development opportunities varies between high-poverty schools that are heavily populated with students of color and more affluent schools serving fewer students of color (Lhamon, 2014). Although gaps by race and income in student access to technology are narrowing at the national level, disparities persist in the extent to which teachers are effectively utilizing these technologies (Lhamon, 2014; NCTM, 2014). While there are numerous positive benefits to effectively utilizing technology within the mathematics classroom and ways to obtain the technological resources, some mathematics teachers do not take advantage of this opportunity to advance student learning (NCTM, 2014; Dick & Hollebrand, 2011; Brown et al., 2007).

Purpose of Study

The purpose of this study was to explore the impact of providing secondary mathematics teachers in a school with a high African American, low-income student population with situated professional development that focuses on integrating technology within teaching practices. This study focused on how the professional development affected the teachers' pedagogical beliefs and integration of technology.

Research Questions

The research questions guiding this study were:

In a school with a high African American, low-income student population, how does participation in situated professional development focusing on integrating technology in secondary mathematics instruction impact teachers':

1. pedagogical beliefs about technology use during instruction?
2. decisions to integrate technology within their instructional practices?

An outcome of this study may be that curriculum developers, professional development coordinators, K-12 administrators, and teachers within this demographic gain an understanding of how mathematics teachers' pedagogical beliefs affect their decisions to use technology within their instructional practices. This will allow them to assist mathematics teachers with selecting appropriate professional development opportunities to increase the effective use of technology within the teachers' instructional practices.

Chapter 2: Review of Literature

The first section of the literature review will focus on the research surrounding educational reform specific to technology use in the teaching and learning of mathematics. Following this section is a discussion of the research pertaining to the relationship between teachers' pedagogical beliefs and the influence of those beliefs on the incorporation of technology within their instructional practices. The third section focuses on technological pedagogical content knowledge (TPACK) as defined by Mishra and Koehler (2006) and mathematical TPACK (Guerrero, 2010; AMTE, 2009). Given the difficulties many secondary mathematics teachers face with successful technology integration, the benefits of and barriers to technology integration within mathematics teaching practices will be discussed in section four. The fifth section of the literature review will include a discussion of professional development models that focus on changing teachers' instructional practices to impact their pedagogical beliefs regarding technology implementation within their mathematics classroom. The final section of the literature review will discuss the historical context of African American and low-income students in the United States as well as their opportunities to learn through the use of technology.

Mathematics Reform Incorporating Technology

In the 1980s, a mathematics reform movement began in reaction to the acknowledged failure of traditional methods of teaching mathematics, the impact of technology on curriculum, and the fundamental change in approach in the scientific study of how mathematics is learned (Battista, 1999). This led to the formation of committees and the publication of documents outlining important mathematical pedagogy, curriculum, and assessment practices. In 1980, the National Council of Teachers of Mathematics

[NCTM] (1980), published *An Agenda for Action: Recommendations for School Mathematics of the 1980s.* Within this document, NCTM (1980) proposed eight recommendations to improve the teaching and learning of mathematics. The third recommendation called for the increased use of technology during instruction at all grade levels. NCTM (1980) contended that students must be prepared to "live in a world in which more and more functions are being done by computers" (p. 8). To accomplish this, the following actions were recommended:

1. All students should have access to calculators and computers throughout their school mathematics programs.
2. The use of electronic tools should be integrated into the core mathematics curriculum.
3. Curriculum materials that integrate and require the use of the calculator and computer in diverse and imaginative ways should be developed and made available.
4. A computer literacy course, familiarizing the student with the role and impact of the computer, should be a part of the general education of every student.
5. All mathematics teachers should acquire computer literacy either through pre-service programs or through in-service programs funded by school districts in order to deal with the impact of computers on their own lives and to keep pace with the inevitable sophistication their students will achieve.
6. Secondary school computer courses should be designed to provide the necessary background for advanced work in computer science.
7. School administrators and teachers should initiate interactions with the home to

achieve maximum benefit to the student from the coordinated home and school use of computers and calculators.

8. Educational users of electronic technology should demand a dual responsibility from manufactures: the development of good software to promote the problem-solving abilities of the student and, eventually the standardization and compatibility of hardware.
9. Provisions should be made by educational institutions and agencies to help in the necessary task of educating society's adults in computer literacy and programming.
10. Teachers of other school subjects in which mathematics is applied should make appropriate use of calculators and computers in their instructional programs.
11. Teacher education programs for all levels of mathematics should include computer literacy, experience with computer programming, and the study of ways to make the most effective use of computers and calculators in instruction.
12. Certification standards should include preparation in computer literacy and instructional uses of calculators and computers. (NCTM, 1980)

These twelve recommendations highlighted the importance of student access to technology and the integration of technology within the curriculum. Additionally, these recommendations called for support from administrators and students' guardians to assist with effective use of technology. These standards also point to teachers receiving adequate pre-service training and in-service professional development to ensure teachers have the necessary skills to effectively utilize technology within their classrooms.

Continuing to lead the charge in mathematics education reform, NCTM (1989) established the Commission on Standards for School Mathematics and produced the Curriculum and Evaluation Standards for School Mathematics. Their first goal was to create a coherent vision that thoroughly outlined "what it means to be mathematically literate both in a world that relies on calculators and computers to carry our mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied to diverse fields" (NCTM, 1989, p. 1). Their second goal was to develop a set of standards to "guide the revision of the school mathematics curriculum and its associated evaluation towards this vision" (NCTM, 1989, p. 1). The resulting document contained 54 standards for the composition and evaluation of mathematics curricula. The Curriculum Standards called for a shift from memorization of facts and procedures and computational proficiency towards conceptual understanding, multiple representations and connections, mathematical modeling, and problem solving. Three assumptions were made about mathematics that provided a framework for the Curriculum Standards: (1) learning is a process, (2) mathematics has changed, and (3) changes in technology have changed the nature of problems and the methods used to investigate them (NCTM, 1989). Moreover, student activities should grow out of problem situations rather than expecting computational skills to precede word problems and curriculum must provide opportunities to develop an understanding of mathematical models, structures, and simulations applicable to many fields (NCTM, 1989).   In addition, calculators and computer tools should be available to all students to help simplify problems and assist them with learning mathematics concepts (NCTM, 1989). These technology tools should be used by students to process information and perform calculations to investigate and solve problems (NCTM, 1989).

Practices such as the use of calculators and other technology tools in elementary and secondary grades, the lack of a requirement for basic skills mastery, collaborative efforts to solve problems, and assessments other than conventional testing measures that were promoted in the 1980s were the basis for reform efforts in the 1990s (Klein, 2003). During the 1990s, states made progress in response to the suggestions of *A Nation at Risk*. Standards for what students should know and be able to do were established in state curriculums, and NCTM continued to be instrumental in helping states address reform in mathematics education. *Professional Standards for Teaching Mathematics* (NCTM, 1991) provided a clear picture of what mathematics teachers could do to support student learning. Mathematics teachers were encouraged to use computers, calculators, and other technology tools to enhance discourse, reason, and make connections (NCTM, 1991). Since teachers were challenged to shift their approach to teaching mathematics, they must also shift their approach to assessing student learning. To assist teachers with shifting their approach regarding assessment, NCTM (1995) released *Assessment Standards for School Mathematics*. The standards include the (1) mathematics standard, (2) learning standard, (3) equity standard, (4) openness standard, (5) inference standard, and coherence standard. Each of these standards should be considered when assessing student learning. Following the release of these two standards documents, NCTM (2000) released *Principles and Standards for School Mathematics.* In this document, NCTM (2000) outlines the basis of six principles focusing on equity, curriculum, teaching, learning, assessment, and technology. The technology principle stressed the importance of technology use in mathematics and described it as essential and influential to students' learning (NCTM, 2000). Additionally, mathematics content standards for each grade band and process standards were discussed. The process standards include, problem Solving, reasoning and proof, communication, connections, representations (NCTM, 2000). Together the *Professional Standards for Teaching Mathematics* (NCTM, 1991), *Assessment Standards for School Mathematics* (1995), and *Principles and Standards for School Mathematics* (NCTM, 2000) provided teachers with a clear picture of effective teaching and learning of mathematics.

On January 8, 2002, President George W. Bush signed the landmark *No Child Left Behind Act* (*NCLB*) into law. The *No Child Left Behind Act of 2001* (USDE, 2001) called for a highly -qualified teacher in the core subjects in every classroom, the use of proven, research-based instructional methods, and timely information and options for parents (p. 1). The law required test scores to be disaggregated according to students who: (a) are economically disadvantaged, (b) represent a major racial or ethnic group, (c) are disabled, or (d) have limited English proficiency (Popham, 2004). Because of its focus on measuring outcomes with test scores, NCLB failed to provide the resources to ensure that every student had the opportunity to learn and excel (Walker, 2015). As a result, achievement goals were never reached (Walker, 2015). In 2010, state education chiefs and governors in 48 states collaborated to sponsor the creation of clear college and career ready standards for kindergarten through 12th grade in mathematics, what is known as the Common Core State Standards for Mathematics [CCSSM] (National Governors Association Center for Best Practices [NGA] & Council of Chief State School Officers [CCSSO], 2010). The CCSSM contained the content standards, to be used in conjunction with the standards for mathematical practice, that were intended to bring greater focus and coherence to mathematics education and counter the current practice in the U.S., labeled as a "mile wide and an inch deep" (NGA & CCSSO, 2010, p. 3). The standards for mathematical practice are 1)make sense of problems and persevere in solving them, 2) reason abstractly and quantitatively, 3) construct viable arguments and critique the reasoning of others, 4)model with mathematics, 5) use appropriate tools strategically, 6) attend to precision, 7) look for and make use of structure, and 8) look for and express regularity in repeated reasoning. The standards for mathematical practice are connected to NCTM's (2000) process standards and describe varieties of expertise and habits of mind that mathematics educators at all levels should seek to develop in their students (NGA & CCSSO, 2010).

CCSSM provided guidance and direction that help teachers focus and clarify common goals, but it did not address teaching practices at the classroom level. As a result, the primary purpose of *Principles to Actions: Ensuring Mathematical Success for All* (NCTM, 2014) was to "fill the gap between the development and adoption of CCSSM and other standards and the enactment of practices required for their widespread and successful implementation" (p. 4). Expanding on the ideas presented in *Principles and Standards for School Mathematics* (NCTM, 2000), *Principles to Actions* NCTM (2014) provided a set of strongly recommended, research-based practices for all teachers. The eight Mathematics Teaching Practices (MTPs) outlined by NCTM (2014), provide teachers with a "framework for strengthening the teaching and learning of mathematics" (p. 9). Teachers are encouraged to (1) establish mathematics goals to focus learning, (2) implement tasks that promote reasoning and sense making, (3) use and connect mathematical representations, (4) facilitate meaningful mathematics, (5) pose purposeful questions, (6) build procedural fluency from conceptual understanding, (7) support productive struggle, and (8) elicit and use evidence of student thinking (NCTM, 2014). NCTM (2014) also addresses issues with technology implementation and equity concerns. NCTM (2014) asserted that technology, both mathematical action and non-mathematical action technologies, must be "indispensable features of the classroom" (p. 78). Use of these tools allow students to have a greater ownership of the mathematics that they are learning (Dick and Hollebrands, 2011; NCTM, 2014). As a result, teachers should adopt the use of technology that supports effective instruction (NCTM, 2014). However, in many cases, only high achieving students and students from higher socioeconomic backgrounds are afforded with opportunities to use technology to explore advanced topics. As such, NCTM (2014) proclaimed that mathematics programs should provide all students with "access to high quality mathematics curriculum, effective teaching and learning, high expectations, and the support and resources needed to maximize learning potential" (p. 59).

Despite these reform efforts, the achievement gap between African American and white students has continued to be especially pervasive in mathematics (NCTM, 2014; Flores, 2007; Tate, 1997). Even though research does indicate "when African American and white students complete the same number of mathematics courses the difference in average achievement gap shrinks," many African Americans do not have the opportunity to complete the same number of courses or experience courses taught using effective teaching practices that include the integration of technology (NCTM, 2014; Tate, 1997, p. 16).

Summary. Several decades of education reform measures have pushed for a change in the teaching and learning of mathematics. The 1980s and 1990s saw an increase in the need to integrate technology within instructional practices (NCTM, 1980; NCTM, 1989; Battista, 1999; Romberg, 1997). Reform measures of the 2000s attempted to address this problem. After the failure of NCLB, focus began to shift to equity issues, coherence, and common goals within mathematics teaching and learning (NGA & CCSSO, 2010; United States Department of Education, 2001; Walker, 2015; NCTM, 2014). However, a gap in access to technology, mathematics achievement, and mathematics opportunities was persistent among low socio- economic status (SES), African American, and white students (NCTM, 2014; Flores, 2007; Tate, 1997). Reform efforts emphasize that in order for teachers to effectively implement new practices, they must be provided with and actively participate in professional development dedicated to improving instructional practice based on reform-based practices. This study provided participants with professional development and support focused on improving their teaching practices related to technology integration. Resources such as NCTM's (2014) *Principles to Action* were utilized in this study to provide teachers with a guideline to successfully implement the CCSSM and address concerns with equity issues and effective technology implementation. A section on the literature related mathematical action technology. The use of mathematical action technology brings together reform efforts related to inquiry-based teaching and technology use in the mathematics classroom.

Mathematical Action Technology

According to the National Council of teachers of Mathematics (NCTM, 2015), mathematics teachers should strategically use technology in thoughtfully designed ways and at carefully determined times to enhance how students learn, experience, communicate, and do mathematics (p.1). This strategic use of technology applies to mathematical action technologies as well as conveyance technologies (NCTM, 2015; Dick & Hollebrands, 2011). Conveyance technologies are used to transmit or receive information and are not content specific (Dick & Hollebrands, 2011). They allow users to present, communicate, and collaborate with each other. Conveyance technologies include, but are not limited to, items such as presentation technologies, communication technology, sharing and collaboration technology, and assessment, monitoring, distribution technology (Dick & Hollebrands, 2011). Mathematical action technologies, unlike conveyance technologies, are content-specific and "can perform mathematical tasks and/or respond to the user's actions in mathematically defined ways (Dick & Hollebrands, 2011, p. xii). These include, but are not limited to, computational and representational tool kits, dynamic geometry environments, microworlds with mathematically defined rules, and computer simulations (Dick & Hollebrands, 2011). Mathematical action technologies support student explorations, conceptual understanding, and procedural fluency (NCTM, 2014). The following sections discuss four types of mathematical action technologies that are commonly used in the mathematics classroom and their benefits to the teaching and learning of mathematics: (1) calculators, (2) dynamic geometry and statistics environments, and (3) spreadsheet programs.

Calculators. The role of calculators in the mathematics classroom has been a topic of debate for over 40 years (Kiehl & Harper, 1977; Burrill et. al., 2002; Brown et. al, 2007; NCTM, 1989, 2011). Some mathematics teachers are reluctant to incorporate student use of calculators during mathematics instruction because they fear calculator use, particularly in the early grades, may have a negative impact on students' mathematics abilities (Kiehl & Harper, 1977; Brown et al., 2007). However, when used appropriately during mathematics instruction, calculators can have a positive impact on students' mathematics achievement at all grade levels (NCTM, 2015, 2011; Ellington, 2006; Dewey, Singletary, & Kinzel, 2010; Burrill et al., 2002). NCTM's (2011) synthesis of nearly 200 research studies on calculator use revealed that there was no negative impact on students' skill development or procedural fluency. Instead, appropriate use of calculators "enhances the understanding of mathematics concepts and student orientation towards mathematics" (NCTM, 2011, p. 1). Increasingly popular in secondary mathematics classrooms is the use of graphing calculators (Burrill et al., 2002). Graphing calculators can be found as standalone handheld devices or as digital platforms. The following section describe the benefits of handheld and digital platform graphing calculators on the teaching and learning of mathematics.

Handheld graphing calculators. Graphing calculators are programmable calculators that allow users to perform many mathematical tasks including, but not limited to, plotting graphs, solving equations, matrices, and perform data plotting and analysis (Texas Instrument, 2017a; Doerr & Zanangor, 2000; McCulloch, Hollebrands, Lee, Harrison, & Mutlu, 2018). Graphing calculators are a learning tool designed to help students visualize concepts and make connections in math and science (Texas Instrument, 2017a). Researchers have found that students instructed with graphing calculators demonstrate improved understanding of functions and graphing, greater ability to connect multiple representations of algebraic concepts, and increased understanding of a dual approach to problem solving using both symbolic and graphical solutions (Choi-Koh, 2003; Dick & Hollebrands, 2011; Burrill et al., 2002).

Burrill et al.'s (2002) summary of research studies concerning handheld graphing calculators revealed that teachers' use of handheld graphing calculators was impacted by their beliefs about mathematics teaching and learning. Teachers' who emphasized connections among multiple representations and included activities that promoted reasoning and sense making in conjunction with handheld graphing calculators saw increase in student performance (Burrill et. al., 2002). Additionally, Burrill et al. (2002) found that students with access to handheld graphing technology "use graphs and engage in mathematical explorations more often than students without access" (p. vi).

Choi-Koh's (2003) case study investigated the patterns of a tenth-grade student's mathematical thinking processes and described the nature of the learning experience that the student encountered in trigonometry as he engaged in explorations within an interactive learning environment. The tasks used within the study required the student to use a graphing calculator to complete seven tasks that explored the role of each of the coefficients and constants in the equation $y = a \sin (bx + c) + d$ (Choi-Koh, 2003). Additionally, tasks involved constructing equations from graphs, predictions and hypothesis testing with composite functions, and solving trigonometric equations. Choi-Koh (2003) found that the student's mathematical patterns of thinking progressed through three stages: (1) the intuitive stage, (2) the operative stage, and (3) the applicative stage. The intuitive stage involves gaining knowledge through visualizations and observations (Choi-Koh, 2003). The operative stage uses the knowledge gained during the intuitive stage to explain, comprehend, and abstract information (Choi-Koh, 2003). Finally, during the applicative stage, inductive generalizing, analysis, synthesis, and evaluation of information occurs (Choi-Koh, 2003). Choi-Koh (2003) concluded that the use of the graphing calculator, with the selected tasks, helped advance the student's mathematical thinking. The results of Choi-Koh's (2003) study show that task choice is as important when teachers choose to incorporate technology into their teaching practices.

Ellington (2006) conducted a meta-analysis of 42 research studies to examine the effect of non-CAS graphing calculators on helping students develop procedural skills, computational skills, and overall mathematics achievement. Each of the studies included in the meta-analysis were conducted in middle and high school mathematics classes and college mathematics courses less than or equivalent to first semester calculus. With the exception of four studies, each of the studies were conducted in mixed ability classrooms. All studies contained a control group that was not allowed to use a graphing calculator during class or homework assignments (Ellington, 2006). Ellington's (2006) meta-analysis revealed that the use of graphing calculators during mathematics instruction aids students in developing conceptual understanding of concepts even when the graphing calculators use are not allowed on assessments. In studies, where graphing calculator use was not allowed on tests, there was no statistically significant difference in students' procedural skills when comparing the scores of the treatment and control groups. However, 61% of the students in the treatment group scored higher than the median score of the control group on conceptual skill tests (Ellington, 2006). Similar results were found in in studies that allowed graphing calculator use on tests. There was no statistically significant difference in students' procedural skills when comparing the scores of the treatment and control groups and 63% of the students in the treatment group scored higher than the median score of the control group on conceptual skill tests (Ellington, 2006). Additionally, the meta-analysis revealed that students' attitudes towards mathematics were positively impacted as a result of using the graphing calculators during instruction.

An additional benefit of handheld graphing calculators is that many allow the connection of peripheral devices. For example, handheld graphing calculators manufactured by Texas Instruments have a variety of peripheral devices that allow users to input or share data. One such device is the CBR2 motion detector. The CBR 2 motion detector is a motion sensor that allows users to collect data and analyze real-world motion data (Texas Instrument, 2017b) which is then transferred to the graphing calculator via an included data cable. To collect data, the CBR2 emits electrical pulses and measures the amount of time it takes for the pulse to return to the sensor (Herman & Laumakis, 2008). The CBR 2 or similar devices can be used with the graphing calculator to enhance students' understanding of graphs (Herman & Laumakis, 2008). Herman and Lumakis (2008) created an activity that allows students to experiment with the CBR to create graphs using the CBR/CBL application on the TI-84 graphing calculator. The activity provides students with an opportunity to explore the relationship between distance, time, and the shape of the graph. The activity created by Herman and Laumakis (2008) was used in the departmental workshop with participants from Paige Junior High School.

Digital graphing calculators. Digital graphing calculators have increased in popularity and usage in the mathematics classroom due to their low or no cost and ease of accessibility (McCulloch et al., 2018). They often have many of the same or more features as handheld graphing calculators. For example, the popular Texas Instrument handheld graphing calculators have a digital application or emulator that can be downloaded onto a computer or other digital device (Texas Instrument, 2017a). Additionally, developers have created fully digital platforms as alternatives to the traditional handheld graphing calculator. Launched in 2011, the Desmos graphing calculator is a free HTML5 graphing calculator available via a web browser or mobile application (Desmos, 2017). Desmos allows users to graph equations as well as inequalities in color. Desmos features lists, plots, regressions, interactive variables, graph restrictions, simultaneous graphing, piecewise function graphing, and polar function graphing in addition to features commonly found in popular programmable calculators (Desmos, 2017). Additionally, when using Desmos, teachers can monitor, in real-time, students' progress and share students' work with the entire class (McCulloch et al., 2018). Since its launch, teachers experienced the benefits of using Desmos during mathematics instruction. McCulloch et al. (2018) conducted a study to examine the factors that influence secondary mathematics teachers' integration of technology in mathematics class. The study included 21 early career, secondary mathematics teaches. Each participant's undergraduate teacher education program strongly emphasized integrating technology into their mathematics teaching practices. McCulloch et al. (2018) reported that participants in their study who used Desmos during mathematics instruction did so because they believed Desmos supported the "development of students' understandings of mathematics, was fun for students to use, was easy for students to enter mathematical notation, provided students with feedback, was similar to graphing calculators students were already familiar with, produced graphs more quickly and accurately, and it was available on multiple platforms" (p. 33). Participants also indicated using Desmos increased student engagement and allowed them to use instructional time more effectively.

Dynamic geometry environments. Dynamic geometry environments provide computer-based environments to construct, measure, and manipulate virtual geometric figures (Zhou, Chan, & Teo, 2016; Dick & Hollebrands, 2011). This type of mathematical action technology provides students with opportunities to engage in reasoning and sense-making activities (Dick & Hollebrands, 2011). Dynamic geometry environments have been used in the teaching and learning of geometry to move student thinking beyond the specifics of a single drawing to generalizations across figures. Dynamic geometry environments have been shown to have a positive impact on student motivation, engagement, and achievement in mathematics learning (Zhou, Chan, & Teo, 2016; Dick & Hollebrands, 2011). Geometer's Sketchpad (GSP) provides users with interactive tools to construct and manipulate geometric shapes while preserving all mathematics properties (Key Curriculum, 2018). Hollebrands (2007) examined the use of GSP to develop understanding of geometric transformations. The study was conducted with an Honors Geometry class containing 16 tenth-grade students. Many students had access to GSP both at home and at school and developed a familiarity with the program. Students completed a seven-week instructional unit that included activities utilizing GSP. Four students participated as case studies. Each of the four participants was observed during class and participated in task-based interviews, and additional data was obtained from student work samples. Data analysis revealed that mathematical interpretation of points, lines, and constructions was strengthened as a result of measuring and dragging or selecting portions of the figure to manipulate (Hollebrands, 2007). As a result, students were able to observe behaviors, test conjectures, and make connections between geometric transformations and algebraic functions.

Another popular dynamic geometry environment is GeoGebra. GeoGebra is an open-source, dynamic mathematics software that combines geometry, algebra, spreadsheets, statistics, and calculus in a user-friendly interface (GeoGebra, 2017). Zengin and Tatar (2017) evaluated the impact and effectiveness of the cooperative learning and GeoGebra of 61 high school students' mathematical achievement. Both quantitative and qualitative data were collected using open-ended questionnaires and pre-tests and post-tests. Pre-tests and post-tests were developed by Zengin and Tatar (2017) and reviewed by university faculty members for content validity and accuracy of the items. Prior to the students participating in the study, student's teachers participated in a series of 18 workshops facilitated by Zengin and Tatar (2017). The goal of the workshops was to introduce the teachers to GeoGebra and the cooperative learning model. The first 11 sessions were dedicated solely to software and activities. The last 7 sessions were dedicated to the cooperative learning model in conjunction with the software. Following, the workshop, teachers implemented the model and activities in their classes. Students completed activities using GeoGebra in teams comprised of four students. Zengin and Tatar (2017) found that students mathematics achievement increased. Additionally, students reported that they enjoyed learning and were able to better visualize and make sense of the material as a result of using GeoGebra and working in teams.

Spreadsheet programs. Spreadsheet programs are "computer programs that allows the entry, calculation, and storage of data in columns and rows" (Merriam-Webster, 2018). Data entered into a spreadsheet program can also be displayed as charts and graphs. Spreadsheet programs are widely available and can be used during mathematics instruction to strengthen students' conceptual understanding, procedural fluency, and ability to make connections to real world problems (Niess, Sadri, and Lee, 2008; Alagic & Palenz, 2006). Additionally, spreadsheet software can be used to help students gain a conceptual understanding of statistical measures (Parke, 2005). This allows students to be able to accurately describe and interpret data sets as wells as make inferences. Parke (2005) described how one teacher, Mrs. Remille, used spreadsheets to explore central tendency and variability concepts. Lab activities implemented in Mrs. Remille's class required students to compare and contrast data sets and their statistical properties. Students were familiar with mean, median, mode, and range prior to completing the activities. However, they had not used spreadsheets to explore mathematics concepts. After becoming familiar with the spreadsheet program, students began exploring the first data set. Because of their prior knowledge, they were able to immediately distinguish between the mean, median, mode and range and were able to make comparisons. Following this initial activity, students completed a series of activities that that included data sets that resulted in each of the four measures of central having a greater spread than the original data set and included the addition of outliers (Parke, 2005). Having students examine and compare data sets in this manner resulted in Mrs. Remille's students developing a deeper understanding of the concepts of measures of central tendency and variability (Parke, 2005). Students in Mrs. Remille's class were more engaged in the activities. As activities progressed, student engagement increased (Parke, 2005).

Summary. Mathematical action technologies have been shown to have a positive impact on students' mathematical achievement when used strategically with meaningful tasks (NCTM, 2014, 2015; Dick & Hollebrands, 2011; Choi-Koh, 2003). Combining meaningful tasks and mathematical action technology enables students to explore mathematics concepts without focusing on memorizing a set of procedures. Instead students are able to develop ideas, explore predictions and consequences, justify solutions, and understand connections between different mathematical representations (NCTM, 2015; Dick & Hollebrands, 2011; Burrill et. al., 2002; Brown et. al, 2007). In order for teachers to effectively integrate technology into their teaching practices, they must develop or improve their technological pedagogical content knowledge. This is discussed in the next section.

Technological Pedagogical Content Knowledge

This section of the literature review outlines the development of Technological Pedagogical Content Knowledge from Shulman's (1986) description of pedagogical content knowledge, discusses the Mathematics TPACK Framework, and concludes with a discussion of an additional model for technology integration, the EMPIRe Model.

For nearly 30 years, teacher knowledge has been conceptualized using the framework proposed by Shulman (1986). According to Shulman (1986), teacher knowledge includes the following: (1) content knowledge (2) pedagogical knowledge, and (3) pedagogical content knowledge. Shulman (1986) defined content knowledge as teacher knowledge of the subject (Shulman, 1986). This content knowledge includes knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches toward developing such knowledge (Shulman, 1986, 1987). Pedagogical knowledge refers to the knowledge and practice of teaching that an educator can use (Shulman, 1986, 1987). Connecting content knowledge and pedagogical knowledge, pedagogical content knowledge (PCK) refers to knowledge of pedagogy that is applicable to the teaching of specific content (Shulman, 1986). Central to Shulman's (1986) conceptualization of PCK is the notion of the transformation of the subject matter for teaching. According to Shulman (1986), this transformation occurs as the teacher interprets the subject matter, finds multiple ways to represent it, and adapts and tailors the instructional materials to alternative conceptions and students' prior knowledge.

Building upon Shulman's (1986, 1987) idea of pedagogical content knowledge to include technology knowledge, Mishra and Koehler (2006) developed a framework for teacher knowledge they termed Technological Pedagogical Content Knowledge (TPACK). The TPACK framework was developed as a result of a five year research program that focused on teacher professional development and faculty development in higher education (Mishra & Koehler, 2006). TPACK focuses on the relationship between content, pedagogy, and technology. Mishra and Koehler (2006) designed the TPACK framework around three ideas related to technology: (1) technology knowledge, (2) technological content knowledge, and (3) technological pedagogical knowledge. Technology knowledge is knowledge about standard technologies and advanced technologies and the skills needed to operate the technologies (Mishra & Koehler, 2006). Technological content knowledge is "knowledge about the manner in which technology and content are reciprocally related" (p. 1028). According to Mishra and Koehler (2006), teachers need to know the content they teach as well as how the content can be changed by incorporating technology. Technological pedagogical knowledge is "knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning setting" (Mishra & Koehler, 2006). Additionally, technological pedagogical knowledge involves knowing how teaching might change as a result of incorporating particular technologies within their teaching (Mishra & Koehler, 2006).

Koehler and Mishra's (2009) model of the TPACK framework (see Figure 1) shows the relationships between the three main components of teachers' knowledge: content, pedagogy, and technology.

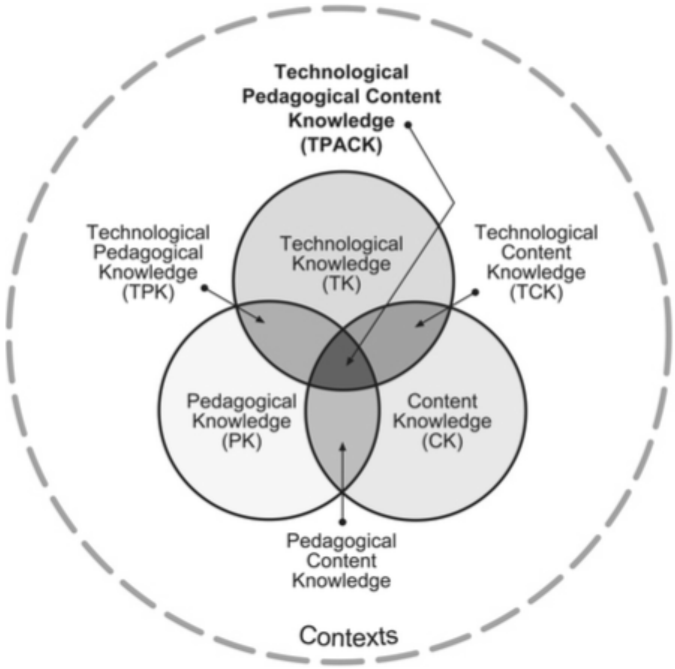


Figure 1. TPACK Framework and its Knowledge Components (Koehler & Mishra, 2009).

According to Koehler and Mishra (2009), simultaneously integrating knowledge of technology, pedagogy, and content allows expert teachers to "bring TPACK into play each time they teach" (p.66). TPACK requires a good understanding of the following:

> (a) representations of concepts using technologies, (b) pedagogical techniques that use technologies in constructive ways to teach content, (c) knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face, (d) knowledge of students' prior knowledge and theories of epistemology, (e) and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (Mishra & Koehler, 2006, p. 1029).

Improving teachers' TPACK. Harris and Hofer (2011) conducted a qualitative study to explore how teachers' TPACK informed instructional planning and if participants'

TPACK could be enhanced through professional development. This study included six secondary social studies teachers and one elementary teacher from six different states. Participants were interviewed before and after participating in professional development that focused on the design of content-based learning activities that were supported by selective and purposeful integration of educational technologies (Harris & Hofer, 2011). These technologies included imaging tools, video creation software, presentation software, podcasts, concept mapping software, virtual fieldtrips, Google Earth, digital archives, and content specific simulations. Additionally, participants' planning products prior to and after participating in the professional development were compared. Harris and Hofer's (2011) study revealed three primary findings: (1) participating teachers' selection and use of learning activities became more conscious, strategic, and varied, (2) instructional planning became more student-centered, focusing primarily on students' intellect rather than affective engagement, and (3) quality standards for technology integration were raised, resulting in deliberate decisions for more thoughtful educational technology use.

TPACK and mathematics. The Mathematics TPACK Framework, developed by the Association of Mathematics Teacher Educators (AMTE) (2009), is based on the work of Mishra and Koehler (2006) and the National Educational Technology Standards for Teachers (International Society for Technology Education, 2002). AMTE (2009) described the intent of the Mathematics TPACK Frame as a guide for mathematics educators and researchers to "plan, examine, improve, and evaluate mathematics instruction at all levels" (p. 1). The Mathematics TPACK Framework outlined four essential components and the guidelines to be followed to ensure that mathematical learning experiences are enriched when technology is effectively integrated. The four components of the Mathematics TPACK

Framework are: (1) design and develop technology-enhanced mathematics learning, (2) facilitate mathematics instruction with technology as an integrated tool, (3) assess and evaluate technology-enriched mathematics teaching and learning, and (4) engage in ongoing professional development to enhance technological pedagogical content knowledge (AMTE, 2009).

Guerrero (2010) outlined four components of mathematical TPACK: (1) connection and use of technology, (2) technology-based mathematics instruction, (3) management, and (4) depth and breadth of mathematics content. Although Guerrero does not focus on professional development activities, the four components of mathematical TPACK are similar to the first three components of AMTE's (2009) Mathematics TPACK Framework that focus on designing and developing lessons, selecting appropriate technology, and mathematics teaching and learning. The first component, connection and use of technology, included a teacher's conception of the use of technology in support of teaching mathematics (Guerrero, 2010). This component serves as a "basis for the instructional and curricular decisions teachers make in rendering the subject matter more accessible to students" (p. 135). The teacher must decide how and what technology to use to effectively address student needs, content, and instruction. Most importantly, this component includes the knowledge in pedagogically appropriate ways that support instruction authentically rather than as a "sideshow" tool (Guerrero, 2010). According to Guerrero (2005), when technology is used in pedagogically appropriate ways student learning is improved because the technology helps to "encourage inquiry, reasoning, contextualized learning, and sense-making" (p. 258). The second component, technology-based mathematics instruction, includes teachers' knowledge of and ability to maneuver through various instructional issues specifically related to the use of technology in support of mathematics teaching and learning (Guerrero, 2010). Guerrero (2010) insisted that teachers understand that technology should not be a replacement for the teacher or quality instruction. It should be viewed as “one of the tools in the teacher’s instructional repertoire” (Guerrero, 2010, p. 135). Additionally, teachers’ should possess the ability to adjust the use of technology to serve the needs of a diverse group of students in terms of mathematical ability, affect, and interest (Guerrero, 2010). The third component, management, covered management issues specifically related to teaching and learning with technology (Guerrero, 2010). Teachers must be able to deal with the physical environment, address technical problems, and understand students’ behavior and attitudes. Although the use of technology has been shown to have positive effects on student attitudes, on-task behavior, initiative, engagement, and experimentation, Guerrero (2010) cautioned teachers to understand that technology, when used too often, too infrequently, or inappropriately, “can also result in student frustration, boredom, distraction, and unwillingness to transition to other activities” (p. 136). The final component focused on teachers’ understanding of mathematics content, both deeply and broadly. Allowing students to use technology appropriately in the mathematics classroom, “gives them the power to explore mathematics to a depth that may be unfamiliar to the teacher” (Guerrero, 2010, p. 136). Therefore, teachers must be confident in their ability to handle students’ investigations and inquiries. Depth in content knowledge enables teachers to explore, emphasize, or deemphasize a variety of mathematical topics that may arise during instruction or student investigation (Guerrero, 2010). Within this component, teachers must also be willing to acknowledge their subject-matter shortcomings and be willing to invest the time and energy to alleviate any gaps in knowledge that surface as a result of students' investigations that lead to concepts or ideas that the teacher may be unfamiliar or unprepared to address (Guerrero, 2010).

EMIPRe model for implementing and evaluating technology integration within teaching practices. Incorporating the ideas encouraged by the TPACK model, the EMPIRe model aims to prepare teachers for "integrated uses of technology by allowing them to explore and understand through design-based activities the complex and dynamic relations between content, pedagogy, and technology" (Sun, 2012, p. 101). According to Sun (2012), the EMPIRe model is "intended to be used by teachers designing and implementing technology integration and by teachers observing technology integration being modeled to them" (p. 104). The EMPIRe model (see Figure 2) consists of five primary stages: (1) evaluating, (2) matching, (3) planning, (4) implementation, and (5) reflection (Sun, 2012).

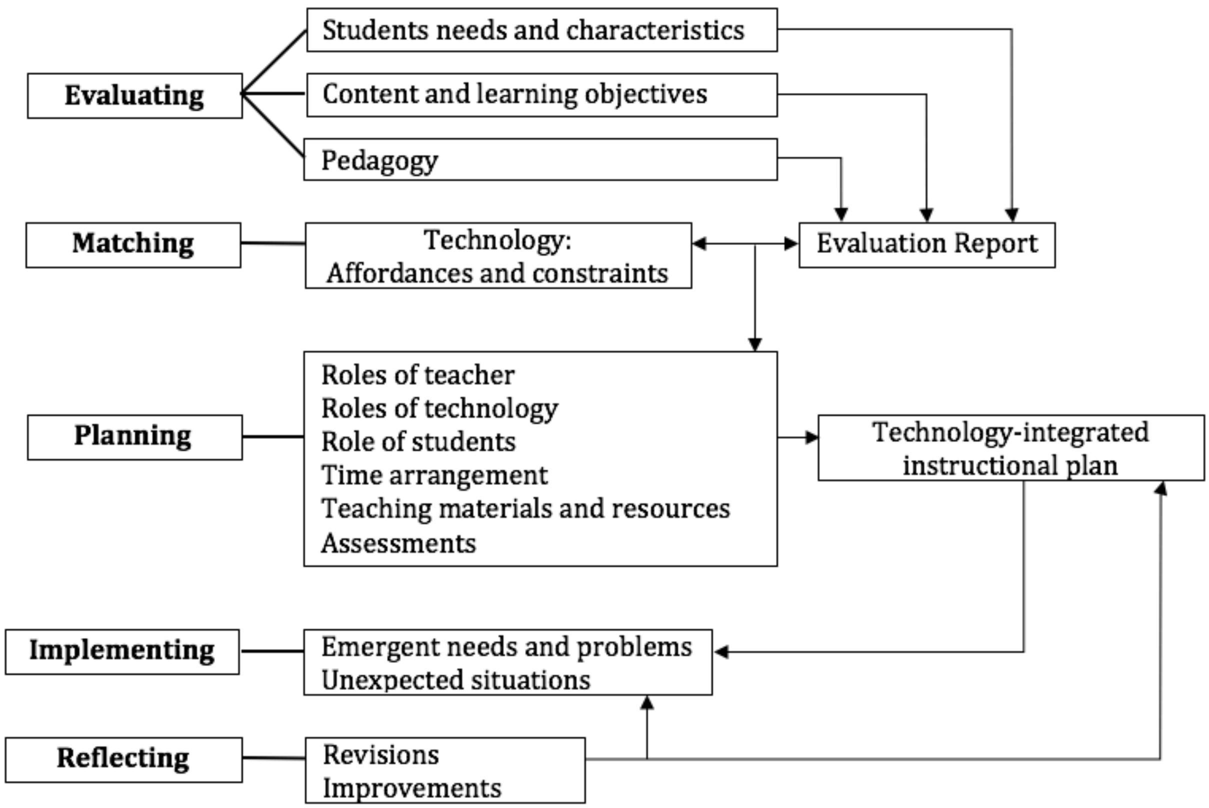


Figure 2. The Five Stages of the EMPIRe Model (Sun, 2012).

During the evaluation stage, teachers are cautioned not to focus on what and how technology will be integrated because it may distract them from making a sound evaluation of the instructional tasks to be performed (Sun, 2012). Instead, teachers should evaluate the instructional task by considering "student needs and characteristics, content to be taught and learning objectives to be achieved, and possible pedagogy in terms of instructional strategies, methods, or activities that would help engage students, make content comprehensible, and promote critical thinking" (p. 104). Following this, teachers will create an evaluation report.

During the matching stage, teachers match technology with the evaluation report. Teachers integrate content knowledge and pedagogy with technologies. Teachers begin by analyzing technologies they have in mind that may be used during instruction (Sun, 2012). The technology analysis can be based on teachers' prior experiences with the technologies or based on their investigation or knowledge about the technologies (Sun, 2012). As a result, teachers grasp a sound understanding about the technologies in terms of their affordances and constraints (Sun, 2012). Then, teachers choose the technology based on the affordances, student needs and characteristics, content and learning objectives, and pedagogical choices and purposes (Sun, 2012).

In the planning stage, teachers think about how the technology or technologies they have chosen should be used and come up with a detailed plan of technology-integrated instruction (Sun, 2012). When developing the plan, teachers should think about the roles the teacher plays during the instructional process, the roles that technology plays, the roles students play, specific time arrangement for instructional activities and for technology uses, the formative and summative assessments that will be used to evaluate student learning, and the teaching materials or resources, including traditional and digital ones, are needed (Sun, 2012). Once teachers complete their plan, they move into the implementing stage.

During the implementing stage, teachers enact the plan in their classrooms. Teachers may have to deal with emergent student needs or problems, unexpected situations, and changes to their original instruction plan (Sun, 2012). Sun (2012) suggested that teachers take note of those situations and the measures taken to deal with them. These notes will be beneficial during the next stage, reflecting.

In the final stage of the EMPIRe model, reflecting, teachers use their notes and student assessment results to "reflect on their technology-integrated instruction plan and the implementation process in terms of student responses and performances and the effects of technology uses" (Sun, 2012, p. 105). Based on their reflections, teachers begin thinking about what revisions are needed in the original instruction plan and what improvements need to be made of the implementation process (Sun, 2012). These reflections, according to Sun (2012), help teachers "enhance their competencies of making integrated use of technology in the long run" (p. 105).

Sun (2012) suggested that the EMPIRe model be used when observing teachers who excel in implementing technology within their teaching practices. When used in this manner, the EMPIRe model guides teachers' understanding of what is being modeled (Sun, 2012). Teachers can refer to the components included in the evaluating stage to develop a clear picture about the instructional tasks involved in the modeled technology integration (Sun, 2012). During the matching stage, teachers critique the matching done by the model teacher (Sun, 2012). Sun (2012) suggested teachers ask the following questions during this stage: (1) "Is the technology chosen appropriate for the students?" (2) "Does the technology chosen help engage the students?" and (3) "Does the technology chosen serve the content and the teaching objectives?" (p. 106). In the planning stage, teachers refer to the six components listed in this stage to understand how technology integration planning is done by the model teacher (Sun, 2012). Next, in the implementing stage, teachers observe how the technology integration plan is implemented (Sun, 2012). They must take notes on how the technology is used in the classroom, the students' responses and interactions with the technology, and how the model teachers deal with problems or needs emerging during the instructional process (Sun, 2012). Finally, the reflecting stage allows teachers to reflect on the modeled technology integration they have observed and think about revisions or improvements that could be made (Sun, 2012).

Summary. Technology has a considerable impact on the teaching and learning of mathematics. Improving mathematics teachers TPACK has been shown to increase teachers' and students effective use of technology during mathematics instruction (Harris & Hoffer, 2011; Guerrero, 2010, AMTE, 2009; Sun, 2012). Improving teachers' TPACK is a continuous process. Teachers must evaluate their technology fluency as well as evaluate the needs and characteristics of their students, content and learning objectives, and pedagogy (Sun, 2012; Guerrero, 2010; AMTE, 2009). Proper planning including identifying student and teacher roles, roles of technology, and management of time and resources must be considered (Sun, 2012; Guerrero, 2010; AMTE, 2009). After implementation, teachers must have an opportunity to reflect on the entire process. Within this study, participants had an opportunity to develop their TPACK by participating in professional development activities that allow them to evaluate and match technology with the needs of their students, content objectives, and teaching practices. Participants had an opportunity to reflect on the implementation and planning of their lessons. The next section of the literature review includes a discussion on how pedagogical beliefs influence teachers' decision to use technology during instruction.

Pedagogical Beliefs and their Influence on Technology Use Within Teaching Practices

This section will begin a discussion of the development of teachers' belief systems and the belief's influence on their teaching practices. This section concludes with a discussion of research findings showing the connection between teachers' pedagogical beliefs and teachers' decisions to integrate technology within their mathematics teaching practices.

Rokeach (1968) defined beliefs as “inferences made by an observer about underlying states of expectancy” (p. 2). A belief system may be defined as having represented within it, in some organized psychological but not necessarily logical form, a person’s countless beliefs about psychical and social reality (Rokeach, 1968). According to Hermans, Tondeur, van Braak, and Valcke (2008), “belief systems consist of an eclectic mix of rules of thumb, generalizations, opinions, values, and expectations grouped in a more or less structured way” (p. 1500). Teacher belief systems comprise a countless number of interacting, intersecting, and overlapping beliefs (Pajares, 1992). Richardson (1996) pointed out that teacher’s beliefs come from three sources: (1) personal experiences of the teacher in general and teaching, (2) teacher’s experience as a student, and (3) the teacher’s knowledge of the content. Teacher’s efforts to integrate technology into their teaching practices are often limited by barriers that are fundamentally rooted in their pedagogical beliefs and views of technology (Levin & Wadmany, 2006; Wang, Ertmer, & Newby, 2004). Teachers’ pedagogical beliefs have considerable influence on their decisions related to how lessons are planned and the selection of tools and materials used during the lesson (Applefield, Huber, & Moallem, 2001). Teachers who were taught in a traditional classroom might hold on to traditional beliefs and carry out practices in support of their beliefs. Additionally, those teachers might not see the affordance of technology beyond those that are already afforded by existing tools in the classrooms or may take up only the affordances that are consistent with their traditional pedagogical beliefs (Holt-Reynolds, 1992; Lim & Chai, 2008).

For this study, examining the relationship between pedagogical beliefs and technology use during mathematics instruction was beneficial to understanding why some teachers decide to utilize or not utilize technology in their instructional practices. Norton, McRobbie and Cooper (2000) conducted a study to investigate the relationships between the beliefs about teaching practices of mathematics teachers and their attitudes toward using computers in their teaching. Although this study was conducted 17 years ago, it shows the connection between teachers' beliefs and attitudes towards technology and their teaching practices. Additionally, Norton et al. (2000) examined the staff discourse that facilitated or hindered the use of computers. The study was conducted in a technology-rich secondary private girls' school. The school, Hill View, had a student population of 650 students with an age range of 11 – 18 (Norton et al., 2000). Hill View was chosen as the study sight because the mathematics staff rarely used computers in their teaching despite the availability of hardware and software (Norton et al., 2000). There were seven designated computer laboratories with 25 to 30 networked computers. Each teacher also had access to a digital projector and their own computer room. Mathematics teachers also had a classroom set of graphing calculators. Eight mathematics teachers and one computing coordinator were chosen to participate in the study. Data was collected in three phases: (1) entry phase, (2) survey phase, and (3) case study phase (Norton et al., 2000). During the entry phase, the computing coordinator was interviewed about the computer resources available to the mathematics staff and how the mathematics teachers used them (Norton et al., 2000). In the survey phase, mathematics teachers completed a survey that provided researchers with information regarding their demographics, use of computers and beliefs about their effectiveness compared to traditional instruction, factors limiting classroom computer usage, beliefs about mathematics, and beliefs about the nature of teaching mathematics (Norton et al., 2000).

The case study phase was separated into three additional phases: (1) exploring beliefs, (2) exploring practices, and (3) response to intervention (Norton et al., 2000). Five of the eight teachers were selected to participate in the case study phase. During the exploring beliefs phase, teachers were interviewed on their beliefs about the nature of mathematics, their images of teaching and learning, their thoughts about the available textbooks and resources, and their beliefs about the use of computers in mathematics teaching (Norton et al., 2000). Teachers' pedagogies were explored through observing and audiotaping several lessons during the exploring practice phase (Norton et al., 2000). Researchers kept detailed field notes, and student work samples were examined. Following each lesson, teachers participated in a brief, informal interview to discuss the instructional practices utilized during the lesson (Norton et al., 2000). During the final phase, response to intervention, researchers explored the teachers' beliefs about the use of computers through interviews and indirectly through their peers' responses to an intervention (Norton et al., 2000). The intervention consisted of the researcher constructing lessons on the topics the teachers were planning to teach in which students would use Maths Helper, an exploratory mathematics software, used to explore mathematics concepts and engage in mathematical modeling.

The results of Norton et al.'s (2000) study indicate that individual teachers' resistance to incorporating computers into their teaching practices was related to their beliefs about mathematics teaching and learning, their existing pedagogies, including their perceptions about testing concerns, time constraints, and preferences for text resources. Additionally, data indicated that teachers who possessed a transmission or absorption image of teaching and learning and a teacher-centered content-focused pedagogy possessed a limited view of the benefits of using computers in mathematics teaching and learning (Norton et al., 2000). Staff discourse was also found to be an important element in determining whether teachers used computers to facilitate students' conceptualization of mathematics (Norton et al., 2000).

More recently, Kim, Kim, Lee, Spector, and DeMeester (2013) conducted an exploratory mixed methods study to investigate how teacher beliefs were related to technology integration practices. They were interested in how and to what extent teachers' beliefs about the nature of knowledge and learning, beliefs about effective ways of teaching, and beliefs about technology integration practices were related to each other (Kim et al., 2013). The study was designed around a four-year professional development project aimed to increase the technology capacity and competency of teachers in poorly performing rural schools in Alabama, Georgia, and Florida (Kim et al., 2013). Additionally, the professional development project aimed to improve the quality of participating teachers' integration of technology in their classrooms to support specific learning skills and competencies described in their state's standards (Kim et al., 2013).

Study participants included teachers who participated in the researchers' Comprehensive School Reform (CSR) program (Kim et al., 2013). Of the 44 participants in the CSR program, 22 elementary and secondary teachers were chosen to participate in the study based on the following criteria: (a) taught in class during the project years and (b) participated in the project for at least two consecutive years (Kim et al., 2013). Researchers provided participants with new technologies, professional development, and technical pedagogical assistance. The technologies included laptops, interactive white boards, digital cameras and recorders, and "other technologies selected in collaboration with participating schools" (Kim et al., 2013, p. 78). Professional development workshops included intensive, one-week summer training workshops each year as well as, workshops on demand during the school year. Training sessions involved such topics as, integrating internet resources such as GeoGebra into lessons, video recording and editing, maintaining a web-based knowledge sharing system, and using video-conferencing (Kim et al., 2013). Technical and pedagogical assistance was given to teachers face-to-face, by phone, and by videoconference. The participating schools received approximately 40% of the total grant to support technology upgrades and teacher professional development (Kim et al., 2013). The schools had voice and choice in selecting which technologies to acquire, although these technologies had to be consistent with project goals and used by participating teachers (Kim et al., 2013).

Teacher beliefs about the nature of knowledge and learning were measured using Schommer's (1990) Epistemological Belief Questionnaire (EBQ) (Kim et al., 2013). The questionnaire consists of 63 questions related to five multidimensional beliefs: (1) the structure of knowledge, (2) the source of knowledge, (3) the stability of knowledge, (4) the speed of learning, and (5) the ability to learn (Kim et al., 2013, Schommer, 1990). Teacher beliefs about effective ways of teaching were measured using part of Becker's (2001) Teaching, Learning, and Computing (TLC) survey (Kim et al., 2013). Researchers used three scales from the survey that addressed beliefs regarding class discussions, learning processes, and teacher roles to determine where teachers' conceptions of teaching were along a teacher-centered and student-centered continuum (Kim et al., 2013). Technology integration was measured using classroom observations and teacher interviews. For classroom observations, Darrah and Blake's (2009) Classroom Lesson Observation (CLO)

Survey of CITERA) was utilized. Kim et al. (2013) used two scales from CLO to rate the design and implementation of teachers' lessons that integrated technologies, ranged from teacher-centered, highly structured, directed learning to student-centered, mostly unstructured, open-ended learning.

The results of the study showed teachers' beliefs about the nature of knowledge and learning, beliefs about effective ways of teaching, and technology integration were positively correlated with one another (Kim et al., 2013). In addition, there was consistency between what teachers do in their teaching and what they reported (Kim et al., 2013). Teachers reported levels of technology use were significantly correlated with both their beliefs about effective ways of teaching and their actual practices related to technology integration. Kim et al. (2013) suggested that teacher beliefs should be considered to facilitate technology integration. Kim et al. (2013) also suggested that teacher beliefs about the nature of knowledge and learning that influence their beliefs about effective ways of teaching should be further studied since those fundamental beliefs can be a starting point to overcome the second-order barriers, such as beliefs, and technology integration.

Brown et al. (2007) investigated elementary and secondary mathematics teachers' beliefs regarding calculator use during instruction. The four research sites included one large Midwest- urban district and smaller suburban and rural districts from neighboring states (Brown et al., 2007). All mathematics teachers from the 26 high schools and 29 middle schools within the districts were included in the study and received a survey through their interschool mail systems. Additionally, a random sample of elementary teachers from 86 elementary schools was also included. Three different surveys were utilized, one each for high school, middle school, and elementary school teachers. The surveys contained demographic items as well as 20 common and 8 grade-band specific items related to their instructional beliefs, instructional practices, and knowledge with respect to calculator use (Brown et al., 2007). Researchers received 814 survey responses (248 from high school teachers, 239 from middle school teachers, and 327 from elementary school teachers) (Brown et al., 2007).

Brown et al. (2007) found that overall high school teachers, when compare to other grade bands, had a higher percentage of teachers who perceived calculator use as a catalyst for developing mathematical understanding. However, results also showed a correlation between teachers' grade level of instruction and the belief that calculators can be a crutch to obtaining mathematical understanding. Brown et al. (2007) found that as the grade level of the teacher increased, the perception that calculator use during instruction leads to students obtaining answers without understanding mathematical processes increased. Despite this finding, results for all three grade bands indicated that teachers believed that calculator use during instruction can be beneficial to students when learning mathematics, can lead to better understanding of the mathematics, and can make mathematics instruction more interesting (Brown et al., 2007). Based on their results, Brown et al. (2007) suggested that mathematics teachers in all grade bands should be provided with intellectual and technical support for incorporating calculators into their instructional practices. This support should focus on impacting their beliefs, knowledge base, and pedagogical skill (Brown et al., 2007). Professional development must emphasize judicious use of technology and move teachers to a belief that technology can enhance learning, not just function as an easy shortcut (Brown et al., 2007, p. 113).

Summary. The studies conducted by Norton et al. (2000), Kim et al. (2013), and Brown et al. (2007) show that teachers' beliefs regarding pedagogy and technology are important factors to consider when developing interventions to facilitate teachers' integration of technology into their teaching practices. Teachers' beliefs about mathematics teaching and learning, existing pedagogies, time constraints, and preferences for text resources heavily influence their decisions to integrate technology (Norton et al., 2000; Kim et al., 2013; Brown et al., 2007). Their findings will influence the development of professional development activities and choice of instruments used in this study. The next section of the literature review will discuss the role of teacher beliefs, attitudes, and pedagogical practices related to using technology and teaching African American and low-income students.

Role of Teacher Beliefs, Attitudes, and Pedagogical Practices on Instruction and Technology Integration with African American and/or Students in Poverty

This section of the literature review includes a discussion of the benefits and barriers affecting the integration of technology. Additionally, teacher beliefs related to the teaching and learning of mathematics for African American and low-income students is discussed. Teachers' beliefs and attitudes regarding this demographic often impact their teaching practices and their decision to integrate technology during instruction is discussed.

Teachers' beliefs concerning African American and low-income students. Research on teacher beliefs suggests that many teachers lack confidence about their abilities to teach African American students effectively (Ladson-Billings, 1994; Lynn, Bacon, Totten, Bridges, & Jennings, 2010). For decades, research has shown that although a teacher's aptitude, credentials, and experience are important factors in determining his or her potential to be successful with minority and low-income students, it also matters whether teachers are culturally competent. Teachers who were the most successful with African American students respected and valued students' culture and possessed sophisticated understandings of their own culture and its connection to teaching in equitable ways (Ladson Billings, 1994).

In addition to teachers respecting and valuing the culture of their African American students, teacher efficacy also matters. Not only do African American students tend to have teachers who tend to lack the cultural competence Ladson-Billings (1994) described, they also tend to have teachers who have a low sense of self-efficacy (Lynn et al., 2010). Nogurea's (2008) study exploring the efforts of two school districts to close the racial achievement gap revealed that teacher self-efficacy had an impact on student achievement. Both schools had a disproportionate amount of low-performing African American and Latino student. According to Nogurea (2008), "of all the factors most consistently cited as influencing the achievement and motivation of students of color, teacher efficacy ranked the highest" (p. 95). Teachers who have a low sense of teaching efficacy tend to demotivate and discourage their minority students (Nogurea, 2008).

Teacher beliefs about teaching African American students are also greatly influenced by their perceptions of prior students' academic performance, socioeconomic status, and race (Lynn et al., 2010; Bakari, 2003; Ferguson, 2005). These beliefs, paired with a low sense of efficacy for teaching African American and low- income students, shape teachers' dispositions about students' academic ability. As a result, teachers fail to provide students with opportunities to experience effective teaching practices (Lynn et al., 2010;

Bakari, 2003; Nogurea, 2008). In many cases, these teachers tend to implement strategies and practices that emphasize repetition, speed, and procedures rather than meaning and understanding (Bakari, 2003; Ferguson, 2005).

Not only do these beliefs influence the teachers' instructional practices, but they also affect disciplinary procedures and students' academic beliefs, values, and achievement particularly with students of color (Diemer, Marchand, McKellar, and Malanchuk, 2016; Wang & Eccles, 2014). Diemer et al. (2016) examined the impact of teacher differential treatment on African American students' mathematics beliefs and achievement. The differential treatment included disciplining students differently on the basis of race, holding lower expectations for African American students, and grading African American students more harshly than non-African American students. For this study, Diemer et l. (2016) analyzed data from the longitudinal Maryland Adolescent Development on Context Study (MADICS). MADICS sampled 23 public middle schools in Prince George's County, a racially and economically diverse county outside of Washington, DC. Diemer et al.'s (2016) study focused on data collected in waves 3 (collected at the end of students' eighth grade year) and wave 4 (fall of 11th grade year) during the MADICS. Waves 3 and 4 were chosen because they measured students' perceptions of race, their school, and their academic abilities. The MADICS sample included 1065 students of various ethnicities. However, only the African American subsample (618 students) was examined. The study measured students' mathematics achievement as well as their perceptions of relevant mathematics instruction, self-concept of mathematics ability, mathematics task value, and differential treatment by teacher. Results showed that teacher differential treatment affected African American students' mathematics beliefs and achievement. Additionally, a negative correlation was found among teacher differential treatment and relevant mathematics instruction, students' self-concept of mathematics ability, and task value.

Benefits of high-level cognitive demand of tasks. Mathematical tasks play a critical role in the teaching and learning of mathematics. Worthwhile tasks give students the chance to solidify and extend what they know and to stimulate mathematics learning (NCTM, 2010). Mathematical tasks deemed "worthwhile" involve a high level of cognitive demand, have important, useful mathematics, promote student engagement and discussion, and have multiple entry points and solutions. These tasks allow students to develop mathematical proficiency and conceptual understanding, make connections to important mathematical ideas, make use of prior knowledge and multiple resources, and also enable teachers to assess learning and difficulty (NCTM, 2010). Implementing high-cognitive demand tasks with students not only increases mathematics achievement within varying ethnic groups, but also decreases achievement gap between ethnic groups. For example, in a longitudinal study of equitable teaching practices conducted at three high schools with varying demographics (Railside High, Greendale High, and Hilltop High), Boaler and Staples (2008) found that students taught by teachers using a reform-oriented approach experienced greater mathematics success than student who were taught by teachers who did not use a reform-oriented approach. Railside High was "an urban high school with an ethnically, linguistically, and economically diverse" student population (Boaler & Staples, 2008, p. 609). At Railside High, students of color accounted for 60% of the student population (40% Latino/a and 20% African American). Additionally, 30% of the student population received free or reduced lunch. The student population at Greendale High was 90% white with about 10% of the student population receiving free or reduced lunch.   The student population at Hilltop High was 60% white and 40% Latino/a with 20% of the student population receiving free or reduced lunch. Unlike students at Hilltop High and Greendale High, mathematics students at Railside were taught by teachers who designed reform-oriented curriculum and used conceptual problems with a high level of cognitive demand. Boaler and Staples (2008) found that "the students at Railside School enjoyed mathematics more than students taught more traditionally, they achieved at higher levels on curriculum-aligned tests, and the achievement gap between students of different ethnic and cultural groups was lower than those at the other schools" (p. 625). Railside students' success in mathematics was attributed to several characteristics of the mathematics instruction. One characteristic was that the teachers at Railside shared a common vision of mathematics as centered around cognitively demanding tasks that allowed for multiple representations, multiple strategies and solutions, as well as making connections between mathematical concepts. The teachers at Railside were committed to implementing a curriculum that comprised of a variety of cognitively demanding tasks and did not reduce the cognitive demand of the work, even when students were showing signs of frustration (Boaler & Staples, 2008). At Railside, the teachers were skilled at supporting students in working on challenging problems with techniques such as asking good questions to probe student thinking, as well as stressing the importance of cognitive effort and persistence. Below, Boston and Smith (2009) used the Task Analysis Guide developed by Stein et al. (2000) to categorize different cognitive demand levels of tasks implemented by mathematics teachers who participated in the Enhancing Secondary Mathematics Teacher Preparation professional development project.

In an effort to improve the selection and implementation of higher-level tasks, Boston and Smith (2009) conducted a study in which 18 teachers participated in a year-long professional development project entitled Enhancing Secondary Mathematics Teacher Preparation (ESP). This project focused on providing opportunities for teachers to solve mathematical tasks, to assess the cognitive demands of mathematical tasks, and to analyze the implementation of mathematical tasks during instructional episodes. The teachers explored aspects of planning, teaching, and reflecting with the goal of improving the selection and implementation of cognitively demanding mathematical tasks.

Instructional tasks and student work were collected, and lessons were observed. The Instructional Quality Assessment (IQA) and Academic Rigor (AR) rubrics as well as the factors associated with cognitive maintenance and decline were used for analyzing tasks, lessons, and student work. The results showed that ESP teachers significantly increased the level of cognitive demand of the main instructional tasks in their data collections and their ability to maintain higher-level cognitive demands in students' work. Smith and Boston (2009) used Stein, Smith, Henningsen, and Silver’s (2000) Task Analysis Guide created to analyze mathematical tasks and found that the teachers moved from using lower-level tasks (memorization and procedures without connections) to using higher-level tasks (procedures with connections and doing mathematics) after participating in the workshop (see Figure 3).

Low-Level Cognitive Demands	High-Level Cognitive Demands
Memorization Tasks • Involve either producing previously learned facts, rules, formulae, or definitions or committing facts, rules, formulae, or definitions to memory. • Cannot be solved using procedures because a procedure does not exist or because the time frame in which the task is being completed is too short to use a procedure. • Are not ambiguous—such tasks involve exact reproduction of previously seen material and what is to be reproduced is clearly and directly stated. • Have no connection to the concepts or meaning that underlay the facts, rules, formulae, or definitions being learned or reproduced. *Procedures Without Connections Tasks* • Are algorithmic. Use of the procedure is either specifically called for or its use is evident based on prior instruction, experience, or placement of the task. • Require limited cognitive demand for successful completion. There is little ambiguity about what needs to be done and how to do it. • Have no connection to the concepts or meaning that underlie the procedure being used. • Are focused on producing correct answers rather than developing mathematical understanding. • Require no explanations or explanations that focus solely on describing the procedure that was used.	*Procedures with Connections Tasks* • Focus students' attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas. • Suggest pathways to follow (explicitly or implicitly) that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts. • Usually are represented in multiple ways (e.g., visual diagrams, manipulatives, symbols, problem situations). Making connections among multiple representations helps to develop meaning. • Require some degree of cognitive effort. • Although general procedures may be followed, they cannot be followed mindlessly. Students need to engage with the conceptual ideas that underlie the procedures in order to successfully complete the task and develop understanding. *Doing Mathematics Tasks* • Require complex and non-algorithmic thinking (i.e., there is not a predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instructions, or a worked-out example). • Require students to explore and to understand the nature of mathematical concepts, processes, or relationships. • Demand self-monitoring or self-regulation of one's own cognitive processes. • Require students to access relevant knowledge in working through the task. • Require students to analyze the task and actively examine task constraints

	that may limit possible solution strategies and solutions. • Require considerable cognitive effort and may involve some level of anxiety for the student due to the unpredictable nature of the solution process required.

Figure 3. Task Analysis Guide (Stein et al., 2000)

Boston and Smith (2011) used the results from their previous study (Boston & Smith, 2009) to see if teachers sustained the ability to select and implement cognitively demanding tasks after the initial program was completed. Boston and Smith analyzed three points in time: before and after their participation in the program, and two years after the program ended. The researchers used both quantitative and qualitative methods to analyze the three points in time and to create case studies illustrating how teachers' abilities progressed over time. Overall, Boston and Smith (2011) found that the majority of the teachers who participated in ESP had sustained the improvements more than a year after the project ended. The portraits of four teachers, who represented a selection of teachers with similar patterns, demonstrated that several factors were important for sustaining high-level engagement with cognitively demanding mathematical tasks. These factors were use and application of the ESP tools, tasks and frameworks, self-reflection, and the opportunity to mentor preservice teachers. Self-reflection encouraged teachers to apply ideas they gained from the workshop to their own practice, and teachers who mentored a student teacher were more likely to continue to improve their selection and implementation of higher-level tasks. In general, the researchers state that the ESP program promotes gradual, sustained change. This means that change such as this exists on a continuum where teachers may begin and end at different points.

Benefits to technology integration. Technology integration means incorporating technology and technology-based practices into all aspects of teaching and learning (Wachira & Keengwe, 2011). Technology in the context of teaching and learning mathematics includes dynamic software, graphing calculators and other handheld computing devices, internet applets, computers with appropriate mathematical software, and other applications that can be used in mathematics (Wachira & Keengwe, 2011).

Blanchard, LePrevost, Tolin, and Guiterrez's (2016) three-year study investigated the effects of providing twenty mathematics, science, and technology teachers in two high-poverty middle schools with technology-enhanced professional development (TPD) designed to improve participants' integration of technology within their teaching practices. Two thirds of the students in one school were African American and received free or reduced lunch. Over 80% of the students in the second school were students in poverty. One aspect of Blanchard et al.'s (2016) study was to investigate whether mathematics and science scores of students in classrooms where teachers participate in TPD differed from those of students in nonparticipating teachers' classrooms. A second aspect of the study investigated whether the mathematics and science scores of African American students in classrooms where teachers participate in TPD differed from those of students in nonparticipating teachers' classrooms. Results of the study showed that there was a statistically significant increase in students' mathematics and science overall scores for students with teachers participating in TPD. For African American students, this increase was even more significant and nearly double that of the overall increase in mathematics and more than double in science (Blanchard et al., 2016). Parallel analysis to examine separate effects on Caucasian students yielded no significant effect. Additionally, Blanchard et al. (2016) found that there was a statically significant difference in the mathematics and science scores between African American and Caucasian students. However, by the end of the study, for students who experienced three years of participating teachers, there was no longer a statistically significant difference between the scores of African American and white students.

Access and use of technology as barriers to technology integration. During the early 80s and throughout the 90's, a major barrier to technology integration within instruction for mathematics teachers of African American and poverty students was access to technology (National Telecommunications and Information Administration (NITA), 1999; Attwell, 2001; Jackson et al., 2008). This was called the Digital Divide. Initially, the digital divide was framed in terms of access, resulting in a number of policy initiatives in the 1990s to increase the numbers of computers in schools and connectivity to the Internet in classrooms (NTIA, 1999). The concept of the digital divide was originally defined as a gap between those who have access to digital technologies and those who do not (NTIA, 1999). More recently, there has been a focus on the "new digital divide" (Jackson et al., 2008). As the internet has become increasingly widespread in the world, some researchers suggested a conceptual shift of the digital divide from material access to actual use (Wei & Hindman, 2011). Attwell (2001) and Hargittai (2002) pointed to divides at two levels: (1) the ''first digital divide'' refers to the differential access to computers and the Internet, and (2) the ''second digital divide'' includes the disparities in computer and Internet use, users' technological competencies, and skills for both teachers and students.

Access to technology in schools does not always result in use, nor does use always result in enhanced instructional practices or learning outcomes (Mardis, Hoffman, &

Marshall, 2008). As computer and Internet access increases in schools, gaps remain in use and impact (Mardis et al., 2008). According to Reinhart et al. (2011) simply having the physical access to technology within the school does not significantly change learning outcomes. Learning outcomes related to technology are significantly influenced by personal characteristics of the teacher (gender, age, race, ethnicity, language skills and economic background) and the curriculum of the school or district. Studies have also shown that schools with a higher percentage of students who receive free and/or reduced lunch use technology in a way that does not promote higher-order thinking (Jackson et al., 2006; Reinhart et al., 2011). This was attributed to the lack of teaching higher-order thinking skills and the absence of a technology facilitator (Jackson et al., 2006; Reinhart et al., 2011). Schools with a high percentage of free and reduced lunch were found to be less likely to have in-house instructional technology facilitators who provided teachers with the necessary training to effectively integrate technology use within their teaching practices (Reinhart et al., 2011).

Attitudes and beliefs as barriers to technology integration. Although teachers' decisions about technology use are influenced by many factors such as access and confidence level, the most significant barrier is the role teachers' beliefs and attitudes play in determining whether or not to implement technology (Albion, 1999). Thomas and Znaniecki (1918) defined attitude as a mental and neutral state of readiness, organized through experiences, exerting a direct influence on an individual's response to all objects and situations with which it relates. A teacher's attitude toward technology and using technology during instruction are inseparable (Mahmood & Hirt, 1992). The more positive the teachers' attitude toward technology, both personal and professional, the more likely they are to use technology to their advantage in the classroom and convey positive messages to their students in this area (Larner & Timberlake 1995; Okinaka, 1991, 1992). Knowing the level of teachers' attitudes toward technology is an important measure in determining whether the teachers will integrate new technology in their established teaching and learning practices (Koszalka, 2001).

Swan and Dixon (2006) investigated the influence of a mentor-supported model of technology training on middle school mathematics teachers' attitudes and use of technology in the classroom. Their study took place in an urban middle school in the southeast United States. The student population of the school was 65% minority with at least 60% of the students eligible for free and reduced lunch. Eight mathematics teachers participated in the study. Each participant took part in six technology training sessions and informal focus groups. Additionally, each participant received ongoing mentor-provided support. The results of their study indicated that mathematics teachers participating in mentor-supported professional development increased the amount and use of technology in their practice. Participants indicated that they had an increase in desire and positive attitude towards technology and its importance in instructional practice.

Challenging the minds of teachers, specifically their belief system about teaching, learning, and technology is perhaps the most difficult task (Dwyer, Ringstaff, & Sandholtz, 1990a, 1990b). Overcoming intrinsic barriers, including beliefs, requires changes in teachers' thinking and behavior (Ertmer & Ottenbriet-Leftwhich, 2010; Ertmer, Ottenbriet-Leftwhich, Sadik, Sendurur, & Sendurur, 2012). A multiple case study of twelve k – 12 classroom teachers by Ertmer et al. (2012) indicated that teachers' beliefs about teaching practices influence decisions about technology. The results of the study further suggested that teachers' beliefs about the role of technology are very powerful, often affecting teachers' abilities to overcome extrinsic obstacles (Ertmer et al., 2012). When teachers believe in technology's effectiveness, they are more likely to embrace it as an instructional tool (Ertmer et al., 2012; Swan & Dixon, 2006; Okeke, 2014; Koszalka, 2001; Stols & Kriek, 2011). If convinced of the value and appropriateness of using technology, educators will be motivated to integrate technology in their practice and work to overcome extrinsic barriers (Ertmer et al., 2012).

Additional barriers to technology integration. Many schools throughout the country lack the proper infrastructure to support student and teacher use of technology during instruction. More than 70 percent of public K–12 schools do not have sufficient broadband to allow most of their students to engage in digital learning activities at the same time (Darling-Hammond, Zielezinski, Goldman, 2014). These slow connections were mainly concentrated in non-white and low-income communities (Darling-Hammond et al., 2014). This makes it nearly impossible for teachers in schools with a large student population to engage their students in technology rich lessons that require the use of the internet or web-based applications.

Wachira's and Keengwe's (2011) study sought to explore perspectives on barriers that hinder technology integration during mathematics instruction for teachers in urban high schools. This study consisted of 20 high school teachers enrolled in a master's program at a large western university. The teachers in this study identified several barriers that hindered their own technology integration. Most of the teachers reported that although there are computers, calculators, and other technology hardware available in their schools, many of the items were not functioning properly and unreliable (Wachira &

Keengwe, 2011). Additional barriers to technology integration reported by study participants included lack of time and lack of knowledge (Wachira & Keengwe, 2011). Teachers felt that they did not have time to invest in learning to use or to develop specific mathematics activities that included technology. They cited increasing accountability demands, such as preparing students for state testing, as reason for the lack of time. They viewed using technology during instruction and learning how to integrate technology as "additional work" (Wachira & Keengwe, 2011, p. 20). In addition, many teachers reported that they believed classroom management would be an issue. Teachers felt that it would be difficult to manage a large number of students using technology, and they believed many students would be off task. Teachers cited that their lack of training on appropriate technology use was minimal and not adequate to effectively integrate technology into their mathematics teaching practices. Two-thirds of the teachers did not have the skills necessary to use popular applications such as PowerPoint or spreadsheet programs (Wachira & Keengwe, 2011). Most teachers reported that their technology training was "generic and did not help them learn content specific ways of technology integration" (Wachira & Keengwe, 2011, p. 21). Although 77% of the teachers were convinced of the cognitive advantages of technology to improve students' understanding of mathematics and 100% of the teachers expressed the willingness to learn how to use technology for instructional activities, the enumerated barriers were preventing them from doing so.

Summary. According to NCTM (2014), "An excellent mathematics program requires that all students have access to a high-quality mathematics curriculum, effective teaching and learning, high expectations, and the support and resources needed to maximize their learning potential" (p. 59). Research has shown that teacher beliefs concerning instruction and technology are a major factor in determining whether a teacher will integrate technology during instruction (Ertmer, 2012; Blanchard, 2016; Wachira & Keengwe, 2011). Shifting teachers' beliefs to more student centered, raising expectations of students, and providing teachers with proper support and training have been key factors in increasing the use of technology for mathematics teachers in schools with a high African American, low-income student population (Blanchard, 2016). Increasing effective technology use in this setting improves the likelihood that students will be exposed to high quality instruction, raised expectations from teachers, and the opportunity to reach their full learning potential (Darling-Hammond et al., 2014). Student achievement and performance are affected by teachers' sense of efficacy for teaching African American students (Darling-Hammond et al., 2014). The participants of my study were mathematics teachers with a high population of students that can be identified as both African American and low-income. By allowing these teachers to examine their own biases and beliefs regarding their student population and the role of technology in instruction, my hope was that teachers would begin the process of changing any beliefs that are detrimental to students' mathematics achievement. Within this study, participants had opportunities to discuss their beliefs in conjunction with examining how their beliefs align with NCTM's (2014) productive and unproductive beliefs related to technology and equity within the teaching and learning of mathematics.

Changing Beliefs and Teacher Change

The previous section discussed the role teachers' beliefs had on instructional decisions. When teachers' beliefs do not align with current best practices and reform efforts, effective teaching strategies may not be implanted in their instructional practices.

This section of the literature review will discuss the process of changing beliefs and teacher change. This section begins with a discussion of Rokeach's (1968) idea of connectedness, followed by beliefs revisions. The section concludes with a discussion of various models of teacher change.

Connectedness. According to Rokeach (1968), beliefs may have multiple connections to other beliefs. This idea of connectedness has four defining assumptions or criteria of connectedness: (1) existential versus nonexistential beliefs, (2) shared versus unshared beliefs about existence and self-identity, (3) derived versus underived beliefs, and (4) beliefs concerning and not concerning matters of taste (Rokeach, 1968). Existential versus nonexistential refer to the beliefs that directly concern how one's own existence and identity in the physical and social world are assumed to have more functional connections and consequences for other beliefs than those which less directly concern one's existence and identity (Rokeach, 1968). Shared versus unshared beliefs about existence and self-identity refer to beliefs concerning existence and self-identity that may be shared or not shared with others (Rokeach, 1968). Those shared with others are assumed to have more functional connections and consequences for other beliefs than those not shared with others. Derived beliefs are learned not by direct encounters with an object of belief but, indirectly, from reference persons and groups (Rokeach, 1968). According to Rokeach (1968), derived beliefs are "assumed to have fewer functional connections and consequences for other beliefs from which they are derived" (p. 5). Many beliefs represent more or less arbitrary matters of taste and are often perceived by the individual holding them. These beliefs are assumed to have relatively fewer functional connections and consequences to other beliefs than beliefs that do not represent arbitrary matters of taste (Rokeach, 1968).

Beliefs that have multiple connections to other beliefs are considered to be "core" or central beliefs (Ertmer & Ottenbriet-Leftwhich, 2010). Additionally, "the more a given belief is functionally connected or in communication with other beliefs, the more implications and consequences it has for other beliefs, and therefore the more central the belief" (Rokeach, 1968, p. 5). Core beliefs are the most difficult to change, as their connections to other beliefs need to be addressed as well (Richardson, 1996).

Belief revision. Griffin and Ohlsson (2001) described belief revision as being highly subjective to motivational influence and epistemological values. Participants in their study indicated that, even if presented with sound conflicting evidence, they would not be willing to change their affect-based beliefs, but were relatively willing to change their knowledge-based beliefs. Griffin and Ohlsson (2001) explained these results by noting,

> "Affect-based beliefs, by virtue of their *lack* of coherence with the conceptual framework might be immune to threats posed by conflicting information. Any new information is likely to be distorted, and if it is accurately comprehended, it will have little influence" (p. 6).

Although beliefs are not readily changed, this does not mean that they will never change (Pajares, 1992). As teachers embrace others' ideas and attitudes, individual beliefs are developed and nurtured (Pajares, 1992). A belief change during adulthood usually results from an exchange of one authority for another. To effectively change beliefs, meaningful material or experiences that promote application of the new concept must be repeatedly presented (Pajares, 1992; Boethel & Dimock, 1999).

Professional development and teacher change models. According to Guskey (1985), the three major outcomes of effective professional development are changes in teachers' beliefs and attitudes, teachers' instructional practices, and students' learning outcomes. The traditional model for teacher change initially focused on initiating change in the beliefs, attitudes, and perceptions of teachers with the assumption that these changes would lead to changes in their classroom practices and improve student learning (Guskey, 1985). Professional development programs based on the assumption that changes in attitudes and beliefs come first are typically designed to "gain acceptance, commitment, and enthusiasm from teachers and school administrators" (Guskey, 2002, p. 383). However, these types of professional development programs rarely result in significant changes in attitudes or elicit strong commitment from teachers (Guskey, 1985, 2002). On the contrary Guskey's (1985) model of teacher change (see Figure 3) showed that "significant change in teachers' beliefs and attitudes takes place only after student learning outcomes have changed" (p. 58).

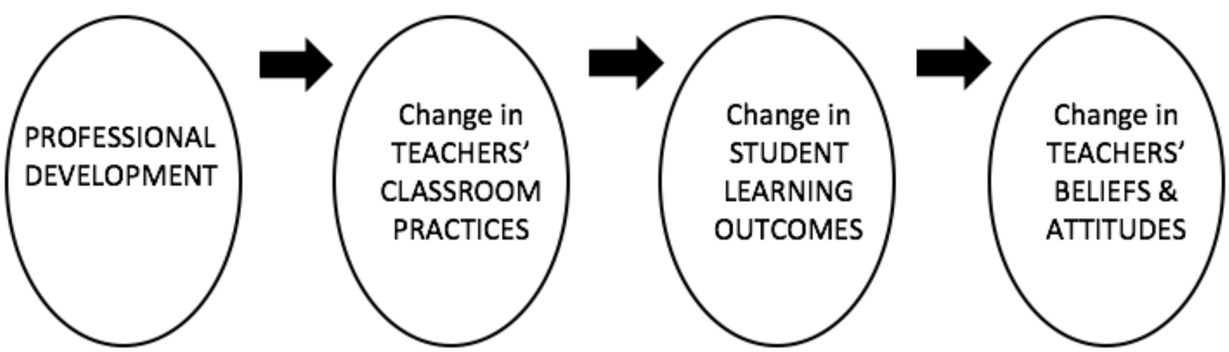


Figure 4. A New Model of Teacher Change (Guskey, 1985).

Changes in student learning outcomes are a result of specific changes teachers make in their classroom practices following professional development (Guskey, 1985). According to Guskey (2002), “high quality professional development is a central component for improving education” (p. 381). Based on this model, Guskey (1985) outlined three important principles to consider when planning and implementing effective professional development: (1) change is a slow, difficult, and gradual process; (2) teachers need to receive regular feedback on student learning outcomes; and (3) continued support and follow-up are necessary after initial training. These principles are critical to the sequence of teacher change because the experience of successful implementation is what leads to the changes in teachers’ attitudes and beliefs because the teachers see the direct results of their changed practices (Guskey, 2002).

Although Guskey’s (1985) framework suggested that changes in student learning are necessary for teacher change, others have argued that beliefs must change prior to change in practices. For instance, Andreasen, Swan, and Dixon (2007) presented a framework of how teachers change their practice through extended professional development that results in a four- stage process (see Figure 5). First, teachers initially resist change and insist on continuing to do things as they have always been done. Second, Andreasen et al. (2007) posited that teachers then begin to talk about change and at least express some willingness to alter practices. Third, the framework suggests that teachers then duplicate activities presented at the professional development. Finally, teachers change their practices. In this stage, teachers take what they have learned and apply it in their classrooms.

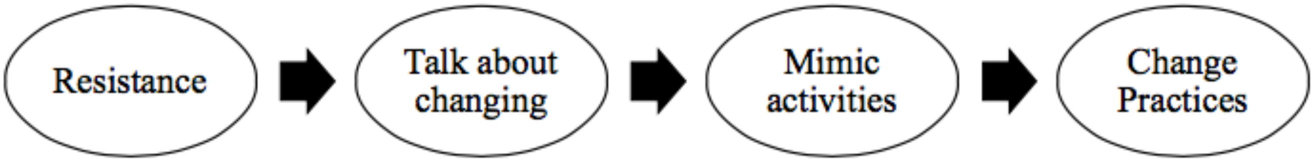


Figure 5. Stages of Teacher Change (Andreasen et al., 2007).

Clarke and Hollingsworth (2002) posited that the linear models of teacher change aforementioned oversimplified the process of teacher growth and failed to capture the dynamic and interactive aspects of teacher change. In response, Clarke and Hollingsworth (2002) described an Interconnected Model that accounts for the possibility of multiple avenues of change through four domains (see Figure 6). In the Interconnected Model, the processes of enactment and reflection serve as the mediators by which change in one domain translates into change in another.

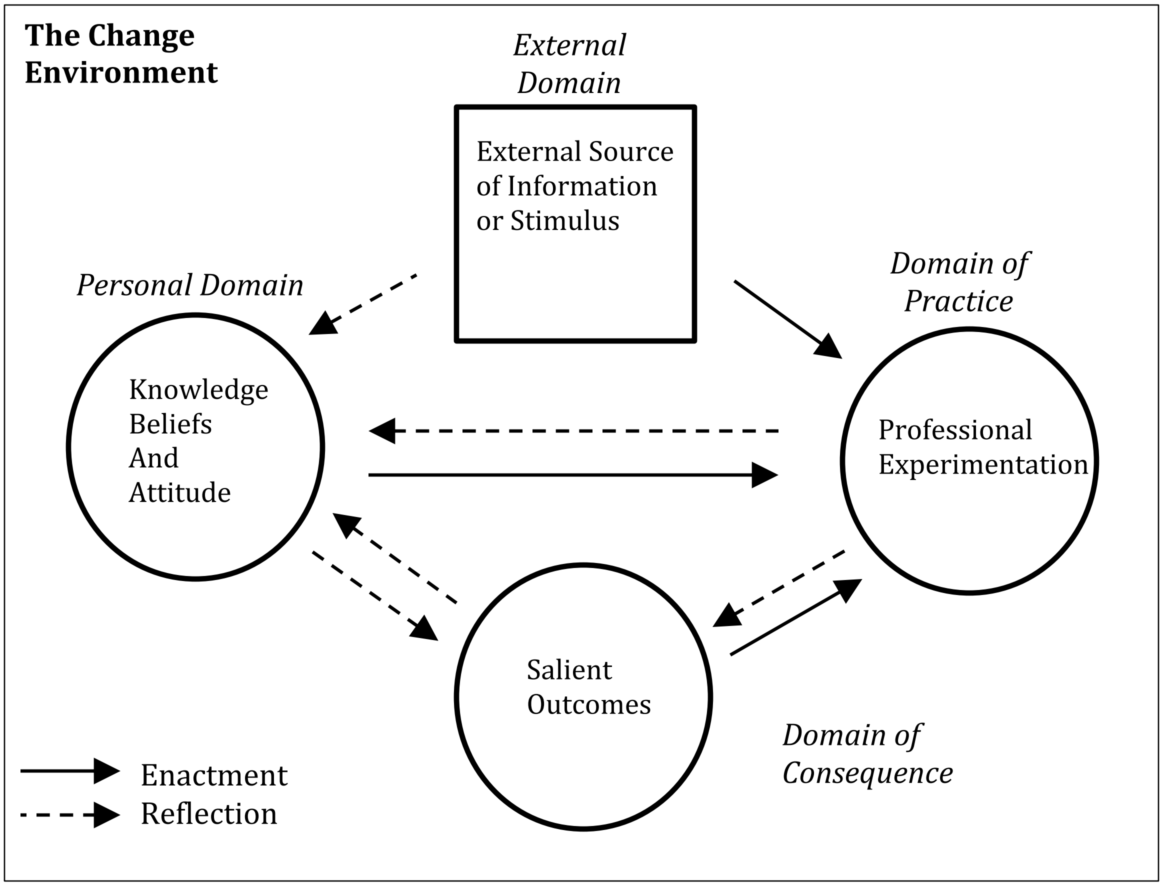


Figure 6. The Interconnected Model of Professional Growth (Clark & Hollingsworth, 2002).

The external domain represents the systems, information, and policies that shape teachers' learning (Clarke & Hollingsworth, 2002). For example, a teacher experiences a new teaching strategy related to group work during a professional development setting. The personal domain represents teachers' characteristics such as attitudes, beliefs, dispositions, and knowledge (Clarke & Hollingsworth, 2002; Goldsmith, Doerr, & Lewis, 2014). For example, a teacher's beliefs about the effectiveness of group work would exist in the personal domain. Next, the domain of practice signifies teachers' instructional practices (Clarke & Hollingsworth, 2002). For instance, a teacher may experiment with group work within his or her classroom. The domain of consequence represents the students' learning and other outcomes interpreted by teachers as consequences of their actions (Clarke &

Hollingsworth, 2002; Goldsmith et al., 2014). For example, a teacher might interpret an increase in student communication as a positive result of group work. As teachers reflect or enact on changes in one domain, change in another domain occurs. As teachers are going through the change process their growth may be hindered or increased by their school environment. Clarke and Hollingsworth (2002) identified four aspects of the school environment that can have a substantial impact on professional growth: access to opportunities or professional development, restriction or support for certain types of participation, support or opposition to experimentation with new teaching techniques, and administrative decisions related to long-term application of new ideas. The four aspects can promote or constrain any change that might occur in any one of the domains.

Summary. Changing one's beliefs is not an easy task. This is because beliefs are shaped overtime and are connected to a variety of experiences and other beliefs (Rokeach, 1968). Similarly, teachers' beliefs about students' abilities, instructional practices, and learning outcomes are shaped overtime by their experiences both in and out of the classroom (Guskey, 1985). Teacher change in beliefs and attitude has been shown to change after student learning outcomes have changed (Guskey, 1985). However, this linear change model, proposed by Guskey (1985), does not take into account the interconnected relationship of the external and internal factors that affect teacher change. Similarly, Andreasen et al.'s model of teacher change outlines a linear change from resistance to change in practices without fully addressing the interconnected relationship of the external and internal factors. However, Clark and Hollingsworth's (2002) Interconnected Model of Professional Growth outlines the process of reflection and enactment and its impact on each domain in the change model. With this model, there is no linear path to teacher change in beliefs and actions.

Transitioning from traditional methods of teaching to reform-oriented practices can be a very difficult task to achieve and sustain (Richardson, 1990). However, Clarke and Hollingsworth (2002) suggested that teachers can change their practices when given opportunities to learn within the classroom setting and observe new practices with their students.

Situated Professional Development for Teacher Change

This section begins with a discussion of situated learning theory and situated professional development. Following this is a discussion of professional development that utilize aspects of situated learning theory. These include instructional coaching, cooperative and collaborative inquiry, and collaborative apprenticeships.

Situated learning theory and situated professional development. Lave and Wenger (1991) argue that learning is embedded within activity, context and culture. Knowledge should be presented in authentic settings and situations that would normally involve that knowledge (Lave & Wenger, 1991). Social interaction and collaboration are essential components of situated learning. Learners become involved in a “community of practice” which embodies certain beliefs and behaviors to be acquired (Lave & Wenger, 1991). In a community of practice, individuals participate in mutual activities and have varying levels of expertise in a domain of common interest (Lave & Wenger, 1991). Participation within a “real-world” environment broadens learning to include not only content knowledge, but also tacit knowledge such as a common language and expected behaviors of community members (Lave & Wenger, 1991). Learner participation in authentic tasks facilitates their engagement within the community (Lave & Wenger, 1991). As newcomers to the field, learners begin their engagement through legitimate peripheral participation in tasks that are less vital to the community, and then increase their level of responsibility to full participation in the central tasks of the community (Lave & Wenger, 1991).

Within education, this community of practice often manifests as professional learning communities. Professional learning communities (PLCs) have been acknowledged as a mechanism for school-embedded teacher professional development that contains many elements necessary to establish a community of practice and promote teacher change (DuFour, DuFour, Eaker, & Many, 2010; Moss, Messina, Morley, & Tepylo, 2012). Many public schools utilize PLCs to engage teachers in collaborative efforts to improve teaching (Vescio, Ross, & Adams, 2008). DuFour (2004) described a PLC as a "community of educators committed to working collaboratively in an ongoing process of collective inquiry and action research to achieve better results for the students they serve" (p. 10). Successful PLCs are supportive with shared leadership. Also, successful PLCS contain shared values and vision, collective learning and application of learning, shared personal practice, and are results orientation.

The advantages of situated learning are (a) learners are placed in realistic settings where socially acquired ways of knowing are often valued, (b) learners' likelihood of application within similar contexts is increased, and (c) learners' prior knowledge on a given subject is strategically applied (Lave & Wenger, 1991). To realize the benefits of situated learning, learners should: (a) have opportunities to learn in real-life contexts and participate in authentic tasks, (b) feel welcome in communities of practice, (c) have contact with experienced community members who demonstrate expert performance, and (d) engage in assessments that reflect these opportunities and their participation (Lave & Wenger, 1991). As the novice learner moves from the periphery of a community to its center, they become more active and engaged within the culture and eventually assume the role of an expert (Lave & Wenger, 1991).

Putnam and Borko (2000) discussed emerging trends in research surrounding professional development and technology integration by examining the nature of situative learning. They identified three conceptual themes central to a situative perspective: (1) cognition is situated in particular physical and social contexts, (b) it is social in nature, and (c) knowledge is distributed across the individual, others, and tools (Putnam & Borko, 2000, p. 4). Situated professional development has several advantages. Situated professional development can be utilized to link learning about technology with authentic practice, thus fostering the development of technology integration (Swan et al., 2002). Professional growth could occur in daily encounters with interventions, colleagues, structured settings or in classroom practice (Borko, 2004). Additionally, situated professional development provides intrinsic reinforcement for learning about technology in the form of successful lessons and enthusiastic students (Swan et al., 2002).

The following two studies conducted by Kopcha (2012) and Swan et al. (2002) highlight the positive effects of implementing sustained and situated professional development that focuses on increasing teachers' technology integration. Although the studies were conducted in an elementary setting, the methodology and models developed can be modified to impact mathematics teachers at the secondary level.

According to Kopcha (2012), situated professional development, such as mentoring, is a promising way to prepare teachers to negotiate common barriers and improve their use of technology for instruction. Teachers that participate in sustained professional development such as mentoring integrate technology more frequently over time than teachers who do not learn with a mentor (Kopcha, 2012). Kopcha's (2012) study examined teachers' perceptions of the barriers to technology integration and instructional practices with technology after two years of sustained and situated professional development.

The research study was conducted in an elementary school that serviced 600 students in kindergarten through fifth grade. The faculty consisted of 30 teachers. A total of 18 teachers and 1 mentor participated in the study. Teachers had between 3 and 30 years of experience and only one participant was male. Prior to the study, participants had little instructional technology available or professional development on using technology for instruction (Kopcha, 2012). Kopcha, who served as the mentor, had prior experience as a public-school teacher and in training teachers to use technology for instruction.

Professional development at the school was prompted by a campus-wide upgrade of technology which included a teacher computer with document camera and projector in each classroom, a lab with 32 new computers and an interactive whiteboard, 5 mobile carts each containing 15 wireless laptop computers, online computer-based instruction available for all students, and district technical support three days a week (Kopcha, 2012). Following the upgrade, school leaders hired a mentor, who worked 30 hours per week, to conduct a variety of professional development activities over the course of one school year. The mentor was hired to provide teachers with the skills and knowledge needed to integrate technology into their instruction on a long-term basis. Because the mentor's role was temporary, one of the mentor's goals included transitioning teachers to communities of practice in order to sustain technology use over time. The communities of practice were established during the following school year.

During year 1, the mentor began by aligning the professional development with the needs of the teacher. A needs assessment consisting of surveys, interviews, and observations was conducted to establish the mentor's goals for the first year. The needs that were identified led to the following goals: address issues with access and time, improve teachers' technical skills with technology, create a shared vision for technology use at the school, support teachers' beliefs about using technology for instructional purposes, and introduce teachers to a variety of pedagogical strategies with technology (Kopcha, 2012).

The mentor began by addressing the barriers of access and time (Kopcha, 2012). Although teachers had access to a variety of technology, most of the resources did not work, needed troubleshooting, or needed to be set up for teacher and student use. Additionally, teachers were concerned that using technology throughout the day would be an interruption in their instructional time (Kopcha, 2012). The mentor addressed these barriers by establishing systems for teachers to acquire the available hardware and software, resolving existing technology issues and bringing technology to working order, and establishing systems to receive technology support from the district (Kopcha, 2012). Next, the mentor began addressing teachers' lack of technical skills and creating a shared vision for technology use on the campus (Kopcha, 2012). Teacher workshops and team trainings focused on teacher knowledge of technical skills such as methods of distributing and using laptops and basic software skills. The training provided opportunities for active learning including co-development and modeling of lessons with the mentor (Kopcha, 2012). These activities were aligned with teachers' needs by regularly assessing progress on school-wide technology goals and aligning technology-integration efforts with existing school initiatives (Kopcha, 2012).

After teachers' technical skills improved, the mentor provided professional development that focused on reinforcing teacher beliefs about using technology for instruction and introducing pedagogical strategies for technology integration (Kopcha, 2012). These activities were aligned with teachers' needs through continued assessment of school-wide goals and by meeting with teachers individually to help them integrate technology. In addition, students were trained to assist teachers with troubleshooting and maintaining the computers during the school day (Kopcha, 2012). Teacher workshops and team trainings focused on teachers' instructional uses of technology, including classroom management techniques, project-based learning, use of interactive web-based materials, and computer-guided instruction. The training provided opportunities for active learning including modeling, peer coaching, co-teaching, and co-development of lessons with the mentor (Kopcha, 2012). Grade-level teams met monthly to share and report on technology integration lessons, and those lessons were made available to all teachers through a shared drive on the school-wide network. These were summarized each month in a community newsletter (Kopcha, 2012).

The same mentor remained during the second year of the study to facilitate the formation of teacher-led communities of practice (Kopcha, 2012). The principal selected three teachers (one from each grade 3 to 5) to act as technology leaders for their grade-level team. These were teachers that the principal felt were proficient with integrating technology and best suited to take a leadership role (Kopcha, 2012). The technology leaders were provided with a small stipend to maintain and schedule the laptop computers and lead a community of practice within their grade level. The community met weekly as a team to resolve common issues and coach each other on technology use. Technology leaders supported teachers' active learning by conducting observations of their peers and offered feedback to improve their teaching practices with technology (Kopcha, 2012). Technology leaders' knowledge was addressed through participation in mentor-led training that consisted of weekly phone meetings to resolve persistent issues and monthly workshops on effective mentoring techniques (Kopcha, 2012).

The results of the study indicated that after transitioning from mentoring to teacher-led communities of practice, teachers continued to report positive perceptions of several barriers and were observed engaging in desirable instructional practices (Kopcha, 2012). Interviews suggest that the situated professional development activities helped create an environment that supported teachers' decisions to integrate technology (Kopcha, 2012).

Kopcha (2012) found that situated professional development activities can play a key role in shaping teachers' perceptions of the common barriers across a school site. The mean survey ratings on the barriers of vision and access and the items within those barriers were relatively high across both years. Teachers reported that this was due to the mentor communicating the vision for using technology and helping them keep the technology working on a consistent basis (Kopcha, 2012). The mentor also played a role in promoting positive beliefs about technology. Nearly half of the teachers reported that their beliefs remained strong or grew stronger as a result of their mentoring, and the highest-rated item on the entire survey was from beliefs (Kopcha, 2012). Other teachers reported that the mentor helped improve their beliefs in their own ability to plan and implement technology-integrated lessons (Kopcha, 2012).

Kopcha (2012) also found that teachers' perception of time was consistently negative, even as their access to technology and training improved, and they learned more about teaching with technology. Despite teachers' negative perception of time, teachers under this program of sustained and situated professional development adopted a number of desirable practices and routines (Kopcha, 2012). Teachers were observed using technology in student-centered ways to support learning subject-matter content. Students in those lessons were on-task and frequently engaged in problem solving and critical thinking (Kopcha, 2012).

Many of the changes in teachers' beliefs and practices persisted nearly a year after engaging in those activities, even as teachers' support decreased and technology issues increased. This suggests, according to Kopcha (2012), that the professional development activities that took place during Year 1 were highly effective at supporting the factors that led to a teacher's decision to integrate technology.

The Capital Area Technology and Inquiry in Education (CATIE) program was established through the Center for Initiatives in Pre-College Education (CIPCE) at Rensselaer Polytechnic Institute as an innovative means for addressing technology-based, constructivist-oriented staff development in elementary schools in the greater Troy, New York region (Swan et al., 2002). The major goals of the CATIE program were to foster individual teacher and student development of technological skills, to assist teachers with the infusion of technology into existing curricula, to broaden the use of computing technologies within the elementary school setting, and to foster constructivist teaching and learning around electronic technologies (Swan et al., 2002).

This program placed technology experts in school buildings where they serve as mentors to teachers interested in integrating the use of technology into their day-to-day classroom activities. The school-based mentors provided training to teachers on technology utilization. Additionally, the mentors worked with teachers to jointly design computer-supported lessons that integrate technology into existing classroom curricula (Swan et al., 2002). Teacher learning about technology integration was thus situated in authentic technology integration activities (Swan et al., 2002).

The mentors first met with teachers, both individually and in groups, to discuss how technology might be used to enhance learning in planned units on particular topics (Swan et al., 2002). They tried to avoid planning that was either artificial or focused on specific software applications and worked with teachers to design computer-supported lessons that were integral parts of larger, classroom-based learning units (Swan et al., 2002). They encouraged inquiry-based, student-centered, constructivist uses of computing technologies, but they did not insist on them (Swan et al., 2002). Mentors regularly modeled best practices in computer-based teaching and learning by taking the lead in implementing jointly created lessons (Swan et al., 2002). They then guided teachers in designing and implementing their own computer-based lessons, gradually fading their support as teachers became more confident in the use of electronic technologies (Swan et al., 2002).

Mentor support did not immediately end once teachers were confident in their ability to effectively integrate technology into their teaching practices. Each mentor structured his or her schedule according to his or her school's and participating teachers' individual needs. Generally, the mentor was available two days each week for a period of two years or more to work with teachers and students on a continuing, as-needed basis (Swan et al., 2002). Some teachers only came to share with their mentors the ways in which they were using technology on their own, and some mentors met regularly with groups of teachers to discuss technology integration. As mentors became a part of the culture of the school, formal and informal conversations became more common and ongoing, and a discourse community grew up around technology integration (Swan et al., 2002).

Hardy (2008) conducted a mixed methods study regarding the impact of a professional program called The Technology in Mathematics Education (TIME) Project. The participants in the study included a total of 19 high school and middle school mathematics teachers. The participants completed a course that focused on exploring resources and methods for teaching mathematics with technology. Eleven of the participants (high school) completed a five-day course that averaged 35- 40 hours. The remaining middle school teachers completed a 12-week course of 35-40 hours. Each course focused on methods of teaching mathematics by way of technology. Some activities were different in order to better meet the diverse needs of the middle and high school teachers. In addition, the participants had a second teacher present to assist them with technical problems. The mathematics topics addressed in the course included probability, patterns, sequences, linear regression, data representation, distance, rate and time, problem limits, and mathematical modeling. The technology topics included using videos, PowerPoint, Geometer's sketchpad, graphing calculators, locating and using internet resources, and writing plans for technology infused lessons. The participants completed a survey instrument, which included open-ended questions and Likert scale questions. One-time observations were conducted for the qualitative data. The findings from the quantitative data indicated that the participants felt the TIME project positively affected their ability to teach using technology, and that they would recommend the 40 TIME project to other teachers. The results of the qualitative data indicated that teachers had enhanced knowledge of resources and methods of using technology, and their confidence level about using technology to teach mathematics increased.

Instructional coaching. Coaching provides teachers with sustained, embedded professional development that focuses on improving teachers' instructional practices (McGatha, 2008). Adapting Desimone's (2009) core conceptual framework for successful professional development, Campbell and Griffin (2017) outlined the conceptual framework model for the coaching cycle for mathematics coaches and mathematics teachers (see Figure 7).

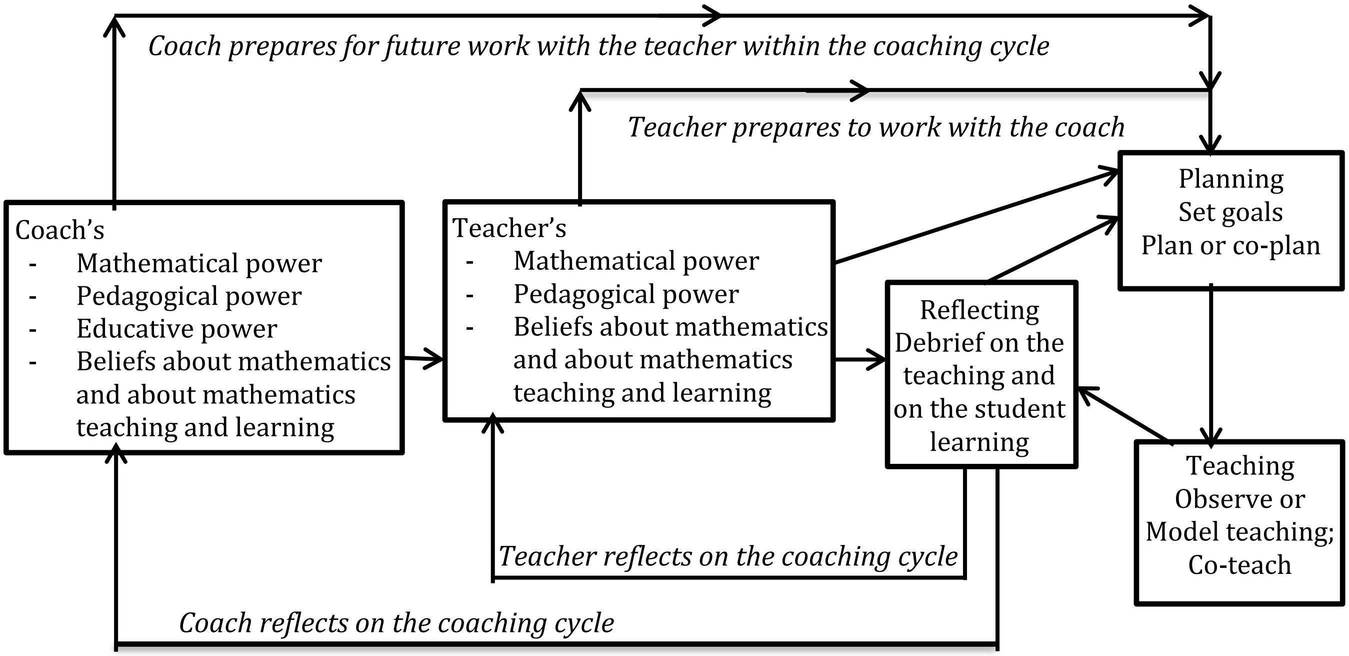


Figure 7. Conceptual framework modeling coaching and individual teacher co-learning through the coaching cycle (Campbell & Griffin, 2017).

Successful coaching in the mathematics teaching context, requires coaches and mathematics teachers to adhere to the core features of the framework. Core features include content focus, active learning, coherence through discussions that address teachers' beliefs and perspectives of mathematics content, duration that brings attention to a problem of practice, collective participation that promotes analysis, reflection and experimentation within a community of practice, and meaning focused on instructional approaches and the interpretation of student work (Campbell & Griffin, 2017, p. 5-6). These core features are similar to the elements of situated learning theory and situated professional development, as described earlier (Lave and Wenger, 1991). Campbell and Girffin's (2017) study of the complexities of mathematics coaching revealed that coaches who had less administrative and teaching duties and engaged teachers in meaningful dialogue about mathematics content, mathematical learning, and student understanding were the most effective and resulted in greater instructional change.

Corroborating with Campbell and Griffin (2017), McGatha (2008) examined the levels of engagement of two mathematics coaches as they sought to establish effective coaching relationships with the mathematics teachers at their schools. McGatha (2008) utilized reflective analysis to analyze the data collected during the seven-week study. Throughout the study, participants completed reflective journals. Additionally, McGatha (2008) conducted pre- and post-surveys with teachers and coaches as well as audio-recording interviews and meetings with coaches and teachers. McGatha's (2008) analysis revealed the importance of coaches having clearly defined roles and goals. Both participants indicated that initially this was not done and resulted in them not being as effective as they wanted to be. However, both participants saw improvements in their effectiveness once their role and goals were defined and understood by all parties involved in the coaching process (McGatha, 2008). Additionally, McGatha (2008) found that the coach that was more engaged with teachers was more successful at developing a productive relationship with teachers.

In addition, Rebora (2016) found that professional development which allowed idea sharing with other teachers, collaborative planning time, and job-embedded training or coaching to be beneficial in helping teachers to effectively integrate technology into their instruction. Mangin and Dunsmore (2014) shared that many states have been implementing instructional coach initiatives which may have consisted of any number of coaches, including technology coaches, who performed in a formal, informal, or mixed capacity role. They reported that the use of instructional coaches has been correlated to increases in teacher efficacy, improved pedagogical practice, and higher levels of achievement in student learning outcomes. Knight (2005) stated numerous school districts have begun placing teachers on special assignments for coaching the improvement of various teaching skills (i.e., literacy, mathematics, technology, etc.). He described coaches as very well versed in the interventions they taught, and as a result worked closely with on-site administrators in preparing professional development, or coaching sessions, which were tailored specifically for those receiving instruction. Moreover, Knight (2005) asserted coaches could be very instrumental when new educational reforms were announced. When it came to new educational reform, the majority of teachers' perspectives were: If the reform made a difficult and time-consuming task easier, they would work to adopt it. Therefore, the job of the instructional coach was to make the tools as easy to learn, use, and develop as possible (Knight, 2005). It has been proposed that coaches should work to empower teachers in making their own decisions for their classrooms (Wall & Palmer, 2015). On a daily basis, Fullan and Knight (2011) posited effective instructional coaches spent their time planning lessons with teachers, modeling strategies, facilitating professional learning communities and meetings, and observing classroom instruction. Through this process, coaches developed caring, supportive relationships with the teachers they supported. Trust was cultivated from the relationship, which afforded them opportunities to model and propose necessary changes in pedagogical philosophy and mindset to move the teacher toward a student-centered learning environment (Fullan & Knight, 2011).

Sugar's (2005) research was a project which focused on the work of an instructional technologist as a coach. He found that individualistic professional development delivered by an instructional coach was critical for successful technology integration. Sugar (2005) studied the effects of an instructional technologist as a coach supporting nine teacher participants. The nine teachers selected had a variety of subject responsibilities and varied levels of experience with technology. The coach scheduled time to meet face to face with participants and followed up with emails to be mindful of their time. Three different surveys were sent out; the first was a two-page survey at the beginning of the third month to assess the overall effectiveness of the project. The second, a six-page survey was sent out at the end of the project, again assessed the overall effectiveness of the project, but also asked the participants to rank their work on their technology project. A third and final survey was sent out seven months after the project ended, where again the teachers assessed the overall effectiveness of the project, gave new rankings for their work on their technology project, and reported any progress made. The surveys, combined with interviews, coach handouts and notes, lesson plans, and student projects, were analyzed, using the constant comparison technique. Results were reported using descriptive statistics showing, of the 50 coach projects, 94% were rated either "Effective" or "Very Effective." The remaining projects (three) were rated as "Undecided" on effectiveness. Sugar (2005) found that although the use of an instructional technologist as a coach effectively increased the use of technology for those supported, not all teachers had the need for a coach (one innovative social studies teacher). However, those who benefited from the support of the coach reported having an "extra boost of confidence and increased problem-solving skills" with respect to troubles with technology and its integration in instruction (p.564).

Cooperative and collaborative inquiry. Cooperative inquiry, first introduced by John Herron in 1971 and expanded on by Peter Reason, is a fully participatory process in which people engage together in cycles of action and reflection to gain and share knowledge (Reason & Heron, 1985). The original model for cooperative inquiry included three kinds of knowledge: (1) experiential knowledge, (2) practical knowledge, and (3) propositional knowledge (Reason & Heron, 1995). Experiential knowledge is gained through a direct contact (Reason & Heron, 1995). Practical knowledge is the knowledge needed to demonstrate a skill or competence (Reason & Heron, 1995). Propositional knowledge is knowledge one has regarding a subject matter expressed statements or theories (Reason & Heron, 1995).

Resting on the principles of cooperative inquiry, collaborative inquiry (CI) is "a systematic process consisting of repeated episodes of reflection and action through which a group of peers strives to answer a question of importance to them" (Bray, Lee, Smith, & York, 2000, p. 6). Participants organize themselves in small groups and engage in cycles of reflection and action, evoke multiple ways of knowing, and practice validity procedures (Bray, 2002; Kasl & York, 2002). Typically, they balance exploration of inner experience with action in the world. CI is especially appropriate for pursuing topics that are professionally developmental.

Hughes and Ooms (2004) longitudinal study utilized collaborative inquiry to examine the process of establishing and sustaining content-focused technology inquiry groups. A professional development model was implemented that grouped teachers with similar content and grade areas to identify problems of practice and find technology-supported solutions (Hughes & Ooms, 2004). Participants were chosen from an urban K-8 school with 610 students in which 83% were eligible for free/reduced lunch and 47% received English Language Learner service (Hughes & Ooms, 2004). Although the school updated the technology laboratory, added new network wiring to ensure all classrooms had internet access, established a computer-assisted instruction curriculum in mathematics and reading, and provided at least three computers in each classroom, the school was challenged by technology integration (Hughes & Ooms, 2004). The data collected in this study included an initial (pre-involvement) interview with each participant that focused on the participant's experience as an educator, as a teacher of the discipline chosen for inquiry, and as a user of technology (Hughes & Ooms, 2004). Participants indicated that they “had the availability but not necessarily the knowledge or direction to use the resources for technology-supported problem-based learning in content areas” (Hughes & Ooms, 2004, p. 400). Interviews were repeated with all participants on an annual basis and classroom observations and collaborative inquiry groups were conducted monthly for all participants (Hughes & Ooms, 2004). The results of the study were organized into three phases. Phase 1 focused on collaboratively identifying site specific problems, defining the group’s identity and purpose, and exploring and defining the concepts related to technology-supported teaching (Hughes & Ooms, 2004). In Phase 2, participants identified topics to pursue and technologies to learn (Hughes & Ooms, 2004). University participants conducted demonstrations of technology possibilities that connect with content, and some specific problems were resolved (Hughes & Ooms, 2004). Additionally, preparation for technology inquiries was initiated. During Phase 3, participants learned and used technology while being supported by the university participants (Hughes & Ooms, 2004). As technology was implemented into the classroom, implementation challenges emerged. "First, technology problems emerged on site; second, technology-related student learning issues were raised as a concern; finally, technology-related instructional problems surfaced" (Hughes & Ooms, 2004, p. 405). The study revealed promise for content-focused technology collaborative inquiry groups as a professional development approach (Hughes & Ooms, 2004). "Teachers are tackling the collective challenge of integrating technology in ways that transform subject area learning for children" through inquiry study (Hughes & Ooms, 2004, p. 409). According to Hughes and Ooms (2004), the three phases described may serve as a guide to the kinds of things that can emerge from collaborative inquiry groups if implemented at other institutions.

Collaborative apprenticeships. The Collaborative Apprenticeship model is "a professional development model designed to support teacher learning in their professional teaching community during the school day" (Glazer, Hannafin, & Song, 2005, p. 59). Collaborative apprenticeships feature reciprocal interactions between peer-teachers and teacher- leaders (Glazer et al., 2005). Collaborative apprenticeship is comprised of four progressive phases: (1) introduction, (2) developmental, (3) proficient, and (4) mastery (Glazer & Hannafin, 2006; Glazer et al., 2005). Novice teachers gradually evolve from the role of peer-teachers into that of the teacher leaders by moving through the four progressive phases of the model (see Figure 8) (Glazer & Hannafin, 2006).

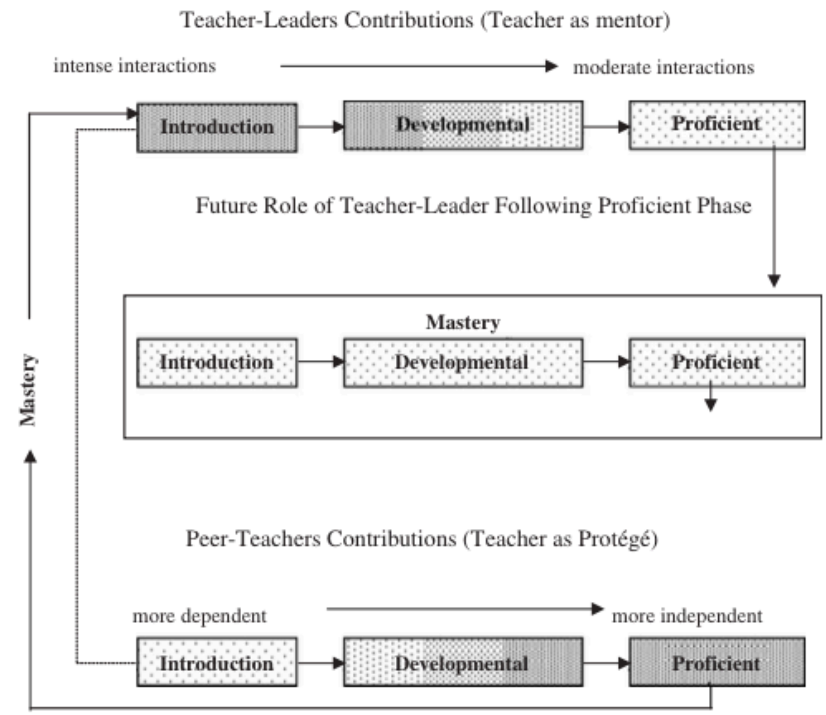


Figure 8. Collaborative Apprenticeship Model (Glazer & Hannafin, 2006).

The introduction phase involves a teacher-leader mentoring peer-teachers as well as establishing shared goals (Glazer et al., 2005). During this phase, the teacher-leader models the implementation of a new instructional method or resource to peer-teachers who then reflect on and discuss skills and strategies needed in their development (Glazer & Hannafin, 2006). During the developmental phase, teacher-leaders and peer-teachers work collaboratively to design, develop, and implement learning activities using new instructional strategies or resources (Glazer et al., 2005). This occurs in planned and informal meetings to establish and support an ongoing and sustained professional development effort (Glazer & Hannafin, 2006). The teacher-leader facilitates a discussion involving the knowledge and skills of the peer-teachers so they collaboratively develop the purpose of the lesson and learning outcomes (Glazer & Hannafin, 2006). Also, the teacher-leader "initially assumes responsibility for managing the design and development process, then scaffolds and coaches the peer-teacher's development and assists the novice in performing a task" (p. 184). During the proficient phase, peer-teachers develop learning activities independently with on-site support from teacher-leaders (Glazer et al., 2005). Peer-teachers independently develop lessons for collective goals as they become more confident in the skills and strategies they have learned and articulated through the collaborative apprenticeship (Glazer & Hannafin, 2006). Finally, during the mastery phase, teacher-leader coaching is reduced to feedback as peer-teachers become increasingly skillful and capable (Glazer et al., 2005). This phase emphasizes the importance of "supporting peer-teachers to become mentors or teacher-leaders in their community of practice" (Glazer & Hannafin, 2006, p. 185).

Glazer and Hannafin (2008) examined the factors that influences teachers' technology integration during Collaborative Apprenticeships designed to provide onsite, ongoing, and peer mentoring to create technology-enhanced materials (Glazer & Hannafin, 2008). Participants were selected from a K-5 elementary school with approximately 1400 students. Participants included two teacher-leaders and nine peer-teachers. The school had an existing peer mentoring program that consisted of experienced teachers who supported new teachers as they became familiar with and adapted to school policies, procedures, and culture (Glazer & Hannafin, 2008). Because the existing mentoring program was consistent with the Collaborative Apprenticeship model's focus in "refining skills and strategies, developing relationships, and supporting individual needs", Glazer and Hannafin (2008) believed the use of the model was ideal (pp. 37 - 38).

A pre-interview was conducted to determine how technology was used in teaching and how participants' learning was supported (Glazer & Hannafin, 2008). Informal interviews were conducted to document and clarify concerns and reflection sessions were convened with teacher-leaders to devise strategies to empower peer-teachers (Glazer & Hannafin, 2008). A post-study interview was conducted to document technology use, critical factors and interactions that supported teachers' growth, and future plans for technology use and mentoring (Glazer & Hannafin, 2008). Observation notes documented interactions during planning meetings and informal encounters. Finally, journal reflections, focusing on likes, dislikes, interactions, and growth, documented teachers' perceptions of their own as well as their peers' growth (Glazer & Hannafin, 2008).

Glazer and Hannafin (2008) found that teachers who were successful in designing technology-enhanced lessons tended to interact differently from their peers (Glazer & Hannafin, 2008). Rapidly developing teachers assumed greater ownership in their learning and interacted more frequently to obtain support and advance their development (Glazer & Hannafin, 2008). Also, when teachers' primary motivation was to improve student learning, successful teachers were more likely to overcome obstacles (Glazer & Hannafin, 2008). Peer mentoring also influenced both the interactions among peers and quality of teacher growth in the community. Generally, "mentors resisted interactions perceived as potentially jeopardizing collegial and interpersonal relationships, even when peers failed to demonstrate growth" (Glazer & Hannafin, 2008, p. 57).

Summary. Situated learning theory supports the notion that learning takes place in authentic settings (Lave & Wenger, 1991). Learning should take place within a context that allows participants to share their experiences with a community of practice. Situated professional development allows teachers to develop tools that help strengthen their teaching practices, including applying new practices in their classrooms. Incorporating aspects of situated learning theory, instructional coaching, cooperative and collaborative inquiry, and collaborative apprenticeships occur within the context of teachers' work setting and allow for reflection of their practices within a community of practice. Allowing teachers to engage in authentic learning within the settings that they are expected to apply the skills that were gained increases the likelihood of teachers improving their professional practices (Rebora, 2016; Mangin & Dunsmore, 2014; Kopcha, 2012; Hughes & Ooms, 2004).

Historical Context of African American Students in the U.S. Education System

According to Gardner and Mayes (2013), the "acquisition of knowledge has traditionally been the vehicle that has allowed individuals from disadvantaged backgrounds to achieve success" (p. 22). However, African American students have historically been deprived of many educational opportunities. This section of the literature review includes a discussion of the critical moments in education relevant to African American in the United States. Additionally, Critical Race Theory is discussed in relation to the educational opportunities provided to African American students.

Historical context. The landmark case of *Brown v. Board of Education* (1954), in Topeka, Kansas, known as *Brown I*, was a pivotal moment in educational history for African Americans because it reversed the "separate but equal" Supreme Court ruling of *Plessy v. Ferguson* (1896). The decision set the stage for recognizing the inherent inequality in education for African American students (Obiakor, 2014). Although the case produced many positive changes and was instrumental in integrating numerous school systems within the United States, the Court's decision yielded some negative effects as well (Lash & Ratcliff, 2014). The *Brown I* decision provided no direction on how the process of integration was to occur, nor did it address what would happen to African American schools, teachers, and administrators once it was implemented (Lash and Ratcliff, 2014). The well-intended changes that accompanied the *Brown* decision had far reaching results, including negative effects on African American communities and the schools themselves (Lash and Ratcliff, 2014).

Although the U.S. Supreme Court had outlawed segregation, states were slow in following through with this decision, which led to Brown v. Board of Education II (1955). In this court ruling, known as *Brown II,* the Court ruled that states must implement its ruling in *Brown I* and desegregate public elementary and secondary schools with "all deliberate speed." However, segregation continued to be the customary standard in most cases which extended into other segments of life, both implicitly and explicitly. Ten years after the *Brown* decision, in 1964 only 1.2% of the Black students in 11 Southern states attended desegregated public schools (Brown & Hunter, 2009).

Equity based reforms continued with the Civil Rights Act (1964). The law was designed to protect the rights of citizens by prohibiting discrimination on the basis of race, color or national origin and to ensure that no discriminatory practices occur in programs or activities that receive financial aid from the federal government. Additionally, the passage of the Elementary and Secondary Education Act (ESEA) (1965) reaffirmed the Brown decision of every child has the right to an equal education. The Title I section of ESEA proposed by President John Kennedy and enacted during President Lyndon Johnson's administration provided funds to schools for disadvantaged students. ESEA was the central legislation in pre-collegiate education with the focus of establishing primary and secondary education as part of President Johnson's War on Poverty (Jennings, 2012). ESEA's Title I section increased the role of federal involvement in the education of students and granted equal access for education, high educational standards, and accountability for all students including African American students and those from poverty (Groen, 2012).

The reauthorization of ESEA entitled, No Child Left Behind (NCLB) (2001), changed the landscape of federal involvement in K-12 education. The major focus of NCLB was to close student achievement gaps by providing all children with a fair, equal, and significant opportunity to obtain a high-quality education (Rebora, 2011). NCLB increased testing intensity and creation of state standards although most states had already established curriculum standards and assessments. By 2014, all students were to be proficient in reading and math. Teachers had to be highly qualified in their teaching area and results published in state school report cards (Rebora, 2011). Schools had consequences of school choice and takeover penalties if they did not show yearly progress. States had greater flexibility in federal funding disbursement with a larger portion targeted to support poorer school divisions (Groen, 2012). NCLB was the federal government's attempt to deliver access and opportunity to students who had historically failed to achieve in the American education system (Ravitch, 2010, p. 97). Students who were minorities, had special needs, were low socioeconomic status, or students who were English language learners (ELL) became a greater focus for educators around the United States because of the accountability measures imposed by NCLB. Schools increased their focus on student achievement and addressed the decoupling problem by attempting to provide academic equity and achievement to the student groups that had failed to attain outcomes at the same rate as their white peers through monitoring and sanctions (Ramanathan, 2008). However, the emphasis on test scores, inadequate funding, and unreachable academic progress goals ultimately led to increased inequities and more than 50% of schools being classified as failing by 2011 (Rebora, 2011).

Another attempt by the federal government to bring equity to students historically disenfranchised, President Obama signed the latest reauthorization of ESEA into law in December of 2015 entitled Every Student Succeeds Act (ESSA) (U. S. Department of Education [USDE], 2015). The goal of the act was to ensure opportunity for all students by holding them to high academic standards, guarantees steps to help students and schools improve, and prepare all students for college and career success (USDE, 2015). Provisions also include access to high quality preschool experiences for more students, reduction in the burden of testing while maintaining accountability measures for parents and students, and promotion in local innovation with investment into what works (U. S. Department of Education [USDE], 2015). The focus of ESSA was an attempt to advance equity by providing protections for students who are high need or disadvantaged by setting an expectation that there will be accountability and action in lowest performing or "vulnerable" schools (USDE, 2015).

Critical race theory. When considering the low performance and underrepresentation of African Americans in mathematics, a Critical Race Theory perspective best captures the difficulties involved (Delgado & Stefancic, 2017). Critical Race Theory (CRT) began in the early 1970s by legal scholar who believed that the 1960's civil rights era had begun to lose its foothold, and in most areas, seemed to be headed back to a time when African Americans had no rights (Delgado & Stefancic, 2017). CRT provides scholars and activist tools to change and transform society for the better (Delgado & Stefancic, 2017). According to Delgado and Stefancic (2017), the basic tenets of CRT are (1) racism is ordinary, (2) racism serves the self-interest of elite and working class White people, who reap more benefits from it than any other ethnic groups, (3) race and racism are products of social thought and relations and is independent of personality, intelligence, or moral behavior, and (4) CRT provides people of color with a voice to communicate their experiences regarding race and racism that may not be cognizant to White people.

Racism is still very active in our society and in the educational system (Delgado & Stefancic, 2017; Esposito, 2011; Kumasi, 2011; Wallace & Brand, 2011). When utilized as a lens in education, CRT examines how “color blind” institutional policies and practices continually perpetuate inequality along ethnic and racial lines while exacerbating White privilege (Ladson-Billings & Tate, 1995; Solórzano, 1997; Yosso, 2005). The inequities and inequalities that persist in education may stem from past racial beliefs regarding who has the right to be educated in our nation (Garrison, 2013; Kumasi, 2011; Martin, 2009). Through the use of CRT, African American students’ ability, intellect, and positionality in mathematics are questioned, challenged, and changed (Farinde & Lewis, 2012; Pringle et al., 2012; West-Olatunji et al., 2010). For some African American students, a school may be the first step in identifying and forming future decisions regarding college majors and careers. CRT is a way of determining whether influences of educators’ teaching practices, perceptions, and beliefs affect African American students’ academic success and decisions about their futures.

In Ladson-Billings (1999) work on CRT and its place in education, she explains how capturing the voice of members of those marginalized by race has been a historical goal of CRT in an attempt to alleviate the social burdens imposed by racial hegemony. Ladson-Billings (1999) expands on the work of key pioneering CRT theorists and researchers by demonstrating how extracting the lived voice of people of color is necessary to highlight the deeply pervasive nature of racial marginalization across a wide array of social structures, including educational institutions. CRT has evolved into a tool which challenges the growing momentum of "colorblind" merit-based systems in higher education and demonstrates the inequitable distribution of resources, power, and privilege permeating across a vast array of social institutions, which often exacerbate deeply pervasive disparities faced by racial minorities (Delgado & Stefancic, 2017; Ladson-Billings & Tate, 2006). The application of critical race theory to education means that critiques of education can no longer be "race neutral" or "colorblind" (Ladson-Billings & Tate, 1995). CRT recognizes that African-American students, regardless of their economic standing and/or gender, suffer the harmful effects of a racist society. According to Ladson-Billings (1999), CRT has the potential to shape great minds and the capacity to build leaders and scholars. This shaping of great minds can easily be railroaded if curriculum, instruction, assessment, and desegregation are not monitored through CRT.

Within the curriculum, the voices of African American students and their accomplishments are often distorted. In other cases, through for-profit publishers, their voices are silenced and not part of the conversation. The curriculum that is presented is one that promotes a societal agenda rooted in racism, hegemony, and falsehoods (Ladson-Billings, 1999). Curriculum in K-12 schools promote the use of remediation and tracking (Ladson-Billings, 1999; Oaks, 1992). CRT questions the nature of remediation and tracking that take place at high levels among many African American leaners in urban schools. This remedial thinking causes teachers to search for the right strategy or technique to engage students. When the strategy or technique fails to produce the desired academic results, the students are blamed and not the methodology (Ladson-Billings, 1999; Oaks, 1992).

Curriculum and instruction should be presented using practices that do not view African American students as having deficits (Ladson-Billings, 1999; Oaks, 1992). This deficit thinking surfaces early in education. It manifests itself when primary-grade students are placed in specific reading groups. These reading groups assign students labels and special colors to identify their aptitude. In middle and high school, it surfaces when African American students are scheduled in basic math and science classes, which set the course for them to be not as competitive as their White peers when pursuing postsecondary options (Ladson-Billings, 1999; Oaks, 1992).

According to Ladson-Billings (1999), when assessments are related to intelligence and students fail miserably, this is merely another way to deem African American students as inferior and further supports overreaching stereotypes. These assessments act as gatekeepers for African American students. Gatekeeping strategies keep African American students from qualifying to enroll in certain universities after they graduate from high school (Ladson-Billings, 1999). If students do not enroll in certain high school mathematics and English classes and pass those classes with grades of C or better, they forfeit chances of even qualifying for entry into certain universities.

The final concept that contributes to a negative spiraling for African American learners is the role of desegregation. Desegregation mostly surfaces in school districts that have majority student populations of Black and/or Latino students (Ladson-Billings, 1999). As non-minorities flee to more affluent neighborhoods, they enroll their students in schools that are not underperforming. This fleeing only supports a model of segregation in our schools and seriously jeopardizes the basic ideals set forth in *Brown v. Board of Education* *of Topeka, Kansas (1954)*.

Culturally relevant pedagogy. Although this is not the emphasis of my study, teachers may choose to implement culturally responsive and relevant pedagogy in addition or in conjunction with technology to enhance the mathematics learning experiences of African American students. Culturally responsive pedagogy uses the cultural knowledge that children bring into the classroom as a strength (Gay, 2000). This pedagogy takes into account the cultural knowledge and prior experiences of children of color and uses these experiences to further engage students in learning. Culturally responsive teachers develop intellectual, social, emotional, and political learning by using culture to impact positive student outcomes (Ladson-Billings, 1994). The understanding of culture and its relationship to positive academic outputs is essential. In order for teachers to be successful with African American students, they need to recognize the role that race and racism play within our society (Foster, 1990). African Americans have been systematically categorized from the perspective of underachievement and this belief permeates schools (Ladson-Billings, 1994). In many cases, teachers place little value on the prior knowledge that African American students bring to their school environments (Gay, 2000; Foster, 1990; Ladson-Billings, 1994). Ladson-Billings (1994) asserts strongly that instead of capitalizing on these strengths, teachers work to eradicate these links that are intertwined with cultural ways of being.

The frame of culturally relevant pedagogy is one in which the discontinuities that often exist between the school and the home environment are diminished to the point that the two components act in ways that validate the other (Gay, 2000). This frame allows educators to draw positively on the culture and language that students bring into the classrooms. Other researchers view culturally relevant pedagogy as frames of reference that teachers use in meeting the academic and social needs of culturally and linguistically diverse students (Howard, 2001; Gay, 2000; Ladson-Billings, 1994).

Gay (2000) states that this type of pedagogy is also about creating a multidimensional approach in which a strong connection is made between the relationship of the teacher and the student. Within this multidimensional approach, the teacher views the classroom climate, instructional strategies, assessments, and curriculum within the frame of the students' cultural awareness and responsiveness. This contributes to a pedagogy that is transformational (Gay, 2000). Within this transformation, individuals grow to not only appreciate and validate their own culture, but also empathize with the cultures of others (Gay, 2000).

The central component of culturally relevant pedagogy is that it rejects deficit thinking about why children of color do not succeed academically (Howard, 2003; Ladson-Billings, 1994). Ladson-Billings (1994) states that a primary component of this pedagogy is the belief that students from less than desirable socioeconomic conditions and those that are diverse, can learn in spite of their circumstances. Moreover, even with horrendous circumstances, when students are treated with respect and are validated, they can learn at high levels, and they attain mastery. This type of teaching and engagement is possible when teachers are willing to dialogue in honest ways about how their own culture shapes the learning environment. However, this calls for critical reflection about how race, class, and culture shape our daily lives (Ladson-Billings, 1994).

Summary. The theme of the history of education of African Americans in the U.S. appears to be the elusive quest for social justice. The evolution of laws and racial politics has resulted in schools which are still segregated and enshrined a prescriptive curriculum which does not meet the needs of African American students resulting in reduced academic achievement (Lhamon, 2014). This state of affairs lends credibility to Critical Race Theory. These policies can foster unproductive beliefs within educators tasked with educating African American and low-income students. Changing those beliefs is difficult. However, "Change hinges on our ability to confront potentially negative and/or outdated normative beliefs that determine who is worthy of an education, which students are deemed able, and who is pushed and who is left behind" (Ullucci & Battery, 2011, p. 1196). If education is truly about leveling the playing field, race and racism must be tackled head-on in connection with how we educate students, especially African American male students who are often performing in the lowest quartiles on most standardized measures. This study provided participants with an opportunity to discuss and reflect on their beliefs related to the teaching and learning of mathematics with African American students. Additionally, this study provided participants with the opportunity to strengthen teaching practices that are in alignment with current mathematics reform efforts.

Summary of Literature Review

The question of why some mathematics teachers believe technology should be an integral component of educational practices and integrate it, while others do not, inspired this study. The purpose of this chapter was to explain the theoretical foundation and empirical studies upon which this study was based. Mathematics education has been the topic of much debate for many decades. It seems controversy is derived from the dissatisfaction about what mathematics is being taught, the way it is being taught and assessed as well as the support teachers receive while trying to accomplish ever-changing goals and expectations. In reaction to the dissatisfaction in mathematics education a movement toward reform emerged. This led to the development of committees and publishing of documents highlighting important mathematical pedagogy, curriculum, and assessment practices. Alongside publications and government legislation such as A Nation at Risk, Goals 2000, and NCLB, the National Council of Teachers of Mathematics (NCTM) (1980, 1989, 1991, 1995, 2000, 2014) created documents supporting the vision of reform in the teaching, curriculum, and assessment practices of teaching mathematics. Each of these publications focused in improving the teaching and learning of all students and addressing gaps in achievement with respect to race and socioeconomic status.

Further efforts to improve the teaching and learning of mathematics for each and every student focused on effectively implementing technology throughout instruction. Literature supported the proposition that there is a relationship among teacher attitudes towards technology, knowledge of effective use of technology, pedagogical beliefs, and technology integration in the teaching practices. Developing TPACK and more specifically Mathematics TPACK has proven to improve teachers effective use of technology and have a positive impact on students' mathematics achievement (Mishra & Koehler, 2006; Harris & Hoffer, 2011; Guerrero, 2010; AMTE, 2009; Sun, 2012). When barriers to technology implementation exist such as limited TPACK, negative attitudes and beliefs regarding teaching with and student use of technology during instruction, limited knowledge of the benefits of using technology, and lack of professional development designed to increase technology implementation, teachers' use of technology within their teaching practices is lower than when those barriers do not exist.

When teachers feel the motivation to transition to reform-oriented teaching, they need the support of their professional learning community, principal, and others (Lave & Wenger, 1991). Although cultural beliefs of parents and educators may hinder the implementation of these practices (Philipp, 2007), new images of mathematics learning can be developed through reflection, collaborations, and observation. For decades, the process of teacher change and professional growth has been a topic of discussion. Early models described teacher change as a linear relationship (Guskey, 1985). Guskey's (1985) linear model of teacher change heavily relied on teachers observing a change in student outcomes as a precursor to a change occurring in the teachers' beliefs. Guskey's model neglect to include the important relationship between individual and collective accountability and teacher change. For this reason, Clarke and Hollingsworth (2002) posited that linear models of teacher change oversimplified the process of teacher growth and failed to capture the dynamic and interactive aspects of the teacher change process. Clarke and Hollingsworth's (2002) Interconnected Model of Professional Growth described a cyclic change environment that allows teacher change to occur. Within this environment, teachers reflect individually and with colleagues on their beliefs, teaching practices, support, and student outcomes. The Interconnected Model of Professional Growth highlights individual reflection and collaboration as a key component necessary for teacher change and professional growth (Clarke & Hollingsworth, 2002; Goldsmith, Doerr, & Lewis, 2014).

Secondary mathematics teachers in schools with a high African American, low income student population often find it extremely challenging to integrate best teaching practices, including the use of technology during instruction. These teachers are often faced with both internal and external barriers that greatly impact their instructional decisions (Ertmer, 2012, Blanchard et. al., 2016; Darling-Hammond, 2014; Wachira & Keengwe, 2011). Too often they have low expectations regarding their students' mathematical abilities. Additionally, many are burdened with low self-efficacy regarding their perceived ability to teach African American or low-income students. In many instances, African American students fall into both categories. Additionally, teachers in this situation have to deal with inferior or malfunctioning hardware, inadequate infrastructure, and lack of professional development and support. The combination of these issues makes integrating technology into their mathematics instruction very difficult despite the documented benefits technology can provide to African American and low-income students. When teachers are motivated to reconsider their beliefs about the teaching and learning of mathematics, they need learning opportunities that align with shared goals, opportunities for active learning of new teaching strategies, provide opportunities for collaboration among teachers, and adequate time for reflection. Most importantly, the primary focus of meaningful professional development should be to help teachers teach their students using reform-oriented strategies (Rebora, 2016; NCTM, 2014). Therefore, I developed this study utilizing situated learning theory to assist secondary mathematics teachers in schools with a high African American and low income, student population with integrating technology into their instructional practices. By the end of the study, I determined if this type of professional development and support had an impact on participants' beliefs regarding the teaching and learning of mathematics using technology and decision to integrate technology into their instructional practices. The next section describes the research methodology for the study.

Chapter 3: Methodology

The purpose of research is "to contribute knowledge that improves our collective understanding of education" (Gall, Gall, & Borg, 2007, p. 35). The researcher is involved in a continuous process of collecting data and analyzing data over time to develop a coherent story (Corbin & Strauss, 2008). In order to develop these results, the researcher begins with a single focus, employs thorough data collection procedures, and typically writes so the reader feels a connection to the study (Creswell, 2007). The insight gained from analysis is instrumental in answering research questions guided by the literature review within his/her study. This study explored the relationship among the beliefs and technology implementation of secondary mathematics teachers at a school with a high African American, low-income student population and examined the impact of situated professional development that focused on incorporating technology within the teachers' practices. This chapter describes the methodology for this study, including researcher biases, research design, setting, instrumentation, participant selection, data collection and analysis, and methods for ensuring validity and reliability.

Theoretical Framework

Two theoretical perspectives helped guide the decisions of the researcher and provided a lens through which the process of teacher change in beliefs and practices were observed. The theoretical perspectives are situated learning theory (Lave & Wenger, 1991) and Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006). Situated learning theory was selected because it helps capture the context in which the professional development takes place and the affordances brought about by authentic experiences. Technological Pedagogical Content Knowledge (TPACK) was chosen because it provides a theoretical framework for understanding teacher knowledge required for effective technology integration (Mishra & Koehler, 2006).

Situated learning theorists support the notion that learning takes place in authentic contexts in which shared experiences can be then transferred to new situations (Lave & Wenger, 1991). Knowledge is viewed as arising conceptually through dynamic construction and reinterpretation within a social context (Clancey, 2009). In other words, learning needs to take place within authentic contexts, settings, and situations (Lave & Wenger, 1991). Through such an experience, situated learning theorists suggest that teachers can develop tools that shape students' identity and beliefs in such a way that members are able to transfer forms of participation to new settings (Lave & Wenger, 1991), such as applying new practices in their classrooms. The key components of situated learning theory influenced the development of the situated professional development component of this study. Professional development activities occurred within the context of each participants teaching environment. Each participant participated in a departmental work shop that focused on integrating mathematical action technology within their teaching practices. Participants were also provided with opportunities to participate in a community of practice. Participants collaborated with the researcher during individual planning sessions and collaborated with colleagues during their planning sessions and departmental meetings. By participating in a community of practice and reflecting on their actions, as well as their colleagues, participants were able to improve their teaching practices.

The TPACK framework builds on Shulman's (1986) construct of Pedagogical Content Knowledge (PCK) to include technology knowledge as situated within content and pedagogical knowledge. TPACK is a framework that introduces the relationships and the complexities between all three basic components of knowledge (technology, pedagogy, and content) (Koehler & Mishra, 2008; Mishra & Koehler, 2006). The framework focuses on designing and evaluating teacher knowledge that is concentrated on effective student learning in various content areas (AACTE Committee on Innovation and Technology, 2008). Thus, TPACK is a useful frame for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge. More specifically, the Mathematics TPACK Framework developed by AMTE (2009) provides an outline for effective technology implementation within a mathematics classroom. This framework addresses designing and developing technology-enhanced mathematics learning, facilitating mathematics instruction with technology as an integrated tool, accessing and evaluating technology-enriched mathematics teaching and learning, and engaging in ongoing professional development to enhance technological pedagogical content knowledge (AMTE, 2009).

Research Design

This study utilized qualitative research methodology. Merriam (2009) stated, "Qualitative research is not conducted so that the laws of human behavior can be isolated. Rather, it is performed to explain the world from those who experience it" (p. 238). Qualitative research seeks to understand the world from the perspectives of those living it (Hatch, 2002). Data is collected from those immersed in everyday life of the setting in which the study is framed. This study was designed in hopes to contribute additional knowledge and improved practice in the field. This study explored the impact of situated professional development for integrating technology in mathematics instruction on pedagogical beliefs and teaching practices of secondary mathematics teachers in a school with a high African American, low-income student population

My justification for selecting a qualitative research design over a quantitative approach for the study was grounded in the work of Creswell (2012), Hurt and McLaughlin (2012), and Yin (2008). According to Creswell (2012), qualitative design allows the researcher to investigate the phenomenon of the study with greater depth. Hurt and McLaughlin (2012) stated that qualitative research is more open-ended and flexible than quantitative research. Moreover, Yin (2008) submitted that case study methodology is best to determine perceptions and beliefs. Creswell (2012) described a case study as "an in-depth exploration of a bounded system based on extensive data collection" (p. 485). The case may be a single individual, several individuals separately or in a group, program, event, or activity (Creswell, 2012). The case study approach investigates detailed, thorough data collection from numerous sources of data that usually includes interviews, observations, documents, and transcribed information (Creswell, 2012; Burg & Lune, 2012). Case study methods with well-established protocols in a bounded system contain the opinions, perceptions and beliefs of the individuals in the bounded system (Hatch, 2002). To effectively discover, remain open-ended, and explore bounded perceptions, I selected case study methodology because it provided the proper method of collection of data to answer my research questions. This study is a collective case study. A collective case study involves one issue and includes multiple cases which are described and compared to provide insight to an issue (Creswell, 2012). This study focused on the impact of situated professional development for integrating technology in mathematics instruction on the pedagogical beliefs and teaching practices of secondary mathematics teachers in a school with a high African American, low-income student population. For this study, the unit of analysis was the individual teachers. The artifacts that were used for analysis were interviews, observation debriefing notes, and lesson plans.

Setting

The study was conducted during the 2017 – 2018 school year at Target High School (THS) and Paige Junior High School (PJHS), located in a rural community in the southern United States. PJHS is the feeder school for THS. Both THS and PJHS were chosen because each school has a high African American and low-income student population, both were within a reasonable driving distance to conduct my research, and I had a prior working relationship with the system's administration and faculty.

THS is the only high school in the school system. THS is a public high school that serves grades nine through twelve. According to the State Department of Education Enrollment Report for the 2017 – 2018 school year, THS has 511 students enrolled (XSDE, 2017a). The student population is currently 72% African American and 76.2% of students receive free or reduced lunch (XSDE, 2017b). 2014 -2015 ACT Plan results indicated that 100% (64.37% Level I and 35.63% Level II) of the African American students and 97.8% (58.24% Level I and 39.56% Level II) of students receiving free or reduced lunch did not meet or exceed academic content standards (Levels III and IV) on the mathematics portion of the assessment (XSDE, 2017c).

THS also houses a Career Tech Center which focuses on computer technology, carpentry, cosmetology, plant systems, and agriscience and construction programs. THS has 66 staff members including 20 core subject area teachers. Each core area has a departmental common in which all teachers assigned to that department are located.

Within the mathematics department commons are 6 classrooms and six teacher offices. At the time of the study, the mathematics department consisted of 3 African American male teachers and 1 white female teacher.

Similarly, PJHS is the only junior high school in the system. PJHS serves students in grades 7 and 8. According to the Enrollment Report for the 2017 – 2018 school year, published by the state in which THS and PJS are located, PJHS had 274 students enrolled (XLSDE, 2017). The student population is currently 69% African American and 93.11% of students receive free or reduced lunch (XLSE, 2017). ACT Aspire eighth grade Math 2014-2015 results indicated that 85.26% (61.05% Level I and 24.21% Level II) of the African American students and 84.21% (59.65% Level I and 24.56% Level II) of students in poverty did not meet or exceed academic content standards (Levels III and IV) (XSDE, 2017). Additionally, Aspire seventh grade Math 2014 -2015 ACT results indicated that 86.41% (45.63% Level I and 40.78% Level II) of the African American students and 86.51% (42.86% Level I and 43.65% Level II) of students in poverty did not meet or exceed academic content standards (Levels III and IV) (XSDE, 2017). At the time of the study, the mathematics department consisted of 1 African American female and 1 white female teacher.

Procedure

This section outlines the procedures used to conduct this study. It includes a discussion of the method used to select participants and data collection activities.

Participant selection and sampling method. After receiving approval of this proposal and obtaining IRB approval, I met with the principals of THS and PJHS to obtain permission to conduct my research study at this site. After obtaining written permission to conduct my study at THS, I met with the instructional technology specialist and principal to determine available technology resources and infrastructure capabilities. Packets containing recruitment letters and consent forms were mailed or hand delivered to the principal of THS. The principal distributed recruitment letters and consent forms to participants that met the requirements for participation. To be eligible to participate in this study, participants had to be current mathematics teachers at the THS. Participants who choose to participate signed and returned the consent form to the principal. The principal returned the consent form in a provided pre-addressed envelope. Each consenting participant was contacted by email or phone to schedule the initial interview. Participants' email addresses and phone numbers were obtained from the consent form. Participants were allowed to opt out of participation at any time without consequence.

All consenting participants participated in the individual initial teacher interview. Following the initial teacher interview, all consenting participants that wished to participate in the departmental workshop were allowed to participate. At the conclusion of the workshop, all participants were given an opportunity to participate in the remaining study activities. Six participants were selected in order to complete a cross case analysis. If there would have been more than 6 participants willing to participate in the remaining portion of the study, 6 participants would have been chosen using the following criteria and order:

1. Willingness to integrate technology -based mathematics lessons into their instructional practices, but were unsure of its benefits in the teaching and learning of mathematics (expressed during initial interview or workshop)
2. Willingness to integrate technology- based mathematics lessons into their

instructional practices, believed that they are beneficial, but have very little to no experience incorporating technology into their mathematics teaching practices (expressed during initial interview or workshop)

3. Willingness to integrate technology-based mathematics lessons into their instructional practices, believed they are beneficial, and integrate technology more than 4 times per semester but less than once a week.
4. Integrate technology-based mathematics lessons into their teaching practices at least once per week.

I believed that choosing participants first that fell into categories 1 and 2 would allow me to see the greatest change in beliefs if participants found the professional development beneficial.

Data collection. The study took place during the 2017- 2018 school year. Situated professional development activities included a departmental workshop and multiple planning sessions. Data collection activities included initial teacher interviews, lesson observations, document collection, and final teacher interviews. Additionally, data was obtained from notes and participant responses captured during departmental workshops and planning sessions. A description of the situated professional development activities and data collection activities is provided below.

Initial teacher interview protocol. Interviews were conducted in person at THS and PJHS during the 2017-2018 school year and prior to the departmental workshop. Interviews provide researchers with rich and detailed qualitative data for understanding participants' experiences, how they describe those experiences, and the meaning they make form those experiences (Rubin & Rubin, 2012). To develop this survey, I began by reading literature pertaining to instructional technology, teacher pedagogical knowledge, and current trends in mathematics technology. To create the Initial Teacher Interview, I modified the questions on a survey I created and developed questions based on productive and unproductive beliefs about technology, access and equity as discussed in *Principles to Actions* (NCTM, 2014). This allowed me to gain insight into the teachers' beliefs regarding use of technology during instruction and the teaching and learning of mathematics. Teachers' beliefs about the teaching and learning of mathematics directly influence their instructional practices (Ertmer & Ottenbriet-Leftwhich, 2010; Ertmer et al., 2012; Norton et al., 2000; Kim et al., 2013; NCTM, 2014). Also, because the participants' students were primarily African American and low-income, these questions had the potential to reveal if the teachers had any underlying biases related to the abilities of their students related to their ethnicity and socioeconomic background. Often teachers of African American and low-income students do not provide them with opportunities to use technology to explore mathematics topics or advanced mathematical topics (Flores, 2007; Strutchens and Silver, 2000).

Following Castillo-Montoya's Interview Protocol Refinement (IPR) framework, the Initial Teacher Interview Protocol was further developed. The IPR framework is most suitable for refining structured and semi-structured interviews (Castillo-Montoya, 2016). The four phases of the IPR include: (1) ensuring the interview questions align with the study's research questions, (2) organizing interview protocol to create inquiry-based conversation, (3) having the protocol reviewed by others, (4) piloting the interview protocol.

Phase 1 of the IPR, ensuring interview questions align with research questions, requires researchers to be intentional in their questions. Questions must be designed to allow participants to explain their experiences with sufficient follow-up questions if needed (Castillo-Montoya, 2016). To check the alignment of questions, Castillo-Montoya (2016) suggests creating a matrix for mapping interview questions to research questions. This will help disclose whether any gaps exist in what is being asked and adjustments can be made (Castillo-Montoya, 2016). Following these guidelines, I created the Initial Interview Protocol Matrix (see Appendix B).

Following the social rules that apply to ordinary conversation is also a component of phase 2 of the IPR. Questions should be asked one at a time without interrupting the interviewee. Questions should flow in a logical manner with appropriate transitions between questions (Castillo-Montoya, 2016). I revised the Initial Teacher Interview Protocol to include a script, transitions between major sections, and a closing. This made the interview script more conversational.

Phase 3 of the IPR is to receive feedback on the interview protocol to enhance its reliability or its trustworthiness as a research instrument (Castillo-Montoya, 2016). Feedback can provide the researcher with information on how well participants understand the interview questions and whether their understanding is close to what the researcher intends or expects to find. Castillo-Montoya (2016) suggests conducting a close reading of the interview to receive feedback from colleagues. A close read of my interview protocol was held during my committee meetings. Any suggested modifications were made to the protocol.

Phase 4 of the IPR is to pilot the interview protocol with participants who mirror the characteristics of the sample to be interviewed for the actual study (Castillo-Montoya, 2016; Maxwell, 2013). Through piloting, the researcher aims to get a realistic sense of how long the interview takes and whether participants indeed are able to answer questions (Castillo-Montoya, 2016). To pilot this protocol, I selected four teachers from two schools with similar demographics to the study sites and conducted the interview. During this pilot, I took notes on what might be improved, made final revisions to the interview protocol, and resubmitted the revised protocol to my dissertation committee as suggested by Castillo-Montoya (2016) and Maxwell (2013).

Departmental workshop. The departmental workshop occurred after the initial interview. The workshop was scheduled during a time that was convenient for all consenting participants and took place at THS. The primary focus of this seven-hour workshop was to discuss beliefs and practices related to technology use during instruction and to allow participants to explore and discuss four mathematical action technology tools:

(1) Shodor Interactivate Website is a non-profit organization that serves students and educators by providing them with interactive materials and instructional resources available via a web browser (Shodor, 2017).

(2) Texas Instrument TI-84 Plus and TI-73 Explorer graphing calculators are learning tools designed to help students visualize concepts and make connections in math and science (Texas Instrument, 2017a). The TI-84 Plus and TI-73 Explorer graphing calculators are programmable calculators that allow users to graph and compare functions, solving equations, and perform data plotting and analysis.

(3) Desmos graphing calculator is a free HTML5 graphing calculator available via a web browser or mobile application. Desmos allows users to graph equations as well as inequalities. Additionally, Desmos features lists, plots, regressions, interactive variables, graph restrictions, simultaneous graphing, piecewise function graphing, and polar function graphing in addition to features commonly found in popular programmable calculators (Desmos, 2017).

(4) GeoGebra is an open-source, dynamic mathematics software that combines geometry, algebra, spreadsheets, statistics, and calculus in a user-friendly interface (GeoGebra, 2017).

(5) CBR 2 motion detector is a motion sensor that allows users to collect data and analyze real-world motion data (Texas Instrument, 2017b).

These tools were chosen because they are easily accessible to the mathematics faculty at THS and PJHS, and they can be used to facilitate student learning. Additionally, these tools allowed teachers to engage in mathematics tasks that utilize mathematics action technology to explore mathematics concepts.

Departmental workshops were held separately at THS and PJHS due to scheduling issues. The four mathematics activities participants from THS completed included: (1) Interactive Slope Activity (Martin, 2015a), (2) Statistics Activity – TI 84 (Martin, 2014); (3) Tremendous Triangles (Martin 2015b); and (4) Linear and Quadratic Function Activity – Desmos (Martin & Ellis, 2014). The four mathematics activities participants from PJHS completed included: (1) Interactive Slope Activity (Martin, 2015a), (2) Statistics Activity – TI 84 (Martin, 2014); (3) Introductory CBR Activity Sheet 1 (Herman & Laumakis, 2008); and (4) Linear and Quadratic Function Activity – Desmos (Martin & Ellis, 2014) (see

Appendix F). Each activity was chosen because it allows students to gain a better understanding of the mathematics content Dick and Hollebrands, 2011). Additionally, participants from PJHS had access to CBR 2 motion detectors. Therefore, an activity was included for PJHS participants to learn how to use the CBR2 motion detectors to teach mathematics content.

Throughout the workshop, participants had the opportunity to participate in partner and whole-group discussions. Participants also demonstrated how and what they learned from each of the tools presented. The workshop was audio and video recorded so that conversations and could be transcribed and coded for analysis. Additionally, participants answered the following reflection questions in Nearpod: (1) "How will you use the information you learned today to enhance your instructional practices? If you will not use any of the information learned today, please tell why", (2) "What part of the workshop was the most beneficial to you? Explain.", and (3) "What part of the workshop was the least beneficial to you? Explain." Nearpod is a collaborative presentation tool designed to allow teachers to easily engage and assess their students using computers or mobile devices (Nearpod.com, 2017). An outline of the workshop and accompanying activities is included in Appendix G.

Co-planned and individually planned lessons. Following the workshop, participants scheduled their individual planning sessions if they wished to continue as participants in the study. All consented participants co-planned one technology driven lesson using the THS lesson plan protocol with the researcher. Following the co-planning and implementation of the technology lesson, each participant co-planned a technology-based lesson with another participant in the study and planned an additional technology-based lesson alone.

Observations. Observations in a case study allow for first hand views of phenomena being examined and can be used to validate information from other sources (Creswell, 2012; Burg & Lune, 2012). Each participant was observed a minimum of four times. The first observation was a lesson that the teachers had planned prior to the co-planning sessions. The participant chose this lesson. The remaining observations were of the co-planned and individually planned lessons. Each of these observations were followed by a lesson debrief during their planning period using the Observation debrief Protocol (see Appendix E).

Document collection. Participants' lesson plans from the 2016 -2017 school year, when available, were collected. The purpose was to determine the number of technology-based lessons the participants implemented during the prior school year. Additionally, the types of technology utilized were obtained. Participants' lesson plans for the Fall semester of 2017 were also collected and analyzed in the same manner. The purpose was to determine if participants were planning and implementing technology-based lessons in addition to the lessons that were observed.

Final individual teacher interview. After completion of all observation debriefs, each participant participated in a final interview (see Appendix C). The purpose of the final teacher interview was to gain an understanding of participants' perceptions of the benefits of participating in the study, perceived changes in participants' beliefs related to their students and the use of technology during mathematics instruction, desires to continue integrating technology into their instructional practices, and plans to participate in future professional development opportunities that focused integrating mathematical action technology within mathematics instruction. To develop the finial interview protocol, I followed the first three phases of Castillo-Montoya's (2016) Interview Protocol Refinement (IPR) framework. Each of the phases was described in the Initial Teacher Interview Protocol section on page 97. To ensure the interview questions aligned with the research questions, a matrix for mapping interview questions was created (see Appendix D). Including a script, transitional phrases between major sections, and a closing allowed the interview protocol to be more conversational (Castillo-Montoya, 2016). Finally, revisions were made to the protocol based on feedback received from my committee chair.

Data Analysis

In qualitative inquiry, a code "is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, or evocative attribute for a portion of language-based or visual data" (Saldana, 2016, p. 4). The act of coding is cyclical (Saldana, 2016). Rarely is the first cycle of coding perfectly attempted. Subsequent cycles of coding further manage, filter, highlight, and focus the salient features of the data for generating categories, themes, and concepts. There are many techniques that can be used to code qualitative data. Selecting the appropriate coding method or methods depend on the nature and goals of the study (Saldana, 2016). First cycle coding methods include attribute coding, structural coding, descriptive coding, and In Vivo coding. Saldana (2009,2016) suggests using descriptive coding for field notes, documents, interview transcripts, and artifacts as a detailed inventory of their contents. Additionally, Saldana (2009, 2016) suggests using In Vivo coding for interview transcripts as a method of attuning to participant language, perspectives, and world views. Data collection in my study included interviews, documents, and observations. Therefore, these two methods are discussed.

For this study, I utilized descriptive and In Vivo coding methods. Descriptive coding summarizes in a word or short phrase the basic passage of qualitative data (Saldana, 2009, 2016). It was important that these codes were identifications of the topic and not abbreviations of the content (Saldana, 2009, 2016). The topic is what is being talked or written about, and the content is the substance of the message. According to Saldana (2009) description is the "foundation for qualitative inquiry, and its primary goal is to assist the reader to see what you saw and heard" (p. 71). Descriptive codes from data collected across various time periods are essential for assessing participant change (Saldana, 2009, 2016). If there is a large amount of data, the use of more detailed sub-codes may be used. Analysis of descriptive codes leads primarily to a categorized inventory, tabular account, summary, or index of the data's contents (Saldana, 2009, 2016). This is essential groundwork for second cycle coding and further analysis and interpretation. It is allowable to include predetermined codes in addition to the codes developed from the data with this method. My predetermined codes and sub-codes included Beliefs (Instructional, Technology, African American and Low-income Students), Expectations of Students, Barriers, Support, Collaboration, Resource, Decision to Integrate Technology, and Professional Development. These codes were determined from the questions in the initial interview protocol. The initial interview protocol contains questions that required participants to discuss each of these topics.

Similar to descriptive coding, In Vivo coding uses words to describe a passage or phrase within the data. However, In Vivo coding uses a word or short phrase from the actual language found within the actual language in the qualitative data. The aim of this type of coding is to ensure that the concepts stay as close as possible to research participants' own words or uses their own terms because they capture a key element of what is being described (Strauss & Corbin, 1998). For this reason, In Vivo coding is particularly useful in educational settings (Saldana, 2009). Analysis of In Vivo coding can provide a crucial check on whether the researcher has grasped what is significant to the participant and may help "crystalize and condense meaning" (Saldana, 2009, p. 75).

If needed, second cycle coding methods are ways of reorganizing and reanalyzing data coded through first cycle methods. Before categories are created, data may have to be recoded because more accurate words or phrases were discovered for the original codes (Saldana, 2009). Some codes may be merged together because they are conceptually similar; infrequent codes will be assessed for their utility in the overall coding scheme; and codes that seemed like good ideas during first cycle coding may be dropped all together because they are later deemed "marginal" or "redundant" (Saldana, 2009). The primary goal of second cycle coding is "to develop a sense of categorical, thematic, conceptual, and/or theoretical organization" from the first cycle codes (Saldana, 2009, p. 149). The second cycle coding method of focused coding searches for the most frequent or significant initial codes to develop "the most salient categories" in the data and "requires decisions about which initial codes make the most analytic sense" (Saldana, 2009, p. 155). Pattern coding may be used in subsequent coding cycles. Pattern coding involves examining the codes developed during the first cycle of coding to look for similarities and differences within codes, frequency of codes, sequences of codes, correspondence, and causation

(Hatch, 2002). Once second cycle coding is completed, repeated cycles of coding may be necessary to ensure categories and themes are adequately developed.

Data from the sources described in the next sections were used to develop a picture of each individual participant, as well as the department as a whole. This picture will include participants' beliefs related to student and instructor technology use during mathematics and participants' decision to integrate technology within instructional practices. Furthermore, the pictures of participants will include the impact of participants' participation in situated professional development that focused on integrating technology on the aforementioned items. Triangulation of data sources will be used to reduce the chance of misinterpretation of the data (Denzin & Lincoln, 2000). Cases were considered individually and collectively addressing similarities and differences between them based on the codes developed during each coding cycle.

Initial teacher interview, observation debriefs, and final interview. Each interview was audio recorded. The audio recordings were transcribed in their entirety. Transcripts for each interview were coded using the descriptive, In Vivo and pattern coding methods previously described. Patterns, similarities, and differences within and between each case were compared.

Departmental workshop. Analysis of the departmental workshop data focused on examining participants' conversations recorded during discussions that occurred throughout the workshop. Recorded conversations were transcribed. Additionally, participant responses were downloaded from NearPod. Transcripts and NearPod responses were coded using the descriptive, In Vivo and pattern coding methods described previously. Patterns, similarities, and differences within and between each case were compared.

Document analysis. Participants' lesson plans from the prior school year were collected and analyzed to determine the number and types of technology used during instruction. Additional lesson plans were collected and analyzed in the same manner during the Fall semester to determine if participants were planning and implementing technology-based lessons in addition to the observed lessons. Simple frequency and type charts were created to display the number of lessons using technology that were implemented before and during participants' involvement in the study.

Ensuring Trustworthiness

The trustworthiness of a research study is important in evaluating its worth (Lincoln & Guba 1985). According to Lincoln and Guba (1985), trustworthiness involves establishing credibility, transferability, dependability, and confirmability. Credibility is confidence in the "truth" of the findings. Showing that findings are applicable in other contexts establishes transferability. Dependability occurs when findings are shown to be consistent and replicable. The degree of neutrality or the extent to which the findings of a study are shaped by respondents and not researcher bias, motivation, or interest establishes confirmability (Lincoln & Guba, 1985; Stenton, 2004).

To establish credibility, I used prolonged engagement as a participant observer, persistent observation, triangulation of data sources, and member checks as suggested by Lincoln and Guba (1985), Stenton (2004), and Patton (1999). Transferability involves showing that the findings are applicable in other contexts. To do this, I provided thick rich descriptions (Lincoln & Guba, 1985). Thick rich description refers to the detailed account of field experiences in which the researcher makes explicit the patterns of cultural and social relationships and puts them in context (Lincoln & Guba, 1985). By describing a phenomenon in sufficient detail, one can begin to evaluate the extent to which the conclusions drawn are transferable to other times, settings, situations, and people (Lincoln & Guba, 1985). In order to address the issue of dependability, Stenton (2004) suggests that the processes within the study should be reported in detail. This will enable a future researcher to repeat the work. For this study, I have outlined each process in my methodology and included supporting material in the appendices. Additionally, I used external audits by enlisting the assistance of an outside reader not involved in the research process to evaluate the accuracy and evaluate whether or not the findings, interpretations and conclusions are supported by the data (Creswell, 2012). External audits provide an opportunity for an outsider to challenge the process and findings of a research study. This can provide an opportunity to summarize preliminary findings, to assess adequacy of data and preliminary results, and to provide important feedback that can lead to additional data gathering and the development of stronger and better articulated findings (Lincoln & Guba, 1985; Creswell, 2012). To ensure reliability of data collected, each participant was offered the opportunity to review transcribed interview data from their interview. Three participants chose to review their transcribed interviews. Mr. Smith reviewed his initial interview and initial observation interview, Mr. Johnson and Mrs. Taylor reviewed their initial interviews. Finally, to ensure that the findings are the result of the experiences and ideas of the participants, rather than my own preferences, a codebook containing, codes, themes, descriptions, and sample data is included in the write-up of the study.

Role of the Researcher and Researcher Bias

According to Creswell (2012), qualitative research relies on the researcher as the primary research instrument for data collection and analysis to understand the social setting or social phenomena. Therefore, a complete description of the role of the researcher must be included. Within this study, my role was that of a participant observer. I conducted all interviews, facilitated the workshop, and participated in co-planning co-teaching sessions. Since the field notes during observations and interviews involved interpretation, I have provided my background related to the teaching and learning of mathematics. Eleven years of secondary teaching, successful completion of a Master of Education and Education Specialist degree in secondary mathematics education, four years of course work towards a Doctor of Philosophy degree in mathematics education, prior experience teaching undergraduate methods courses, serving as the mathematics department head while employed as a secondary mathematics teacher, and experience facilitating professional development for mathematics teachers provided me with a familiarity with reform-based mathematics teaching practices as well as qualitative research methodology. Taken collectively, these experiences prepared me to complete this study. Additionally, I must disclose that I was employed as a mathematics teacher at THS prior to the start of the study. Although I am no longer employed at THS, I may have biases that could impact my interpretation of the data. Two of the participants were employed at THS while I was teaching there. I have personally witnessed technology not being used during mathematics instruction on a frequent basis and have formed my own opinions as to why this was occurring. To ensure that my biases did not skew my interpretation of the data, member checking was used to make sure the participants' thoughts were interpreted in the manner in which the participants intended. I only reported beliefs and findings that were supported within the data and not my personal opinion.

As a former secondary mathematics teacher in schools with a high African American, low-income student population, I have witnessed many of the inequities discussed in the literature review and want to contribute to changing some of those practices. I strongly believe that students of all ethnicities and socio-economic backgrounds deserve high-quality mathematics learning opportunities from teachers that are passionate about their profession. Conducting this study has allowed me to explore the beliefs and practices of secondary mathematics teachers within this demographic, provide them with professional development and support, and hopefully have a positive impact on their beliefs regarding the role of technology and equitable teaching practices in mathematics instruction with African American and low-income students.

Chapter 4: Results

The results presented in this chapter describe the participants beliefs and practices before, during, and after the professional development and coaching that they received during the study. Data was collected from six participants. Mr. Smith, Mr. Johnson, Mrs. Brown, and Mr. Moore were mathematics teachers at Target High School (THS). Mrs. Wallace and Mrs. Taylor were mathematics teachers at Paige Junior High School (PJHS). Multiple data sources were used to develop a deep understanding of the participants' beliefs and practices related to their students, mathematics teaching and learning, and technology use during mathematics instruction. The six cases provide information about the changes in beliefs and practices of the participants resulting from their involvement in this study. Data collection sources included initial interviews, observation debrief interviews, final interviews, classroom observations, departmental meeting observations, lesson planning sessions, lesson plans, and participant responses during the departmental workshop. Each subheading within the cases were determined from the major themes that emerged from the coded data.

A discussion of the factors that impacted participants' beliefs and influenced their decisions to integrate or not to integrate technology into their instructional practices, as well as a cross-case comparison by research site is included in this chapter. The case studies are presented according to the participants' schools and the number of years the participants' have taught in the schools from least to greatest number of years.

The chapter presents each case study and the cross-case comparison in the following format. Each case study begins with the participant's background information. The remaining structure of each case consists of three main sections of analysis: beliefs about the participant's students, beliefs and practices related to the teaching and learning of mathematics, and beliefs related to the use of technology during mathematics instruction. These three categories were chosen as the primary focus of the analysis because they were the three major themes that emerged from the data. Additionally, these three areas of focus were beneficial in answering the research questions. The data for this analysis was collected during the 2017 – 2018 school year during the second, third, and fourth nine weeks grading periods. A cross-case comparison by research site is presented following the case studies. A brief summary of the findings concludes the chapter.

Brief Summary of Procedures and Data Collection

Situated professional development activities conducted during the study included a departmental workshop and planning sessions. Conversations and participant responses collected during both of these activities also served as data for analysis. Data collection activities included interviews, observations, and collection of lesson plans. A description of the individual activities is provided in Chapter 3. Next, you will find a description of the trajectory of activities completed during the study. Prior to participating in the departmental workshop, an initial interview, initial observation, and initial observation debrief was conducted. Following these three activities participants participated in a departmental workshop. Next, each participant participated in planning sessions with me to further improve their knowledge of technology tools, reflect on their practices and beliefs, and plan a technology-based lesson. After planning a lesson with me, each participant was observed implementing the lesson. Following the implementation of the lesson, a lesson debrief interview was conducted. Additionally, sessions with me were held at participants' requests throughout the study. Next, each participant collaborated with a colleague to plan technology-based lesson. Implementation of this lesson was observed and a debrief interview followed. Next, participants individually planned a technology lesson. Implementation of the individually planned lesson was observed and a debrief interview followed. Participants also participated in a departmental meeting. Notes of conversations were taken. All lesson plans participants planned during the 2017-2018 school year were analyzed as well. Finally, all participants completed a finial interview.

Coding

Documents related to the case studies, excluding lesson plans, were analyzed using Nvivo 12, a qualitative analysis computer software. Documents included transcribed initial interviews, observation debrief interviews, and final interviews. Additionally, participant responses from the departmental workshop, field notes from classroom observations, planning sessions, and departmental meetings were analyzed with Nvivo12. A priori codes were developed from interview protocols. Emergent codes identified from individual cases were added during the analysis of the data. The codes were also used during cross-case comparison. Both are denoted in the codebook (see Appendix J). After a document was coded, codes were grouped based on a common theme. Table 1 contains a sample list of the codes from combined cases that evolved as well as a frequency of each code. Appendix J provides a more detailed description of how each code was used.

Table 1. Sample Codes

Codes	Frequency
Beliefs about Students	
Discipline Problems	20
Low Expectations	12
Low Mathematical Ability	14
Unprepared for College	6

High Expectations	26
Beliefs and Practices Related to Teaching and Learning	
Assessing Student Learning	24
Obstacles	
Administration	6
Discipline	10
Planning Lessons	
Choosing Content	17
Test Prep	10
Textbook	14
Online Sources	15
Collaboration	
Desire	9
No Desire	2
Beneficial	12
Not beneficial	1
Old Fashioned/Traditional	3
Real World Connection	6
Teacher-Centered	7
Technology Use During Instruction	
Access to Technology	10
Administrative Support	8
Beliefs About Technology in the Mathematics Classroom	
Crutch	9
Distraction	3
For Upper Level Mathematics	9
Less Technology	5
Real World Applications	7
Beneficial	25
Desire to Use	
As Reward	2
Assessment Purposes	13
Games	8
Willingness to Try	14
Obstacles	
Comfort	2
Overwhelmed	12
Student Behavior	12
Student Needs	6
Technical and Hardware issues	9
Time	15
Training	17
Technology Use Outside of Classroom	8

Participants' lesson plans were coded in the following manner. Each participant was required by their school to keep their daily lesson plans and handouts, organized in weekly folders in a crate to be viewed by school and system administrators during walk-throughs. Each task or assignment students were required to complete in the daily lesson plans were examined and coded as either low level or high-level cognitive demand based on the characteristics of mathematics tasks at each of the four levels of cognitive demand (Smith & Stein, 1998; Stein et al., 2000; and Boston & Smith, 2009; NCTM, 2014). Tasks were coded as low-level cognitive demand if they met the characteristics for memorization tasks or procedures without connections. Tasks were coded as high-level cognitive demand if they met the characteristics for procedures with connections or doing mathematics. Additionally, lesson plans were coded for technology use if students were required to use technology to explore concepts or if the teacher used technology to demonstrate or explore a concept. Lesson plans at both schools contained a section to check off the technology used by students and the teacher. This section also included space to write in additional technology or programs being used that were not included in the list.

Case 1: Mr. Smith

Mr. Smith was a fifty-year-old, African American male mathematics teacher at Target High School (THS). He has a bachelor's and master's degree in mathematics from a Historically Black University and an Alternative Masters in Secondary Mathematics Education from an online, for-profit university. Additionally, Mr. Smith was pursuing a Ph.D. in Mathematics from a university in the western region of the state where THS is located. Mr. Smith's educational background shows that he had limited educational training with respect to the pedagogical knowledge needed to effectively teach mathematics. At the time of the study, Mr. Smith had been teaching at THS for three months. Mr. Smith taught Algebra 1, Algebraic Connections, Algebra with Finance, and Geometry. However, during the second semester, Mr. Smith's Geometry class was merged with Mr. Johnson's Geometry classes and his Algebra 1 course was divided into two smaller classes. Additionally, he had 15 years of experience as a mathematics teacher. Four of those years were at the secondary level, and 11 were at the post-secondary level. Mr. Smith's secondary teaching experience was in two rural high schools with a high African American, low-income student population. His post-secondary teaching experiences occurred in a Historical Black University and two community colleges in the state where THS is located. Prior to becoming a teacher, Mr. Smith worked at a southern company as a Systems Analyst using the Queuing Model. The Queuing Model provides a systems analyst with a system for designing and evaluating the performance of queuing systems including server utilization, length of waiting lines, and system delays (Kumar & Sharma, 2017).

Mr. Smith's decision to teach mathematics at the secondary level was heavily influenced by his desire to be a positive influence on African American male students and prepare them for success in mathematics at the post-secondary level. Mr. Smith believed that the students from THS would benefit from seeing someone not from the community being successful with mathematics. He believed that this would encourage them to develop a positive outlook on the value of education and the role of mathematics in their future life decisions.

Mr. Smith's Beliefs About THS Students. In this section, Mr. Smith's beliefs about his students and their ability to learn mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs about students prior to the situated professional development, beliefs about students during the situated professional development, and beliefs about students at the end situated professional development.

Mr. Smith's Initial beliefs about THS students. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations and student behavior will be discussed.

Expectations. Mr. Smith repeatedly voiced his low expectations of the students' abilities to be successful in mathematics. Analysis of Mr. Smith's initial interview and data collected during the departmental workshop revealed 21 instances of Mr. Smith expressing these beliefs related to the low expectations he had of his students and their low mathematics abilities. This represented about 80% of the total instances of these types of beliefs that were coded for all of the case study participants' initial beliefs about students. He believed that some students living in poverty lacked the cognitive, emotional, and behavioral characteristics to participate and achieve in mathematics. Mr. Smith initially described the students at THS as "downtrodden", "few of them are gifted", "do not try", "not used to having to work", "lacking background knowledge", "afraid", "don't care about math", and "take too much time to complete simple things." He believed that the students at THS were different from the students he taught in previous high schools. During his prior secondary teaching experience, Mr. Smith taught Advanced Mathematics and Computer Science. This was Mr. Smith's first year teaching the lower level secondary mathematics courses. He believed that the majority of the students at THS were at least two to three years behind with respect to mathematics ability. This belief directly impacted Mr. Smith's decision to be involved with duties outside of the academic classroom. Mr. Smith stated that the principal asked him if he would like to start a scholar bowl team. Mr. Smith declined the opportunity because he did not believe that the students at THS were capable of being successful on a scholar bowl team. These low expectations and perceived low mathematics ability also impacted Mr. Smith' mathematics instruction and were key factors in his choice of mathematics activities.

Student Behavior. Mr. Smith believed that his students exhibited very negative behaviors during class. An excessive amount of his instructional time was constantly devoted to addressing behavior issues. Mr. Smith believed this negative behavior implied that his students did not care about their education or being successful post high school. This behavior greatly affected several instructional decisions related to activities used during instruction. Several planned activities were canceled as a result of his students' behavior and the fear that students would embarrass him if there were guests in the classroom. Because of their behavior, Mr. Smith believed that his students were incapable of working in groups or completing projects that required portions of the project to be completed at home. As a result, the majority of the tasks assigned to his students were low-level cognitive demand tasks. This is explained in greater detail in a later section.

Mr. Smith's beliefs about THS students during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations and student behavior will be discussed.

Expectations. During the situated professional development, many of Mr. Smith's low expectations of students continued. Analysis of Mr. Smith's debrief interviews and data collected during departmental meetings revealed 18 instances of Mr. Smith expressing these beliefs. This represented about 75% of the total instances of these types of beliefs coded for all participant's beliefs about students during the situated professional development. During co-planned and individually planned lessons, many of the activities were heavily scaffolded because he did not believe his students could complete the activities without explicit directions. For example, the lesson planned as a part of the study by Mr. Smith and Mrs. Brown (another mathematics teacher in his school) required students to use Desmos to explore the relationships between the slopes of parallel and perpendicular lines. Students were to complete the task in pairs. When Mr. Smith implemented the task, he did not provide adequate time for the students to explore the relationships with their partners prior to explicitly telling students what they should be noticing. During the lesson, Mr. Smith walked over to a pair of students as they were entering their equations into Desmos and setting up the sliders to begin the activity. As the pair began adjusting the sliders to change the slopes of the two lines, Mr. Smith interrupted the students and asked, "did you notice that the slopes were the same when the lines were parallel?" The students had not yet come to that conclusion. The students then asked Mr. Smith what they should write on the worksheet. He told them to write, "if two lines have the same slope and different y-intercepts then they would be parallel." During the debrief interview, Mr. Smith stated that he wanted to "make sure the students saw the relationship and had the correct wording on the worksheet" and that he "did not think they would come up with that relationship on their own." After observing Mrs. Brown teach the same lesson, Mr. Smith set a goal to work on allowing his students to work more independently. He noticed that she allowed her students to work more independently on the task when she implemented it in her class. As a result, he observed Mrs. Brown's students were more engaged in the lesson and "seemed to enjoy it" more than his students did during the same lesson. He also stated that he was pleasantly surprised that her students were able to see the relationships without Mrs. Brown having to explicitly tell them the relationships. However, Mr. Smith also stated that he believed that her students were able to see the relationships faster than his students because they were the advanced Algebra 1 students.

Student behavior. Mr. Smith reported an improvement in student behavior during each of the lessons that integrated technology. During each of the lessons, Mr. Smith stated that the students were excited to "do something different." There were fewer distractions than there were normally, and he had fewer office referrals during those lessons. During lessons that did not integrate technology, particularly the day following a technology activity, Mr. Smith stated that students complained about "doing regular work." Lessons following the technology lessons utilized direct instruction with little connection to the technology activity. For example, during the implementation that I planned with Mr. Smith, students in his Algebra with Finance class were to use Excel to determine which of two loan offers was the best deal. Students were not given any specific interest formulas to help them determine their answers. Students enjoyed using the computers and remarked that they did not realize how much more money they would be paying back to the lender based on the terms of the loan. There were no disciplinary issues, and students were very engaged in the lesson. The day following the lesson, students were given a similar task. However, Mr. Smith gave students the formulas and told them which values to substitute for each variable. There was no connection to the previous day's lesson. Students asked if they could use Excel to compare their answers to the values obtained by using the formulas. Their request was denied. Students were told, "that was yesterday's lesson, and we are doing this today." This shows that his students wanted to use technology during mathematics instruction. However, Mr. Smith did not feel comfortable with using technology with more lessons because he was concerned with students' behavior on non-technology days. Mr. Smith also attributed the improved behavior to my presence in the classroom even though he also reported an improvement in student behavior during technology lessons he integrated that I did not observe. Additionally, he believed student behavior improved with his Algebra 1 students because they were split into two smaller classes. Mr. Smith continued to view technology as a reward rather than a beneficial instructional tool. As a result, he only integrated additional technology activities that allowed his students to use technology to explore concepts or review for tests when he believed his students had satisfactory behavior for a sufficient amount of time.

Mr. Smith's final beliefs about THS students at the end of the situated professional development. Although Mr. Smith saw an improvement in student behavior and motivation during the lessons implemented as part of the situated professional development, he continued to believe that the students at THS did not possess the mathematics abilities to be successful in mathematics courses post high school. He continued to express his concern about students' negative behavior during instruction and outside of the classroom. Mr. Smith stated that he initially expected students to be off task and not engaged in the lessons. However, he was pleasantly surprised that the activities held their attention, and there was a decrease in the behavior problems.

Mr. Smith's beliefs and practices related to the teaching and learning of mathematics. In this section, Mr. Smith's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs and practices related to the teaching and learning of mathematics prior to the situated professional development, beliefs and practices related to the teaching and learning of mathematics during the situated professional development, and beliefs and practices related to the teaching and learning of mathematics at the end of the situated professional development.

Mr. Smith's initial beliefs and practices related to the teaching and learning of mathematics. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Mr. Smith's pedagogical beliefs were extremely teacher-centered. Analysis of data collected from Mr. Smith's initial interview, initial observation and debrief, and departmental workshop revealed 14 coded references to teacher-centered practices. When asked to describe a typical mathematics lesson in his class, Mr. Smith stated that he "would like for his students to come in, sit down, and begin working on what he has on the board." Mr. Smith believed the best teaching strategy to help students understand the concepts was for him to explain the concepts, work through a few examples, and allow students to work similar examples. Because of behavior issues and class size, Mr. Smith did not allow his students to work in groups or pairs. This was confirmed during the initial observation of a typical lesson in Mr. Smith's classroom. As students entered the classroom, Mr. Smith stood silently in front of a blank whiteboard. Students began taking their seats and asking Mr. Smith what they would be doing in class that day. He did not respond to any of the students' questions. After the tardy bell rang, Mr. Smith continued to stand in the same position with his hands clasped behind his back as students discussed an incident that occurred at the local shopping center. Once students were quiet, 6 minutes after the tardy bell rang, Mr. Smith began writing the first problem on the board. As Mr. Smith silently wrote the first example on the board, several students asked if they were to copy and begin working on the problem. Again, Mr. Smith did not respond to the students' questions. After writing Example 1, he silently walked to a second board and began writing the second problem. Thirteen minutes after the class began, Mr. Smith walked to board 1 and told students, "I want you to find the answers to parts a through e of Example 1". As students began working the problem, Mr. Smith stood silently in front of board 1. An African American female raised her hand and asked for clarification of the directions. She stated that she didn't understand what was meant by "find the percentage that is budgeted" because each part of the problem "already had a percent written". Mr. Smith explained to the student that she was to use the given percent and the amount of the paycheck to find the "dollar amount for each part". Three minutes later, Mr. Smith began to explain how to compute the answer. He began by writing the following equation on the board: 0.2 X $2,000 = $400. Several students did not know what 0.2 represented. Mr. Smith told the students that the 0.2 represented 20% and continued providing the solutions to the problem. Students were then instructed to complete the second example. As students completed the second example, Mr. Smith erased the first example and began writing the third example on the board. Once he finished writing this example, he explained the solution to the second example. There was very little discourse from the students. This continued with the third example as well.

Mr. Smith believed that students learn best with "rote learning". Often, he asked students to complete worksheets generated from the website www.kutasoftware.com that required them to use a particular strategy or formula repeatedly without deviation. He believed that this was “the best way for students to learn math” because “this is how [he] learned”. The lesson plan analysis for lessons completed prior to the departmental workshop confirmed this belief. Almost every lesson, required students to repeatedly use a strategy or formula to solve multiple problems that were similar. Chapter tests contained at least one word-problem that required students to apply one or more concepts from previous lessons. Mr. Smith reported that many of his students skipped these problems on the test. Mr. Smith rarely provided opportunities for students to complete these types of problems. He believed that students should be able to complete these problems once they understand the procedure. If students were unable to complete these types of problems, he believed it was due to students not wanting to complete the problem or that students did not understand the procedures or need to solve the problem.

Task selection. Students should have mathematics learning experiences that allow them to engage with challenging tasks, connect new learning with prior knowledge, and acquire conceptual and procedural knowledge through engagement with meaningful, high quality tasks (NCTM, 2014). However, schools with a high percentage of African American students have a large number of mathematics courses that focus on rote learning, procedures, and test taking strategies (Davis & Martin, 2008; Martin, 2013). This was evident in Mr. Smith’s mathematics courses. Daily lesson plans from August 9th through November 17th revealed that nearly 90% of the tasks implemented in Mr. Smith’ courses were low-level cognitive demand tasks that consisted only of memorization or procedures without connections (see Table 2) (Smith & Stein, 1998; Stein et al., 2000; and Boston & Smith, 2009; NCTM, 2014). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 2

Smith Lesson Plans Analysis from August 9th to November 17th

Subject	Level of Cognitive Demand & Technology Use	Frequency
Algebra with Finance	Low- Level Cognitive Demand Tasks (memorization and procedures without connections)	55
	High – Level Cognitive Demand Task (procedures with connections and doing mathematics)	6
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	0
	Teacher Uses Technology to Explore/Demonstrate Concept	0
Algebraic Connections	Low - Level Cognitive demand Tasks (memorization and procedures without connections)	54
	High– Level Cognitive demand Task (procedures with connections and doing mathematics)	8
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	0
	Teacher Uses Technology to Explore/Demonstrate Concept	0
Algebra 1	Low - Level Cognitive Demand Tasks (memorization and procedures without connections)	56
	High – Level Cognitive Demand Task (procedures with connections and doing mathematics)	5
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	0
	Teacher Uses Technology to Explore/Demonstrate Concept	0
Geometry	Low - Level Cognitive Demand Tasks	45

	(memorization and procedures without connections)	
	High – Level Cognitive Demand Task (procedures with connections and doing mathematics)	7
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	0
	Teacher Uses Technology to Explore/Demonstrate Concept	0

During the initial observation, Mr. Smith's students completed the following three examples:

Example 1:

Your pay check is $2000 per month. Find the percentage that is budgeted for each expenditure.

a. 20% is for child care

b. 15% is for car care

c. 25% is for food

d. 20% is for utilities

e. 10% is for entertainment

f. 10 % is for other

Example 2:

Complete the table.

	June	July	Aug	Sept
Food	$85	$90	$75	$75
Clothing	$175	$180	$100	$100

Entertainment	$50	$50	$50	$50
Car Note	$350	$350	$350	$350
Gasses	$60	$50	$75	$60
Total Budget				

What is the average for all four months?

Example 3:

Your pay check is $3500 per month. Find the percentage that is budgeted for each expenditure.

a. 27% is for child care

b. 16% is for car care

c. 28% is for food

d. 17% is for utilities

e. 12% is for entertainment

f. 10 % is for other

Each of these tasks are examples of low-level cognitive demand tasks.

According to Mr. Smith, he planned his lessons by matching the content in the textbook with the course of study objectives. He followed the order of the textbook and chose examples from the text that he believed would help the students understand the concept. These typically included only the problems at the beginning of the "Practice Problems" section of the textbook or a modified version of the examples provided in the textbook. Additionally, he did not choose the more difficult examples or tasks because he believed his students would not be able to successfully complete them. Many of his lessons focused on the memorization of formulas, definitions, and procedures needed to solve a problem often without a real-world connection or context.

Although technology was present in his classroom, Mr. Smith did not use any technology during mathematics instruction and only allowed his students to use a calculator for computation and often gave students the steps for entering problems into their calculator. He referred to this as a "test taking strategy". Mr. Smith did not want to use technology in his classroom until the second semester because he did not believe his students' behavior would allow for successful use of technology; and he wanted to practice using the technology he had in his classroom over the Christmas holiday to be more comfortable with using them.

Collaboration. Mr. Smith did not have experience planning lessons with colleagues in any of his teaching experiences. Analysis of data collected from Mr. Smith's initial interview, initial observation and debrief, and departmental workshop revealed 8 coded instances of Mr. Smith referring to not collaborating with colleagues regarding mathematics instruction. However, Mr. Smith reported that he will consider soliciting ideas from other teachers in his department to assist him with the negative student behavior he was experiencing from his students. Mr. Smith did not believe that his teaching style or activities had an impact on his students' behaviors. However, during his initial observation, two of his students received office referrals because of comments being made during instruction. As Mr. Smith silently wrote the first example on the board, one of the students asked a question about the example. Mr. Smith did not respond to the student. As a result, the two students began talking to each other. Their conversation consisted of them complaining about Mr. Smith's instructional methods, an interaction their parents had with Mr. Smith at a local shopping center, and their displeasure of Mr. Smith. Mr. Smith did not address the two students at the time of the incident. Instead, he continued to remain silent and gave the students their office referral at the end of class. He believed his students' poor behavior was due to their "lack of desire to learn", "poor disciplinary consequences and follow through from administration", "lack of parental involvement", and "poor math skills". Since, Mr. Smith had very little formal mathematics pedagogical training, he did not understand the teaching practices needed to effectively teach a mathematics lesson. Additionally, he did not believe he would gain any beneficial knowledge from his colleagues with respect to teaching strategies. He stated that he "has the most mathematical knowledge of all of the teachers at THS" and did not "need any help teaching his class".

Mr. Smith's beliefs and practices related to the teaching and learning of mathematics during situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Mr. Smith's teaching practices continued to be strongly teacher-centered. Towards the midpoint of the situated professional development, Mr. Smith began to integrate more partner and group assignments. Because Mr. Smith's geometry class was given to Mr. Johnson (another mathematics teacher at THS) at the beginning of the second semester, his large Algebra 1 class was divided into two smaller classes. As a result, he believed he could better manage student behavior and began allowing partner and group assignments. However, the majority of Mr. Smith's lessons followed the same format: (1) give definitions and procedures, (2) work several examples, and (3) ask students to complete problems that closely resembled the examples previously given. Mr. Smith was comfortable with this format because he believed it allowed him to control the pace of the lesson. He believed it allowed him to minimize the number of distractions and negative student behavior issues that occurred during instruction.

Task selection. Daily lesson plans from November 27th through March 23rd revealed a decrease in the percentage of low-level cognitive demand task from nearly 90% to 67% (see Table 3). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 3

Smith Lesson Plans Analysis from November 27th to March 23rd

Subject	Level of Cognitive demand & Technology Use	Frequency
Algebra with Finance	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	47
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	15
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	13
	Teacher Uses Technology to Explore/Demonstrate Concept	21
Algebraic Connections	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	41
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	19
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	15

	Teacher Uses Technology to Explore/Demonstrate Concept	22
Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	31
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	25
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	20
	Teacher Uses Technology to Explore/Demonstrate Concept	29

Although Mr. Smith continued to plan primarily from his textbooks, he began to integrate technology and lessons found on Illuminations and the state Learning Exchange. He also integrated lessons from Laying the Foundations (LTF) and several units from the Interactive Mathematics Program (IMP). These were a few of the resources mentioned throughout the situated professional development. Although Mr. Smith integrated a few tasks from these sources, the lesson immediately before the tasks focused on the specific procedures needed to complete the task. Similarly, the lesson after implementing these tasks focused on the specific procedures needed to complete the task.

Collaboration. Initially Mr. Smith did not believe that collaborating with his colleagues with respect to mathematics instruction and lesson planning would be beneficial. However, one specific aspect of situated professional development is for participants to become active members in a community of practice. I encouraged Mr. Smith to ask his colleagues for lessons and tasks that required students to reason mathematically rather than perform a set of procedures repeatedly. As a result, Mr. Smith received lesson suggestions not only from me, but also from Mr. Johnson and Mr. Moore (another mathematics teacher at THS). As a student member of NCTM, Mr. Johnson was able to share resources with Mr. Moore from the NCTM website. Additionally, because Mr. Moore previously received training from the state's Mathematics, Science, and Technology Initiative (AMSTI), he was able to share his IMP resources and experiences with Mr. Smith. Although Mr. Smith continued to voice his frustrations about student behaviors during departmental meetings and general conversations outside of the classroom, he also was able to receive feedback from colleagues on how he could address instructional and behavioral issues.

Final beliefs and practices related to the teaching and learning of mathematics. Although Mr. Smith implemented a greater variety of tasks with high level cognitive demand, Mr. Smith's instructional practices remained largely teacher-centered and procedural. He continued to state that he believed students learned best through repetition. He believed activities like the ones he used from LTF, IMP, and Illuminations required "more work than he needed to do to get students to understand the concepts." While Mr. Smith believed the activities were "good activities", he did not believe his students possessed the mathematical ability to complete them without excessive scaffolding.

Lesson plan analysis of lessons completed after the final interview revealed a slight decrease in the low-level cognitive demand tasks from 67% to 62% (see table 4). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 4

Smith Lesson Plan Analysis from April 2 to May 24

Subject	Level of Cognitive demand & Technology Use	Frequency
Algebra with Finance	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	16
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	10
	Students Use Technology to Explore Concept	2
	Teacher Uses Technology to Explore/Demonstrate Concept	5
Algebraic Connections	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	11
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	12
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	4
	Teacher Uses Technology to Explore/Demonstrate Concept	7
Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	20
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	7
	Students Use Technology to Explore or Demonstrate Knowledge of Concepts	8
	Teacher Uses Technology to Explore/Demonstrate Concept	12

Mr. Smith's beliefs and practices related to the use of technology during mathematics instruction. In this section, Mr. Smith's beliefs and practices related to the use of technology during mathematics instruction are discussed. Beliefs will be discussed based on the following continuum: initial beliefs related to the use of technology during mathematics instruction prior to the situated professional development, beliefs related to the use of technology during mathematics instruction while participating in the situated professional development, and beliefs related to the use of technology during mathematics instruction at the end of the situated professional development.

Mr. Smith' class is equipped with a Promethean Board, mounted LCD projector, desktop computer, document camera, class sets of calculators (4-function, scientific, and TI-84), a teacher laptop, and wired and wireless internet. Additionally, Mr. Smith has access to the 3 computer carts stationed in the mathematics commons, an iPad cart, and a Chromebook cart.

Mr. Smith's initial beliefs and practices related to the use of technology during mathematics instruction. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to benefits of technology and barriers to technology integration will be discussed.

Benefits. Mr. Smith did not believe technology was beneficial to the teaching and learning of mathematics in lower-level mathematics courses. Of the 8 times this belief was coded from initial interviews from all participants, 6 of those responses were from Mr. Smith. He believed that students should only be allowed to use technology to explore a few advanced mathematics topics covered in courses such as Algebra 2 with Trigonometry, Statistics, Pre-Calculus, and Calculus. Although Mr. Smith had prior experience teaching Computer Science, he believed that using technology with a high school mathematics course was unnecessary and "nearly impossible in this setting" due to student behavior and low mathematics ability. The lesson plan analysis revealed that 100% of his lessons did not include a technology component (conveyance or mathematical action) (see Table 2).

Calculators were the only technology tools used by Mr. Smith's students during mathematics instruction. Mr. Smith believed the early use of calculators was the reason his students did "not know how to add or subtract." Mr. Smith began allowing his students to use a four-function calculator after he "noticed that they had difficulties with basic arithmetic," and he "didn't have time to teach it". This lack of technology use was observed during the first observation and during lesson plan analysis. Additionally, students were told the exact calculator keystrokes to use to solve the given problems.

Mr. Smith also believed cell phones should not be allowed in the classroom. He believed that cell phones were "the best pieces of worst technology" because they were a "distraction". Mr. Smith observed Mr. Moore, the mathematics department head at THS, teach a lesson where he allowed his students to use graphing apps that were downloaded onto their phones. The lesson required students to explore the end behavior, domain, and range of functions that were entered into the graphing apps. Students were to look for patterns and begin to predict the end behavior, domain, and range of functions based on their equation. Mr. Moore's students were able to successfully complete the task and were engaged in meaningful discussions throughout the lesson. However, Mr. Smith felt that students needed to "know how to graph everything by hand to really show that they understand what's going on." Mr. Smith did not see the value of the technology tool being used in this lesson. Although Mr. Smith believed that technology literacy is a valuable skill in the workforce, he did not believe it is necessary to be successful in mathematics or that it is his responsibility to expose his students to various forms and applications of technology.

Barriers. Analysis of data collected during Mr. Smith's initial interview, initial observation and debrief, and departmental workshop revealed the primary barriers that impacted Mr. Smith's decisions to integrate technology into his teaching practices included knowledge of how to use available resources (6 coded instances), student behavior (13 coded instances), and time constraints (4 coded instances). As previously stated, and shown in Table 2, Mr. Smith did not use any of the available technology in his classroom during mathematics instruction. Mr. Smith stated that he did not know how to use the Promethean Board or the document camera and that he would practice using them during the Christmas break. Additionally, Mr. Smith had not participated in any professional development activities or sought any assistance to learn how to use any of the available technology. Although Mr. Smith did not use technology often with his students, he used technology frequently outside of the classroom to manage his household, entertainment, and collect data for his research project. At this point in the study, Mr. Smith did not believe he would be able to integrate any of the technology he was knowledgeable of with his students.

Throughout the analysis of Mr. Smith's initial interview, initial observation, and departmental workshop, mentions of negative student behavior were repeatedly coded in data sources collected from Mr. Smith. Although the administration at THS encouraged its faculty members to use technology during instruction, Mr. Smith believed that his students' behavior contributed to his lack of technology implementation during mathematics instruction. He did not believe students would "appreciate using the technology" and would "only see it as a toy or something that they will break." Mr. Smith believed that the amount of time he spent addressing disciplinary issues during instructional time would increase if he allowed his students to use available technology resources. He believed students were not mature enough to handle the technology and their parents were not financially capable of replacing the technology if students were to damage them. As a result, neither students nor Mr. Smith used technology during mathematics instruction to explore mathematical concepts.

Mr. Smith felt overwhelmed and frustrated with his daily responsibilities and did not believe he had enough time to integrate technology into his instructional practices. Although he was aware of his administrators' push to integrate technology during instruction, Mr. Smith believed that he did not have time to learn how to use the tools he had access to or how to effectively implement them with his students. However, he expressed a desire to learn how to better utilize the available technology because he believed it would save time during instruction and assessment. This belief was a result of Mr. Smith seeing how Mr. Moore used his Promethean board and its accompanying clicker system. Mr. Smith stated that he would like to practice using the Promethean Board over the Christmas break and begin using it during the second semester of school, if I were willing to assist him in learning the different features.

During his time at THS and previous schools, Mr. Smith had only participated in the required professional development programs offered at the beginning of the school year. These professional development programs were designed to help teachers who were new to the school system get an overview of the school's policies, procedures, and student data classroom management system. He had not participated in instructional technology or mathematics specific professional development due to them not being offered. Mr. Smith stated that he would like to participate in professional development, but, did not know what type of professional development would be beneficial in helping him to integrate more technology into his teaching practices. Additionally, Mr. Smith declined the opportunity to participate in A+ College Ready training.

Mr. Smith's beliefs related to the use of technology during mathematics instruction during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to technology integration, and barriers will be discussed.

Technology integration. As a result of participating in the professional development, Mr. Smith experienced an increase in TPACK. He was able to select and assess the appropriateness of technology tools, specifically Excel. Prior to the professional development, Mr. Smith did not consider integrating technology nor did he see the benefits of integrating technology with his students. However, as a result of the professional development, Mr. Smith implemented several technology lessons in addition to the lessons developed as a part of this study as shown in Table 3. Although Mr. Smith increased his use of technology and his students' use of technology during instruction, he continued to express the belief that technology was best used during assessment, such as quizzes, and not during students' initial exposure to concepts. He believed this use of technology saved time by not having to grade paper quizzes. He also saw this use of technology as a reward or fun way for students to review for an upcoming test. Data analysis revealed 12 instances of Mr. Smith voicing positive statements related to technology being used for assessment and rewards compared to 4 instances of positive statements related to technology being used by students and the teacher to explore concepts. For example, Mr. Smith made several statements about how much he enjoyed using the clicker system to have his students input their responses from multiple choice tests and reviewing for tests using Kahoot! His few positive comments about technology being used to explore mathematics were related to his Algebra with Finance students using Excel. He viewed excel as a beneficial tool and stated that he frequently uses excel to manage his household finances. However, Mr. Smith attributed students' success with understanding a concept when using technology with his teaching the procedures needed to solve similar problems the day immediately preceding a technology-based lesson. Mr. Smith was not willing to allow the technology-based lessons to be students' first exposure to concepts. As a result of implementing these technology activities, Mr. Smith noticed an increase in positive student behavior and student engagement during lessons that integrated technology to explore concepts. However, similarly to the previous discussion regarding increased student engagement, Mr. Smith did not attribute this positive benefit to the design of the lesson.

Barriers. Data analysis revealed 14 instances in which Mr. Smith mentioned using technology during mathematics instruction as being time consuming. Mr. Smith believed that the amount of time used to plan and implement a technology-based lesson was not equal to the benefits he or his students received from the lesson. A significant amount of time was devoted to Mr. Smith learning how to use a particular tool and feeling comfortable using it with his students. Mr. Smith's first exposure to tools like Desmos, GeoGebra, and many of the online tools available for teacher and student use was during the departmental workshop. Several planning sessions, particularly during the first semester, were used to help Mr. Smith gain additional knowledge of the features of specific tools and how to use the features of his Promethean board. Prior to the second semester, Mr. Smith handwrote all of his examples, definitions, and notes on the whiteboards in his classroom. Although

Mr. Smith noted using the Promethean Board to replace his handwritten information and to integrate interactive tools saved time during class, he did not like the amount of time it took to prepare for each day that he used technology during instruction. Additionally, Mr. Smith did not like using class time to setup the computers and make sure the computers were properly put up at the end of class. He stated that he preferred to use this time for instruction. Also, on several occasions, Mr. Smith noted that the computers were not sufficiently charged, and he had to spend time making sure each student had a computer charger and access to a power outlet. This resulted in valuable class time being used to address hardware issues rather than focusing on the mathematics.

Mr. Smith's final beliefs related to the use of technology during mathematics instruction. Mr. Smith continued to believe that the best way for students to learn mathematics was through repetition, he stated that he was aware that teachers are now expected to use technology during their instruction. Although Mr. Smith voiced concerns about technology use with his students, he continued to implement lessons that involved student and teacher use of technology to explore concepts. Mr. Smith stated that he planned to continue to use the technology lessons that he found on Illuminations and the technology lesson developed during the study. He also stated that he was not comfortable using a technology lesson to introduce a concept. However, he will continue to use the Promethean board, Desmos, and a few online interactive tools to demonstrate concepts after the concept has been introduced. Although Mr. Smith believed that technology use was essential in several professions and our daily lives, he continued to express the belief that students should be able to demonstrate understanding of a concept manually, using pencil and paper, and that technology is most beneficial in higher level mathematics courses.

Summary. In all phases of the situated professional development, Mr. Smith expressed low expectations related to his students' mathematics abilities and behavior. He continued to express these beliefs throughout the study. However, Mr. Smith noticed an improvement in behavior during lesson that integrated strategies and activities developed and implemented as part of the situated professional development. Although Mr. Smith reported positive outcomes during these activities, there was little impact on changing Mr. Smith's beliefs related to students at THS. Before the study, Mr. Smith believed that students learned best through repeated practice of similar problems. Additionally, Mr. Smith's teaching style was completely teacher centered with 89% of the tasks utilized in his classes consisting of low-level cognitive demand tasks. During the study, Mr. Smith's teaching practices began to shift towards including student centered practices. However, his overall teaching practices remained mostly teacher centered. As a result of the situated professional development, the percentage of low-level cognitive demand tasks decreased from 89% to 67% during the study and 62% after participating in the study. Before the study, Mr. Smith believed technology use in mathematics was only beneficial for students in advanced mathematics course (Algebra 2 with Trigonometry and above). As such, he chose not to incorporate technology in his teaching practices with his students. Additionally, he believed the incorporation of technology would increase student behavior problems and distract students from grasping mathematical concepts. As a result, none of the mathematics lessons taught prior to his participation in this study integrated student or teacher use of technology to explore or demonstrate concepts. Following the situated professional development, student and teacher technology use during mathematics instruction increased significantly (see Table 5). Although there was a significant impact on Mr. Smith's practices related to the use of technology during mathematics instruction, his beliefs related to technology use in lower-level mathematics course remained unchanged. Percentages for technology use were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately. Similarly, percentages for the cognitive demand of tasks were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans for each time period.

Table 5

Smith Summary Table

	Before	During	After
Teaching Practices	TC	TC/sc	TC/sc
Student Use of Mathematical Action Technology	0%	27%	18%
Teacher Use of Mathematical Action Technology	0%	44%	35%
Overall Low-Level Cognitive Demand Tasks	89%	67%	62%
Expectations of Students	Low	Low	Low

*TC – Teacher Centered, SC – Student Centered, TC/sc – Primarily Teacher Centered with some student-centered practices, TC/SC nearly equal amount of student and teacher centered practices

Case 2: Mr. Johnson

Mr. Johnson was a 33-year-old, African American male mathematics teacher at Target High School (THS). Mr. Johnson grew up in the same city as THS and attended both THS and Paige Junior High School (PJHS). He has a bachelor's degree in mathematics and finance from a Historically Black College located in the same city as THS. Mr. Johnson was teaching on a provisional teaching certificate and enrolled in a Master of Arts Teaching degree program for Mathematics Education Middle Grades that leads to initial licensure at a private, nonprofit, online university. Mr. Johnson's educational background shows that he had limited educational training with respect to the pedagogical knowledge needed to effectively teach mathematics. However, within his current degree program, Mr. Johnson will complete courses specific to teaching, planning, technology, and assessment in mathematics. At the time of the situated professional development, Mr. Johnson had not taken the technology course. This was Mr. Johnson's third year teaching at THS. He taught Geometry and Algebra 2 with Trigonometry. This was his first-year teaching Geometry. Mr. Johnson taught Algebra 2 with Trigonometry and Algebraic Connection during his first two years of teaching at THS. He did not have any other full-time teaching experience.

Prior to teaching at THS, Mr. Johnson was employed in the finance department of the local federal correctional facility. While employed there, Mr. Johnson volunteered to tutor inmates that were pursuing their high school equivalence diploma and inmates earning hours to receive higher pay or Good Conduct Time credit. Good Conduct Time credit reduces the amount of federal time a prisoner is required to serve on their sentence (Federal Bureau of Prisons, 2016). During that time, Mr. Johnson noticed the age of the inmates he was tutoring was getting younger. Many of the young inmates were from the same or nearby counties. Through conversations with these inmates, Mr. Johnson realized that many of them did not have a positive male role model and even fewer had ever experienced being taught in school by an African American, male teacher. Because of this, Mr. Johnson decided to pursue becoming a full-time, certified mathematics teacher. Mr.

Johnson believed that the students from THS and PJHS would benefit from seeing someone from their community being successful and hopefully encourage students to have a positive and productive outlook on life. In addition to teaching mathematics at THS, Mr. Johnson coached baseball, basketball, and track. He sponsored the Chess Club with Mr. Moore (another mathematics teacher at THS).

Mr. Johnson's beliefs about THS students. In this section, Mr. Johnson's beliefs about his students and their ability to learn mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs about students prior to the situated professional development, beliefs about students during the situated professional development, and beliefs about students at the end of the situated professional development.

***Mr. Johnson's initial beliefs about THS students*.** Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations and perceived students' instructional preferences will be discussed.

Expectations. Analysis of Mr. Johnson's initial interview, initial observation and debrief, and departmental workshop revealed 6 coded instances where he stated that he believed the students at THS were capable of being successful and excelling in mathematics. Although many of his students were not successful in mathematics in previous courses, he believed that it was his responsibility to provide students with opportunities to gain confidence in themselves and their mathematics abilities. He believed that it was important for the students at THS to be surrounded by positivity. This belief was developed from Mr. Johnson's experience as a middle school student. While attending PJHS, Mr. Johnson enjoyed seeing the quotes his mathematics teacher, Mrs. Wallace, also a participant in this study, had displayed in her classroom. As a result, Mr. Johnson had posters with positive quotes posted in various places in his classroom. The following quote was displayed across the full length of the front wall of his classroom:

> I am somebody. I was somebody when I came. I'll be a better somebody when I leave. I am powerful, and I am strong. I deserve the education that I get here. I have things to do, people to impress, and places to go. ~ Rita Pierson

He believed that if his students were to be successful in mathematics, they should be motivated to succeed and supported when needed.

Students' wants. During the initial interview and the departmental workshop, there were 12 coded instances where Mr. Johnson stated his students wanted explicit directions for completing tasks. Mr. Johnson believed that a large percentage of his students "just wanted to be told how to solve a problem". When presented with tasks that required students to reason mathematically, many of Mr. Johnson's students became frustrated and did not complete the assignment. He stated that many of his students "were not used to completing problems that required them to think or read a lot of information." For example, Mr. Johnson recalled an instance where his Geometry students were completing an activity to derive the equation of a circle using the Pythagorean Theorem and the distance formula. One part of the activity required students to compare and contrast the Pythagorean Theorem and the distance formula. Following this, students were to square both sides of each formula. Several of his students became frustrated because they could not make the connection between the two formulas and wanted Mr. Johnson to tell them how the two formulas were related to each other. Additionally, several students did not want to complete all of the parts of the activity because they found the equation for a circle on a poster in his room. Typically, when this happened, Mr. Johnson allowed students to come to tutoring before school and receive additional assistance.

Mr. Johnson's beliefs about THS students during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations will be discussed.

Expectations. Analysis of data collected during Mr. Johnson's observation debrief interviews, planning sessions, and departmental meetings revealed 15 instances of Mr. Johnson expressing high expectations of his students. Although some of the tasks implemented during this timeframe were challenging, Mr. Johnson believed that his students were capable of completing them with the proper support and motivation. Students who struggled with the tasks were provided with opportunities to receive additional assistance during class and before school. Additionally, Mr. Johnson expected his students to be respectful and display appropriate student behavior during class. There were very few mentions of negative student behavior during the study. Data analysis revealed only 2 instances of Mr. Johnson mentioning negative student behavior. Each time negative student behavior was mentioned, the behavior was linked to a situation that students were involved in outside of his classroom and briefly continued in his class. Each instance was immediately diffused and did not interfere with his instructional practices. One instance of negative student behavior was centered around two students being involved in an argument during their physical education class the prior period. The argument between both students continued in his class as they entered. Mr. Johnson stated that he immediately separated the two students and allowed one student to sit in the hall until he was calm. The student remained in the hall for about five minutes. During this time, students in the classroom were working on the bell-ringer problems, and Mr. Johnson talked with the student about the proper way to handle conflicts. At the end of class, Mr. Johnson had a similar conversation with the other student involved in the argument. The second mention of negative student behavior involved a similar incident, however it resulted in a disciplinary referral. There were no other mentions of negative student behaviors or disciplinary referrals.

Mr. Johnson believed that his students began show more effort when completing tasks that required them to reason mathematically. Prior to the study, Mr. Johnson's Algebra 2 with Trigonometry students completed a lot of activities that were procedural in nature and followed the examples and steps outlined in the textbook. When presented with non-routine tasks, students frequently got frustrated and did not complete them. Mr. Johnson's geometry students also became frustrated with many of the tasks they had to complete. Mr. Johnson attributed this increase in student effort to him having a better understanding the Mathematics Teaching Practices (NCTM, 2014) and the Standards for Mathematical Practice (NGA & CSSO, 2010). Mr. Johnson stated that prior to the study he was not familiar with the Mathematics Teaching Practices or the Standards for Mathematical Practice. After the departmental workshop, Mr. Johnson found student friendly versions of the Standards of Mathematical Practice and posted them on his wall. He also referred to them throughout instruction. During Mr. Johnson's second observation, the following dialog occurred between Mr. Johnson and a pair of students (Angela and Paul) became frustrated:

Mr. Johnson: What's wrong, Angela?

Angela: I don't get it. I'm tired of trying to figure this out.

Mr. Johnson: You can't quit. What's practice number 1 (referring to the Standards of Mathematical Practice)?

Angela: I know to persevere, but it don't make sense. It has to make sense for me to persevere. You get it, Paul?

Paul: A little. I keep moving the slider to try to figure out what it is doing, and I kind of get it.

Mr. Johnson: Well, tell her (Angela) what you are thinking and see if you can come up with a conclusion.

The above conversation took place during an Algebra 2 with Trigonometry class. Students were using Desmos to explore function transformation by creating sliders. Students were having difficulty understanding the difference between $af(x)$ and $f(ax)$. During the debrief for this lesson, Mr. Johnson stated that he had an expectation for students to continue to challenge themselves and having the Standards for Mathematical Practice posted helped hold students accountable for their efforts.

Mr. Johnson's beliefs about THS students at the end of the situated professional development. Throughout the study, Mr. Johnson continually expressed his belief that the students at THS were capable of succeeding in mathematics. He noticed that overall his students were more willing to persevere with solving problems when they became frustrated. Although some students continued to experience difficulties with mathematics, Mr. Johnson believed his students were more comfortable of completing non-routine tasks than they were prior to his participation in the situated professional development.

Mr. Johnson's beliefs and practices related to the teaching and learning of mathematics. In this section, Mr. Johnson's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs and practices related to the teaching and learning of mathematics prior to the situated professional development, beliefs and practices related to the teaching and learning of mathematics during the situated professional development, and beliefs and practices related to the teaching and learning of mathematics at the end of the situated professional development.

Mr. Johnson's initial beliefs and practices related to the teaching and learning of mathematics. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Mr. Johnson's pedagogical beliefs were primarily teacher-centered. Mr. Johnson's classes typically began with students completing a bell-ringer activity. This usually consisted of problems that reviewed the previous day's lesson or a discussion of the previous day's homework. Following the bell ringer, Mr. Johnson presented definitions and worked through examples with students before giving them problems to work independently. Occasionally, Mr. Johnson integrated non-routine tasks and student presentations into his teaching practices. This occurred more often in his Geometry classes than in his Algebra 2 with Trigonometry classes. This was pattern was observed during the initial observation. As students entered the class, they were instructed to complete the bell-ringer. The bell-ringer required students to graph a figure given a set of ordered pairs and perform a series of translations. As students completed the bell-ringer, Mr. Johnson walked around and checked students' homework for completion. Following this, Mr. Johnson asked a student to show his answers to the bell ringer on the board and answer any questions the other students may have about the problems. Next, Mr. Johnson began the main portion of his lesson by giving students the definition for reflection and showing examples of geometric shapes that were reflected across the x and y axis. Students were asked to develop a rule for reflecting the shapes across each axis. Students began working on developing the rule in pairs. After each pair developed their rule, one pair shared their rule. Mr. Johnson confirmed their rule and demonstrated the rule by completing three more examples and added the term "line of reflection" to the word wall in the back of the classroom. Next, Mr. Johnson asked, "what if the line of reflection is not the x or y axis?" No time was allowed for students to discuss their thoughts. He immediately showed an example of a figure reflected over the line y = x. Students quickly noticed the x and y values in the coordinates of the pre-image were reversed in the image. Students were then given a handout with practice problems similar to those in the discussion. Once students were finished with the handout, Mr. Johnson instructed students to retrieve their laptops from under their desks and login. He then demonstrated how to draw a figure using GeoGebra and reflect it over a line using the reflection tool. As students practiced using the reflection tool, Mr. Johnson walked around made sure each student was able to use the reflection tool. Although Mr. Johnson's instructional practices integrated some student interactions, the discussions did not allow for student discourse at key moments in the lesson. Discussions were led by Mr. Johnson and key concepts related to reflections were not included in the lesson. Additionally, the use of technology in this lesson did not support or enhance students' understanding of reflections.

Task selection. Although Mr. Johnson had high expectations for his students, he often utilized low-level demand tasks during mathematics instruction. Daily lesson plans from August 9th through November 17th revealed that overall 72% of the tasks implemented in Mr. Johnson's tasks were low-level cognitive demand tasks (see Table 6). Of the tasks implemented in Mr. Johnson's geometry classes, 64% of the tasks were low-level cognitive demand tasks compared to 80% of the tasks in his Algebra 2 with Trigonometry classes being low-level cognitive demand tasks. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 6

Johnson Lesson Plans Analysis from August 9 to November 17

Subject	Level of Cognitive Demand	Frequency
Geometry	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	39
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	22
	Students Use Technology to Explore/Demonstrate Concept	6
	Teacher Uses Technology to Explore/Demonstrate Concept	37
Algebra 2 with Trigonometry	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	48
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	12
	Students Use Technology to Explore/Demonstrate Concept	10
	Teacher Uses Technology to Explore/Demonstrate Concept	33

During the initial observation, Mr. Johnson's students completed the following example for their bell ringer:

Example 1:

Graph and label the following figure with these coordinates on the coordinate plane.

A (-2, 6); B (-2, -1); C (0, 0); D (2, 3); E (3, -4)

Complete the following translations:

a. Image 1: up 3

b. Image 2: right 4

c. Image 3: down 3, left 6

This task is an example of a low-level cognitive demand task because it focused solely on a procedure. There was no connection to the properties related to translations. Similarly, examples completed during the main portion of the lesson primarily focused on procedures with no connections to the properties of reflections (see Figure 9).

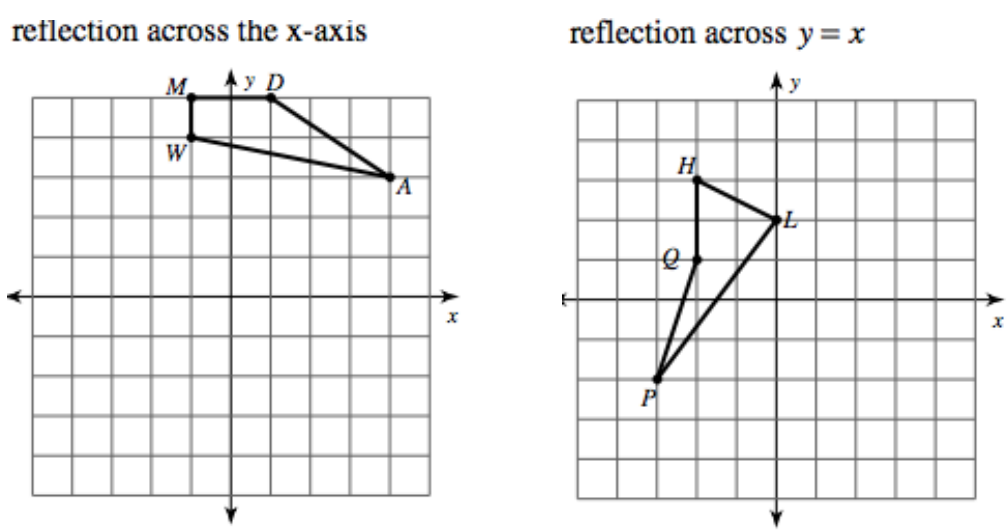


Figure 9. Sample Problems from Student Handout

According to Mr. Johnson, he planned his Algebra 2 with Trigonometry lessons by following the examples and order of the textbook. Additionally, he has used activities he received from Mr. Moore (another mathematics teacher at THS). For Geometry, he used the lessons and activities left by the previous geometry teacher. Mr. Johnson also integrated activities from the Interactive Mathematics Program unit, Shadows. He received this unit from Mr. Moore.

Collaboration. Analysis of data collected during Mr. Johnson's initial interview, initial observation and debrief, and departmental workshop revealed 5 reference to collaboration with colleagues. Mr. Johnson believed that collaboration with his colleagues was necessary for him to grow as an educator. However, he felt discouraged because he was only able to collaborate with Mr. Moore. Because of Mr. Smith's and Mrs. Brown's beliefs about collaboration, he did not feel comfortable asking them for assistance with instruction. Mr. Johnson and Mr. Moore both coached basketball and sponsored the Chess Club. As a result, they spent a lot of time after school together. Additionally, Mr. Moore was Mr. Johnson's calculus teacher when he attended THS. Mr. Johnson frequently asked Mr. Moore for advice related to activities, sequencing lessons, and classroom management issues. Although he received activities that involved student explorations, Mr. Johnson admitted that sometimes he doesn't feel confident in his abilities to teach those types of lessons. As a result, he chose lessons that were "more straightforward" or procedural. This was done more frequently in Algebra 2 with Trigonometry than in Geometry. For example, Mr. Johnson stated that Mr. Moore encouraged him to use the Interactive Mathematics Program unit, All About Alice. However, he chose not to use the unit because he did not believe he could implement it properly.

Mr. Johnson's beliefs and practices related to the teaching and learning of mathematics during situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaborations will be discussed.

Teaching practices. During the situated professional development, Mr. Johnson began to shift his teaching practices to include more student discussions and explorations. He stated during each of the observation debriefs that he purposefully planned time to include student discussions and presentations into his lessons. Additionally, Mr. Johnson obtained a student membership to NCTM and purchased a digital copy of Principles to Action (NCTM, 2014). During our first planning session, Mr. Johnson asked questions regarding locating resources on the NCTM website and activities illustrated in Principles to Action (NCTM, 2014). Mr. Johnson believed that the charts listing student and teacher actions was beneficial to helping him understand how students should interact with the mathematics content. Although he believed it was easier to teach concepts procedurally, he stated that he found himself re-teaching concepts multiple times. For example, Mr. Johnson stated that his students had trouble remembering formulas and knowing when to apply them when the formulas were given to them. However, after he began incorporating more activities found on Illuminations, his students had a better understanding of the formulas and when to apply them. One activity he believed his students really enjoyed was the Law of Sines and Law of Cosines activity found in Illuminations. In previous years, Mr. Johnson simply gave students the formulas for both laws, and students were asked to use them to find missing values of triangles. This year, he believed students had a greater understanding of the concept because they completed activities that required them to derive the formulas prior to applying them. Mr. Johnson also shared this activity with Mr. Moore.

Task selection. Daily lesson plans from November 27th through March 23rd revealed a decrease in the percentage of low-level cognitive demand tasks. Overall the percentage of low-level cognitive demand tasks decreased from 72% to 56% (see Table 7). Low-level demand tasks in geometry decreased from 64% to 49% and decreased in Algebra 2 with Trigonometry from 80% to 59%. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 7

Johnson Lesson Plans Analysis from November 27th to March 23rd

Subject	Level of Cognitive Demand	Frequency
Geometry	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	25
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	24
	Students Use Technology to Explore/Demonstrate Concept	15
	Teacher Uses Technology to Explore/Demonstrate Concept	30
Algebra 2 with Trigonometry	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	36
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	24
	Students Use Technology to Explore/Demonstrate Concept	19
	Teacher Uses Technology to Explore/Demonstrate Concept	27

The increase in the level of cognitive demand of tasks used in Mr. Johnsons class was due to the incorporation of tasks found on Illuminations. Although he continued to use his textbook as a primary resource for planning, he included activities from illuminations to support or introduce topics presented in the textbook. Additionally, Mr. Johnson integrated activities from several Interactive Mathematics Program units.

Collaboration. Mr. Johnson continued to collaborate with Mr. Moore on activities to integrate in his classroom. As part of the situated professional development, Mr. Johnson and Mr. Moore planned a lesson that required their Algebra 2 with Trigonometry students to use Desmos to explore exponential functions. The original task was presented in *Principles to Action* (NCTM, 2014) and suggested that students use graphing calculators to investigate the changes that occur in the graph of $y=a^x$ for different values of a. However, both Mr. Johnson and Mr. Moore decided to use Desmos rather than the graphing calculators. They made this decision because they both believed that their students enjoyed using Desmos and the slider feature of Desmos was more efficient than graphing multiple equations on the graphing calculator. Mr. Johnson also shared some of his activities (those that included technology and those that did not include technology) during departmental meetings. He received feedback from his colleagues, including Mr. Smith and Mrs. Brown, on how to improve portions of the lesson that were not effective and was commended for lessons that were effective. Mr. Johnson stated that he appreciated receiving this type of feedback from his colleagues because it helped him improve his practice.

Mr. Johnson's final beliefs and practices related to the teaching and learning of mathematics. Mr. Jonson continued to have high expectations for his students and integrated more student-centered activities and student led discussions into his teaching practices. He believed that this shift contributed to students retaining information better than what he experienced from students in previous years and with his current students prior to his participation in this study. Lesson plan analysis of lessons completed after Mr. Johnson's final interview revealed an additional slight decrease in overall use of low-level demand tasks from 56% to 54% (see Table 8). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 8

Johnson Lesson Plans Analysis from April 2nd to May 24th

Subject	Level of Cognitive Demand	Frequency
Geometry	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	18
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	17
	Students Use Technology to Explore/Demonstrate Concept	10
	Teacher Uses Technology to Explore/Demonstrate Concept	15
Algebra 2 with Trigonometry	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	16
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	12
	Students Use Technology to Explore/Demonstrate Concept	12
	Teacher Uses Technology to Explore/Demonstrate Concept	18

Mr. Johnson's beliefs and practices related to the use of technology during mathematics instruction. In this section, Mr. Johnson's beliefs and practices related to the use of technology during mathematics instruction are discussed. Beliefs will be discussed based on the following continuum: initial beliefs related to the use of technology during mathematics instruction prior to the situated professional development, beliefs related to the use of technology during mathematics instruction while participating in the situated professional development, and beliefs related to the use of technology during mathematics instruction at the end of the situated professional development.

Mr. Johnson' class is equipped with a Promethean Board, mounted LCD projector, 2 desktop computers, document camera, class sets of calculators (4-function and TI-84), a teacher laptop, and wired and wireless internet. Additionally, Mr. Johnson has access to the 3 computer carts stationed in the mathematics commons, an iPad cart, and a Chromebook cart.

Mr. Johnson's initial beliefs and practices related to the use of technology during mathematics instruction. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to perceived benefits of technology and barriers to technology integration will be discussed.

Benefits. Mr. Johnson believed that technology could be beneficial in helping students learn mathematics. Analysis of Mr. Johnson's initial interview, data collected during the departmental workshop, and initial observation revealed 9 instances where he mentioned technology being beneficial to students learning mathematics and assessing students' mathematical abilities. He believed technology could be used to "provide students with a visual representation of the concepts they are learning." Although Mr.

Johnson frequently used technology to demonstrate concepts, students rarely used technology to explore concepts during class. Lesson plan analysis of lessons from August 8th through November 17th revealed that students only used technology in his Geometry classes in 6 of the 61 lessons (about 10%) during that time period (see Table 6). Technology lessons included the use of Geometer's Sketch Pad and online geoboards. Similarly, students in his Algebra 2 with Trigonometry classes used technology in 10 of the 60 lessons (about 17%) during this time period. Technology used by students only included the TI – 84 graphing- calculator.

Barriers. Analysis of data collected during Mr. Johnson's initial interview, initial observation and debrief, and during the departmental workshop revealed the primary barriers impacting Mr. Johnson's decision to integrate technology into his teaching practices were time constraints (4 coded instances) and lack of technology pedagogy (6 coded instances. Mr. Johnson believed that the amount of time needed to integrate student use of technology into his instructional practices was excessive at times. The time it took for students to retrieve their laptops from the laptop cart and set them up used a significant amount of the 50-minute class period. During the initial observation, student laptops were placed under their desks prior to students entering the classroom. Mr. Johnson stated that this was not the typical practice. He chose to do this because he did not "want the students to spend too much time retrieving and setting up their laptops during the observation." Although this practice saved time, Mr. Johnson was not sure this practice could continue. He was able to have the students assigned laptop under their desks during this observation because his planning period was the previous period, which allowed him time to place each laptop.

Analysis of Mr. Johnson's initial interview, data collected during the departmental workshop, and initial observation revealed 6 instances related to Mr. Johnson's lack of knowledge of how to effectively implement technology as a factor for not including student use of technology more often in his teaching practices. For example, Mr. Johnson stated that although he used Geometer's Sketch Pad to demonstrate concepts, he struggled with getting his students to use the program effectively. Teaching students how to navigate the program so that they can use it effectively was something he found difficult. Because Mr. Johnson's initial observation was conducted the day after the departmental workshop, he decided to use GeoGebra instead of Geometer's Sketchpad. During the debrief of Mr. Johnson's initial observation, Mr. Johnson stated that he was excited that his students found GeoGebra easier to use than Geometer's Sketchpad. However, further discussion of the how GeoGebra was used during the lesson, prompted Mr. Johnson to think about how to use the reflection feature in conjunction with other features to support students' understanding of the properties of reflections. This will be discussed in a later section. Additionally, Mr. Johnson had not participated in any professional development programs that focused on technology implementation. However, within Mr. Johnson's educational program, he will be required to complete a course that focuses on technology implementation in middle grades mathematics. He is scheduled to take this course in the Fall of 2018.

Mr. Johnson's beliefs and practices related to the use of technology during mathematics instruction during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to benefits technology and technology integration will be discussed.

Benefits. Throughout the study, Mr. Johnson continued to view technology as beneficial to student learning. Analysis of data collected during Mr. Johnson's observations and debriefs, planning sessions, and departmental meetings revealed 7 coded instances of Mr. Johnson referring to the benefits of technology. The benefits included deeper understanding of mathematics concepts, increased student engagement, and increased student led discussions. In addition to the tools used during the departmental workshop, Mr. Johnson utilized online mathematics tools and activities found in Illuminations, other NCTM resources, and the Texas Instrument website. As a result, student use of technology to explore concepts increased. For example, during the initial observation, students only used the reflection tool to reflect a figure across a line. During the debrief for this observation, Mr. Johnson was shown how to use the other tools within GeoGebra to explore the properties of a reflection. As a result, Mr. Johnson and I planned an activity that allowed students to use the GeoGebra to gain a better understanding of reflections. In this activity, students connected the corresponding points of the pre-image and the image and used various measurement tools to explore the relationship between the images. Students then used those relationships and other tools to reflect a figure across a line without using the reflection tool. Students were also asked to use the information they gained to determine if a given image was a reflection of the preimage. As a result of this activity, Mr. Johnson decided to revise his previous lesson on translations to include a Geogebra exploration so that students would have a deeper understanding of the concept.

Although Mr. Johnson noticed an overall increase in student engagement and discussions throughout his participation in the study, he reported that student engagement and discussion was greater during lessons that integrated student use of technology. His students enjoyed using Desmos much more than they enjoyed using the TI – 84 graphing calculators. Students were excited to demonstrate and explain concepts using interactive mathematics tools on the Promethean Board. During the observation of the lesson Mr. Johnson planned with Mr. Moore, more than half of the students in the class volunteered to demonstrate and explain their thinking on multiple parts of the lesson. Students seemed confident and comfortable using Desmos on the Promethean board to discuss their thoughts on how different values of "a" changed the graph of $y = a^x$. Additionally, students not presenting contributed to the discussion by asking questions and sharing their thinking.

Technology integration. As a result of participating in the professional development, Mr. Johnson experienced an increase in TPACK. He was able to select and assess the appropriateness of technology tools and plan activities that utilized those tools effectively. As a result, Mr. Johnson planned and implemented more than the three technology-based lessons required for the study. Analysis of lesson plans from November 27 to March 23 revealed an overall increase in student use of technology to explore concepts from 13% to 31% (see Table 7). In geometry, student use of technology to explore concepts increased from about 10% to 31%. In Algebra 2 with trigonometry, student use of technology to explore concepts increased from 17% to 32%.

Mr. Johnson's final beliefs and practices related to the use of technology during mathematics instruction. Mr. Johnson continued to believe that the use of technology was beneficial to students learning mathematics. He was thankful that he was able to improve his instructional practices. Mrs. Johnson believed that the feedback he received as a participant in this study was the primary factor impacting his decision to integrate more student use of technology in his mathematics lessons. Additionally, he felt more prepared to be successful in the technology course he was scheduled to take in the following fall semester.

Mr. Johnson continued to integrate technology in his instructional practices after his final interview. Analysis of lesson plans collected from April 2nd through May 24th revealed that 35% of his lessons included student use of technology to demonstrate or explore mathematics concepts. Mr. Johnson stated that he planned to continue to use activities found in NCTM resources and plans to inquire about AMSTI or similar training to become more comfortable with implementing lessons similar to those found in the Interactive Mathematics Program units. Additionally, he planned to continue watching tutorials on Youtube to learn more about the features GeoGebra and Desmos. During the school year following his participation in this study, Mr. Johnson will be transferred to PJHS and complete his internship for his degree program during the spring semester. He stated that he is interested in finding activities that integrate technology for his middle school students.

Summary. In all phases of the situated professional development, Mr. Johnson expressed high expectations related to his students' mathematics abilities and behavior. He continued to express these beliefs throughout the study. Although Mr. Johnson acknowledged some of his students struggled with understanding mathematics concepts, he continued to encourage and expect all of his students to persevere. As a result of the situated professional development, Mr. Johnson believed that his students were more comfortable completing nonroutine tasks. Prior to the study, Mr. Johnson's teaching practices were mainly teacher centered, and 72% of the tasks implemented were low-level cognitive demand tasks. During the study, Mr. Johnson's teaching practices shifted significantly to include increased use of student-centered practices. Additionally, low-level demand tasks decreased overall to 56%. Following his participation in the study, Mr. Johnson continued to integrate reform-based practices. The percent of low-level cognitive demand task decreased to 54% overall. Prior to the study, Mr. Johnson believed technology use in mathematics was beneficial to all students. As a result, he not only integrated resources introduced during the situated professional development, he also searched for additional technology resources. As a result of his participation in this study, Mr. Johnson's student use of technology increased from 13% prior to the study to 31% during the study. After the study concluded, Mr. Johnson continued to integrate technology into his teaching practices. The overall student use of technology increased to 35% (see table 9). Percentages for technology use were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately. Similarly, percentages for the cognitive demand of tasks were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans for each time period.

Table 9

Johnson Summary Table

	Before	During	After
Teaching Practices	TC	TC/sc	TC/sc
Student Use of Mathematical Action Technology	13%	31%	35%
Teacher Use of Mathematical Action Technology	58%	52%	52%
Overall Low-Level Cognitive Demand Tasks	72%	56%	54%
Expectations of Students	High	High	High

*TC – Teacher Centered, SC – Student Centered, TC/sc – Primarily Teacher Centered with some student centered practices, TC/SC nearly equal amount of student and teacher centered practices

Case 3: Mrs. Brown

Mrs. Brown was a 61-year-old, white female mathematics teacher at THS. Mrs. Brown grew up in the same county as THS. She attended elementary, middle, and high school in schools less than 15 miles away from THS. After graduating from high school, Mrs. Brown completed courses at the local community college that led to her receiving an associate degree in business administration from a community college in the northern area of the state. Mrs. Brown worked as a bookkeeper and secretary for her family's small construction company after receiving this degree. While working for her family's company, she experienced an injury at a construction site. Following this injury and the required rehabilitation, she decided to change her career path. Mrs. Brown stated that she enjoyed mathematics and received good grades in all of her previous mathematics classes. Additionally, she believed that her use of mathematics during her work experience would provide students with an example of how important mathematics is in the "real world". As a result, Mrs. Brown attended the local Historically Black College and received a Bachelor of Arts in Secondary Teacher Education, Mathematics. While enrolled, she served as a substitute teacher in the county and city school systems. Upon graduation, she obtained a full-time mathematics teaching position at PJHS. She taught seventh and eighth grade mathematics for 1 year. The following year, Mrs. Brown accepted a mathematics teaching position at a high school in the same county as THS. The student population of this school was predominantly white and only 41% of the students were eligible for free or reduced lunch (XSDE, 2000). Mrs. Brown taught at this school for 3 years. After not receiving tenure, Mrs. Brown accepted a position at a middle school in a nearby county with similar demographics. She taught eighth grade mathematics there for 2 years before transferring to a high school within the county. She taught Algebra 1A and Algebra 1B for 2 years at this school. Mrs. Brown decided to leave this school due to negative interactions with the principal. At that time, the principal of PJHS was a family friend. As a result, she was able to obtain a teaching position at PJHS. She taught eighth grade mathematics for 2 years before transferring to THS. At the time of the study, she had been teaching at THS for 9 years. She taught Algebra 1, Algebra 1A, Algebra 1B, and a graduation exam remediation course at THS. At the time of the study, Mrs. Brown taught Algebra 1 and Honors Algebra 1.

In addition to teaching mathematics at THS, Mrs. Brown also had served as school counselor for 2 of the 7 class periods from 2016 -2018. Mrs. Brown received a Master of Education in School Counseling degree from a university in the western region of the state THS is located. Because of continuing health issues, Mrs. Brown stated that she was considering retiring at the end of the 2018 – 2019 school year.

Mrs. Brown's beliefs about THS students. In this section, Mrs. Brown's beliefs about her students and their ability to learn mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs about students before and during the situated professional development and beliefs about students at the end of the situated professional development.

Mrs. Brown's initial beliefs about THS students**.** Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations of students will be discussed.

*Expectations***.** Prior to participating in the situated professional development, Mrs. Brown expressed having low expectations for her students. Mrs. Brown's initial interview revealed five instances where she stated that her students were not able to complete complex mathematics tasks. For example, in one instance she referred to her students as "city project kids that were different from the kids in the county". The demographics of the student population at high schools in the county school system were different from the demographics of the student population at THS. Six of the seven high schools in the county were predominantly white with an average of 69% (minimum 44% and maximum 88%) of students receiving free and/or reduced lunch (National Center for Education Statistics, 2018).

Mrs. Brown believed that the academic and behavioral difficulties many of her students exhibited were directly related to factors outside of the control of the school. Data analysis of her initial interview and conversations from the departmental meeting revealed 3 instances of Mrs. Brown attributing students' behavior to and mathematics skills to non-school influences. For example, she believed that many of her students were involved in "gang-like activities" and placed little value on education because of "the shows they watch on tv". Mrs. Brown also believed that there was an increase in discipline issues including an increase in disrespect and defiance. However, Annual School Incident Reports (XSDE, 2011; 2013; 2013; 2014; 2015; 2016) from 2011 through 2016 showed a decreasing trend in discipline issues with a significant decrease in reported issues in 2016 (see Table 10).

Table 10

Reported Annual School Incident at THS

Year	Total Number of Reported Incidents	Defiance of Authority & Persistent Disobedience
2011	454	269
2012	329	203
2013	174	68
2014	152	80
2015	159	70
2016	46	11

Data for 2011 – 2013 only included reported incidents for grade band 10 – 12. Reported incidents for 2011 - 2013 did not include data for 9th grade students due to those incidents being reported with the 7 – 9 grade band and individual school reports were unavailable for those years. The remaining years include data for grades 9 – 12.

Although Mrs. Brown expressed low expectations with her non-honors students, she did not have those beliefs with her honors Algebra 1 students. She frequently referred to those students as her "top students" and periodically made comparison statements between the two levels of students during mathematics instruction. This type of dialogue from Mrs. Brown was coded 4 times during the observation of Mrs. Brown's initial observation. For example, during Mrs. Brown's initial observation, she stated to her honors students "I know you can get this because my other class got it". She was referring to students being able to use the slope formula to calculate the slope when given two ordered pairs.

Mrs. Brown believed that many of her students lacked the foundational skills that they need to be successful in her Algebra 1 class. There were 3 coded instances where she attributed this lack of foundational skills to having ineffective mathematics teachers at PJHS. For example, Mrs. Brown stated that she was able to distinguish the students who were taught by Mrs. Wallace (a teacher at PJHS and a participant in this study) from those who were not taught by Mrs. Wallace. She believed that those students were better prepared to be successful in mathematics than those who were taught mathematics by other teachers at PJHS.

Mrs. Brown's beliefs about students during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations of students will be discussed.

Expectations. During Mrs. Brown's participation in the situated professional development, she frequently expressed low expectations for the students who were not in her Honors Algebra 1 class. Initially, Mrs. Brown was hesitant to allow students who were not in her honors class to participate in the activities. She believed that the students would not be able to fully understand the concepts and exhibit negative behaviors. However, during the lesson debriefs and during departmental meeting, Mrs. Brown stated that those students were focused on the lesson and were able to understand the concepts. She attributed this to the students "being entertained" by the technology. She believed the technology was able to capture students' interest in both levels of her Algebra 1 courses. For example, students in her non-honors course enjoyed using Desmos to determine the equation of a line given a set of ordered pairs. Prior to this lesson, students reviewed how to plot ordered pairs in the coordinate plane and methods for determining the slope of a line that passed thorough the linear ordered pairs. Mrs. Brown stated that many of her students had difficulties plotting ordered pairs on graph paper, and this impacted their ability to see that the ordered pairs were linear when given 3 or more linear ordered pairs. She believed that students would experience difficulties with the concept following this lesson which required students to determine the equation of the line that passed through a set of linear ordered pairs. Therefore, she devoted extra time to reviewing plotting ordered pairs. This resulted in several students being off task because they were already familiar with how to do this. However, during the technology-based lesson, Mrs. Brown noticed that her students were fully engaged in the lesson, and there were no behavior problems. She was also excited that her students who previously exhibited difficulties with plotting ordered pairs were able to determine additional ordered pairs that were on the line. During the departmental meeting, Mrs. Brown stated that she needed to start "trusting the students' (mathematics) abilities more often" and not "be scared to try new things" with her students.

Mrs. Brown's beliefs about THS students at the end of the situated professional development. At the conclusion of the situated professional development, Mrs. Brown continued to express higher expectations for her honors students. During her final interview, Mrs. Brown stated that she would continue to use the activities with her honors students because they "grasp concepts faster than [her] non-honors students". Although she continued to compare her students' mathematics abilities, Mrs. Brown stated that seeing her non-honors students engaged in the lesson planned during the professional development impacted her perception of what her students were capable of doing.

However, she continued to express the belief that those students needed additional practice completing activities using traditional, nontechnology-based, lessons to remediate deficient mathematics skills.

Mrs. Brown's beliefs and practices related to the teaching and learning of mathematics. In this section, Mrs. Brown's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs and practices will be discussed based on the following continuum: beliefs and practices related to the teaching and learning of mathematics before and during the situated professional development followed by and her beliefs and practices related to the teaching and learning of mathematics at the end of the situated professional development.

Mrs. Brown's initial beliefs and practices related to the teaching and learning of mathematics. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Prior to the study, Mrs. Brown's pedagogical beliefs and practices were completely teacher-centered. During Mrs. Brown's initial interview, she stated that a typical mathematics lesson began with Mrs. Brown presenting related vocabulary. Next, Mrs. Brown completed examples with little to no student involvement. This is followed by Mrs. Brown completing examples with student involvement. Finally, students completed examples independently. This was confirmed during Mrs. Brown's initial observation. During the initial observation of an honors Algebra 1 class, Mrs. Brown began her lesson with a brief restatement of the definition of slope its relationship to "rise" and "run". She then reviewed two homework problems assigned to students that required them to determine the slope of a line. The first problem required students to determine the slope of a graphed line with two points given on the line. The second problem required students to graph two ordered pairs, draw the line that passes through the ordered pairs, and determine the slope of the line. The homework assignment for her non-honors Algebra 1 classes consisted of only determining the slope of graphed lines with two ordered pairs clearly marked. There was very little student contribution during this phase of the lesson. After Mrs. Brown worked both examples, she told students that there was another way to determine the slope of a line. Although several students were familiar with the slope formula, students were not discouraged from contributing the discussion. An example of this dialogue is below:

> David: Is this the x sub 2 minus the x sub 1 formula we did in eighth grade?
>
> Mrs. Brown: Yes. But, let me go over it. The rest of the class may not remember what you are talking about.
>
> Ashley: I remember it. You just subtract the y's from the y's and the x's from the x's.
>
> Several students: Oh yeah. I remember that.
>
> Mrs. Brown: Well that's good you all remember. But I need to do a few examples to make sure you all *really* remember how to do it.

Following this discussion, Mrs. Brown proceeded to write the slope formula on a sheet of paper under the document camera. She then listed two ordered pairs and demonstrated how to substitute the x and y values into the formula. She worked another similar example. Next, she passed out a practice worksheet to students. During this phase, Mrs. Brown allowed two students to come to the document camera and work examples similar to the previously worked examples. Again, there was little student contributions to the discussion. When the two students finished working the examples, Mrs. Brown asked if there were any questions related to using the formula to find the slope. No students responded. The lesson continued with students completing the remaining problems on the worksheet until the end of the class period. As students worked on the problems, Mrs. Brown walked around and assisted students when needed.

Although Mrs. Brown participated in a week-long, professional development provided by a state funded mathematics, science, and technology initiative for seventh and eighth grade mathematics, she does not use any of the teaching strategies presented during those professional development sessions. She stated that she only used those strategies and materials when she taught at PJHS. She did not attend similar professional development for Algebra. Additionally, she was unable to attend the A+ College Ready training during the summer prior to the study because of health issues.

Task selection. Prior to participating in the situated professional development, Mrs. Brown primarily utilized low-level cognitive demand tasks. Analysis of daily lesson plans from August 9th through November 17th revealed that overall 86% of the tasks implemented in Mrs. Brown's classes were low-level cognitive demand tasks (see Table 9). However, the percentage of low-level cognitive demand tasks was lower in her honors Algebra 1 class (77%) compared to her non-honors Algebra 1 classes (95%). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

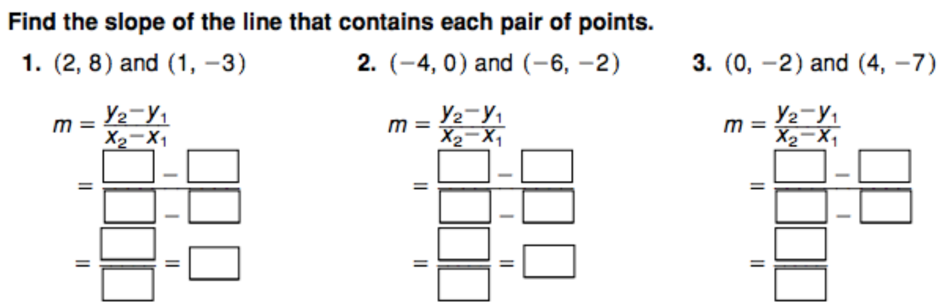
Table 11

Brown Lesson Plans Analysis from August 9th to November 17th

Subject	Level of Cognitive Demand	Frequency
Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	59
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	3
	Students Use Technology to Explore/Demonstrate Concept	0
	Teacher Uses Technology to Explore/Demonstrate Concept	0
Honors Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	48
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	14
	Students Use Technology to Explore/Demonstrate Concept	2
	Teacher Uses Technology to Explore/Demonstrate Concept	2

According to Mrs. Brown, she planned her lessons for both levels by following the examples and order of the textbook. Resources included with the textbook consisted of the following: (1) leveled practice worksheets (A, B, and C), (2) review for mastery worksheets, (3) challenge worksheets, (4) problem solving (application) worksheets, and (5) sample projects. Mrs. Brown believed that practice worksheet C, challenge worksheets, problem solving worksheets, and sample projects were too challenging for the majority of her non-honors Algebra 1 students. As a result, she rarely chose activities from those resources. She reserved those resources for her honors Algebra 1 students. However, the majority of the tasks selected in both levels consisted primarily of low-level cognitive demand tasks that focused on procedures. Mrs. Brown believed that her non-honors Algebra 1 students needed more guided practice than her honors Algebra 1 students. As a result, she often used worksheets with her non-honors classes that consisted of heavily scaffolded procedures. For example, in the lesson discussed during the initial observation, students in Mrs. Brown's non-honors Algebra 1 course completed a worksheet different from the handout completed by her honors Algebra 1 students (see Figure 10 and Figure 11).

Figure 10. Sample problem from non-honors Algebra 1


Find the slope of the line that contains each pair of points.

1. (2, 8) and (1, −3) **2.** (−4, 0) and (−6, −2) **3.** (0, −2) and (4, −7)

$m = \frac{y_2 - y_1}{x_2 - x_1}$

Figure 11. Sample problem from non-honors Algebra 1

Find the slope of the line through each pair of points.

1) (19, −16), (−7, −15) 2) (1, −19), (−2, −7)

Collaboration. Prior to participating in the study, Mrs. Brown expressed mixed beliefs regarding collaboration with her colleagues. Data analysis of Mrs. Brown's initial interview revealed 3 instances of positive beliefs related to collaboration and 4 instances of negative beliefs related to collaboration to improve mathematics instruction. For example, she believed that collaboration with the special education teachers was beneficial for her students who had an Individualized Education Plan. She stated that she has planned activities in the past with those teachers and the results were favorable for her students. However, she also stated that she did not believe collaborating with teachers who do not teach at THS is beneficial because “they don’t know our students and what works for our students.” Additionally, she stated that she had not planned any mathematics lessons with mathematics teachers at THS because “everyone has different teaching styles,” and she preferred the “traditional way of teaching”.

Mrs. Brown’s beliefs and practices related to the teaching and learning of mathematics during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. During the situated professional development, Mrs. Brown began to integrate more student-centered practices with her students in both her honors Algebra 1 classes. She allowed her honors Algebra 1 to participate in more student lead discussions. She allowed students to lead the homework discussions and present more examples during the lessons. Although Mrs. Brown’s teaching practices integrated more student-centered practices for her honors Algebra 1 students, her teaching practices remained primarily teacher-centered with her non-honors Algebra 1 classes. Aside from allowing students to occasionally work in pairs or small groups, the instructional patterns typically followed the same pattern as described prior to her participation in the situated professional development. Data analysis revealed 6 instances where Mrs. Brown discussed her lack of comfort in allowing her non-honors Algebra 1 students to lead class discussions. For example, Mrs. Brown stated that she did not feel comfortable allowing her “regular students to lead discussions because they get off topic too easily,” and it was easier for her “to control the flow of the lesson with those students.” However, Mrs. Brown observed positive student outcomes with respect to behavior, engagement, and mathematics learning with one of her non-honors Algebra 1 classes.

Task selection. During the situated professional development, Mrs. Brown integrated less low -level cognitive demand tasks. Daily lesson plans from November 27th through March 23rd revealed an overall decrease in the percentage of low-level cognitive demand tasks from 86% to 73% (see Table 10). However, the percentage of low-level cognitive demand tasks was lower in her honors Algebra 1 class (63%) compared to her non-honors Algebra 1 classes (80%). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 12

Brown Lesson Plans Analysis from November 27 to March 23

Subject	Level of Cognitive Demand	Frequency
Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	40
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	10
	Students Use Technology to Explore/Demonstrate Concept	6
	Teacher Uses Technology to Explore/Demonstrate Concept	6
Honors Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	26
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	15
	Students Use Technology to Explore/Demonstrate Concept	10

	Teacher Uses Technology to Explore/Demonstrate Concept	10

Although Mrs. Brown continued to plan primarily from her textbook and the accompanying resources, she began to integrate more of the problem solving and challenge problem tasks from those resources. Additionally, Mrs. Brown integrated activities from Texas Instruments.

Collaboration. During the situational professional development, Mrs. Brown experienced an increase in collaboration due to the design of the situated professional development. Mrs. Brown stated that she felt comfortable planning lessons with me and being observed by me because of my teaching experience at THS. However, she experienced difficulties when planning the technology lesson with Mr. Smith. She believed Mr. Smith did not respect her mathematics background. During the debrief of the lesson planned with Mr. Smith, Mrs. Brown stated that Mr. Smith commented that she “only had a math education degree, and he had a math degree.” This comment was made when there was a disagreement about whether they should have students explore parallel slopes before or after perpendicular slopes. Mrs. Brown stated that she often felt intimidated by her colleagues’ mathematics content knowledge because she was the only mathematics teacher in the department that did not have a bachelor’s degree in mathematics.

Mrs. Brown’s final beliefs and practices related to the teaching and learning of mathematics. Analysis of Mrs. Brown’s final interview revealed that she continued to have higher expectations for her honors Algebra 1 students than her non-honors Algebra 1 students. As a result, she continued to integrate more student-centered practices, technology-based lessons, and high-level cognitive demand tasks with her honors students.

She did not continue these practices with her non-honors students. Lesson plan analysis of lessons completed after Mrs. Brown's final interview revealed an increase in the use of low-level demand tasks with her non-honors Algebra 1 students from 80% to 94% (see Table 11). However, the percent of low-level cognitive demand tasks remained at 63% for her honors Algebra 1 class. When compared to lessons implemented prior to the situated professional development, the percentage of low-level cognitive demand tasks remained relatively unchanged for Mrs. Brown's non-honors Algebra 1 classes and decreased from 77% to 63% for her honors Algebra 1 class. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 13

Brown Lesson Plans Analysis from April 2nd to May 24th

Subject	Level of Cognitive Demand	Frequency
Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	29
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	2
	Students Use Technology to Explore/Demonstrate Concept	1
	Teacher Uses Technology to Explore/Demonstrate Concept	1
Honors Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	20
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	12
	Students Use Technology to Explore/Demonstrate Concept	4

Mrs. Brown's beliefs and practices related to the use of technology during mathematics instruction. In this section, Mrs. Brown's beliefs and practices related to the use of technology during mathematics instruction are discussed. Beliefs will be discussed based on the following continuum: beliefs and practices related to the use of technology during mathematics instruction before and during in the situated professional development followed by beliefs related to the use of technology during mathematics instruction after participating in the situated professional development.

Mr. Brown' class is equipped with a Promethean Board, ActivSlate, mounted LCD projector, two desktop computers, document camera, class sets of calculators (4-function and scientific), a teacher laptop, and wired and wireless internet access. Additionally, Mrs. Brown has access to the 3 computer carts stationed in the mathematics commons, an iPad cart, and a Chromebook cart. Mrs. Brown chose not to receive a class set of TI – 84 graphing calculators.

Mrs. Brown's initial beliefs and practices related to the use of technology during mathematics instruction. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to benefits of technology will be discussed.

Benefits. Prior to participating in the situated development, Mrs. Brown did not believe her Algebra 1 students would benefit from using technology, particularly graphing calculators, during mathematics instruction. Analysis of Mrs. Brown's initial interview, data collected during the departmental workshop, and initial interview revealed 8 instances of Mrs. Brown referring to technology as providing no benefit to her students with respect to learning mathematics topics. However, she allowed her students to use 4-function and scientific calculators to assist with computation. She believed that her students who will eventually take more advanced mathematics courses from Mr. Moore (a mathematics teacher at THS and participant in this study) would receive adequate exposure and experience with graphing calculators. Lesson plan analysis of lessons from August 8th through November 17th revealed that students in her non-honors Algebra 1 classes did not use technology to explore or demonstrate concepts in any lessons (see Table 11). Students in Mrs. Brown's honors Algebra 1 class used technology to explore or demonstrate concepts in 2 lessons.

Mrs. Brown's beliefs and practices related to the use of technology during mathematics instruction during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to benefits of technology, barriers to technology integration, and technology integration will be discussed.

Benefits. During the situated professional development, Mrs. Brown reported that the technology lessons proved to be beneficial for her students in both levels. Data analysis revealed 13 instances where Mrs. Brown referred to the benefits of the technology lessons to her students understanding the mathematics content of the lesson. For example, Mrs. Brown stated that allowing her students to use the TI-84 to create box and whisker plots provided her students with a more efficient way of analyzing multiple data sets. Students were also more engaged in the lesson when compared to students from previous years.

Barriers. Mrs. Brown reported several barriers that impacted her ability to integrate technology into her instructional practices prior to participating in the situated professional development. Knowledge of how to use available technology tools was the most significant factor. This barrier was coded 8 times in data collected during the initial interview, initial observation, and departmental workshop. Mrs. Brown did not allow her students to use technology to explore mathematics concepts because she did not know how to use them. For example, she stated, "I don't know how to use those calculators. How can I let my students use them if I don't even understand how to use them?" Mrs. Brown stated that she had not received any professional development related to technology use during mathematics instruction. The second barrier that impacted her decision to integrate technology was time. At the time of the study, THS was in its second year of using a 7-period class schedule. In previous years, THS utilized a 4-period block schedule. Because of this, Mrs. Brown believed that there was not enough time during the class period to set up and use the available technology resources. Additionally, Mrs. Brown believed that the number of standards she was required to teach from the state's mathematics course of study "did not allow for extra activities to be included." Mrs. Brown viewed technology-based activities as supplemental to mathematics lessons that utilized more traditional, nontechnology-based teaching strategies. However, Mrs. Brown used her document camera and projector to display her work as she completed examples.

Technology integration. As a result of participating in the professional development, Mrs. Brown experienced an increase in TPACK. She was able to select and assess the appropriateness of technology tools and plan activities that utilized those tools effectively, specifically Desmos and the TI- 84 graphing calculator. As a result, Mr. Brown planned and implemented more than the three technology based lessons required for the study, primarily with her honors Algebra 1 students. During the situated professional development, student use of technology to explore or demonstrate concepts increased in both levels of Mrs. Brown's Algebra 1 classes. Participants in the situated professional development were only required to plan and implement 3 technology lessons. During the situated professional development, Mrs. Brown planned and implemented more than the required lessons. Analysis of lesson plans from November 27th to March 23rd revealed an increase in the number of technology lessons in her non-honors Algebra 1 classes from 0 to 6 and an increase from 2 to 10 in her honors Algebra 1 class (see Table 12).

During the situated professional development, Mrs. Brown utilized several planning periods to improve her knowledge of the functions of the TI-84 graphing calculator and Desmos. As a result, Mrs. Brown integrated one of these two tools in 10 lessons with her honors Algebra 1 students and in 6 lessons with her non-honors Algebra 1 students. Mrs. Brown stated that she felt comfortable trying these lessons because she knew she could get feedback and assistance from me, as the facilitator of the professional development and observer in her class, if she had any questions or concerns. She expressed concern about creating new technology-based lessons to use with her students after the study was complete. As a result of her interaction with Mr. Smith during the planning of their technology lesson, she continued to express concerns about collaborating with her colleagues.

Mrs. Brown's final beliefs and practices related to the use of technology during mathematics instruction. Mrs. Brown stated that the technology-based activities were beneficial to her students and her technological knowledge of two of the available tools increased, she continued to believe that the most effective method of teaching mathematics did not require the use of technology. She stated that she continued to prefer traditional, non- technology-based, teacher-centered strategies. Also, Mrs. Brown stated that she would continue to use the “I do, we do, you do” approach for the majority of her lessons with her students because this is the method she is most comfortable using. However, she will use the lessons planned during the situated professional development the following school year. Additionally, she planned to retire at the end of the following school year due to health issues. Although Mrs. Brown expressed concerns about planning technology lessons once her participation in the study ended, analysis of lesson plans collected from April 2nd through May 24th revealed that she integrated 1 additional technology-based lesson in her non-honors Algebra 1 classes and 4 additional technology-based lessons in her honors Algebra 1 class.

Summary. Prior to the study, Mrs. Brown expressed high expectations of her students in her honors Algebra 1 class and low expectations of her students in her non-honors Algebra 1 classes. Throughout the study, Mrs. Brown frequently compared students’ mathematics abilities between both levels of students, often voiced directly to her students. However, during the study, Mrs. Brown’s expectations slightly improved for her non-honors students. Additionally, the percent of low-level cognitive demand tasks decreased from 86% to 73% during the study. After the study, the percent of low-level cognitive demand tasks increased to 78%. However, this was lower than the initial percentage. Similarly, the percent of lessons that required student and teacher use of technology increased. Prior to the study, less than 1% of Mrs. Brown’s lessons utilized technology to explore mathematics content. During the study, the percent of student use and teacher use of technology increased to 18%. After the study concluded, Mrs. Brown continued to integrate technology into her teaching practices. Student and teacher use of technology decreased to 8%. However, this was still greater than the less than 1% of lessons prior to the study (see Table 14). Percentages for technology use were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately. Similarly, percentages for the cognitive demand of tasks were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans for each time period.

Table 14

Brown Summary Table

	Before	During	After
Teaching Practices	TC	TC/sc*	TC/sc*
Student Use of Mathematical Action Technology	<1%	18%	8%
Teacher Use of Mathematical Action Technology	<1%	18%	8%
Overall Low-Level Cognitive Demand Tasks	86%	73%	78%
Expectations of Students	Low/High	Low/High	Low/High

*TC – Teacher Centered, SC – Student Centered, TC/sc – Primarily Teacher Centered with some student centered practices, TC/SC nearly equal amount of student and teacher centered practices.

Case 4: Mr. Moore

Mr. Moore was a 47-year-old, African American male mathematics teacher at THS. Like Mr. Johnson, Mr. Moore grew up in the same city as THS and attended both THS and PJHS. After graduation from THS, Mr. Moore attended a Historically Black University in the southern region of the United States. After completing two years at the university, he decided to transfer to the Historically Black College in the same city as THS due to financial issues. Because this college did not have a civil engineering program, Mr. Moore decided to major in mathematics. After graduation, Mr. Moore decided to become a mathematics teacher. As a result, he completed a second bachelor's degree in mathematics education at a public university in the central region of the state. In addition to those two degrees, Mr. Moore has a master's degree in mathematics education from a public university in the western region of the state, a master's degree in curriculum and instruction from an online for-profit university, and an educational specialist degree in curriculum and instruction from an online for-profit university. At the time of the study, Mr. Moore had been teaching at THS for 18 years. During the study, he taught Pre-Calculus, dual enrollment Calculus, and Honors Algebra 2 with Trigonometry. He was also the mathematics department head. Prior to the study, Mr. Moore had experience teaching Algebra 1, Algebra 2, Algebra 2 with Trigonometry, Algebra 3 with Statistics, and Algebraic Connections. Mr. Moore also teaches Pre-Calculus and Introduction to College Algebra 1 and 2 at a Historically Black College in the same city as THS.

Mr. Moore decided to teach mathematics at THS because he was familiar with the community, and he believed he could be a positive role model for the students there. In addition to teaching mathematics, Mr. Moore coached basketball and football and sponsored the mathematics honor society, Mu Alpha Theta. He also sponsored the Chess Club with Mr. Johnson.

Mr. Moore's beliefs about THS students. In this section, Mr. Moore's beliefs about his students and their ability to learn mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs about students prior to the situated professional development, beliefs about students during the situated professional development, and beliefs about students at the end of the situated professional development.

Mr. Moore's initial beliefs about THS students. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations and beliefs will be discussed.

*Expectations and beliefs***.** Mr. Moore had high expectations for his students. Data analysis of Mr. Moore's initial interview, initial observation, and data collected during the departmental workshop revealed no coded instances of Mr. Moore referring to his students in a negative way. All of Mr. Moore's students were on the advanced mathematics track at THS and nearly 100% of his 12th grade students were eligible to receive an advance academic diploma with honors designation. Additionally, Mr. Moore's classes contained between 10 and 18 students. He believed all of his students were capable of being successful in mathematics and a large percentage of his students received no lower than a "B" in their previous mathematics courses. Additionally, there were no instances of Mr. Wallace mentioning behavior issues.

Mr. Moore believed that his students wanted real world application of mathematics concepts to gain an understanding of the concepts. Data analysis from Mr. Moore's initial interview and data collected during the departmental workshop revealed 8 coded instances of Mr. Moore referring to the students wanting real world application problems. For example, Mr. Moore stated that students frequently asked, "how do we use this in the real world?". This was observed during the initial observation as well. During Mr. Moore's lesson on the average rate of change of a function in his precalculus class, three students asked why this concept was important and how can they use it in "real life"? Typically, after Mr. Moore introduces a concept and students work through several examples, he provides them with task that requires them to use the concepts in a real-world scenario. This will be discussed in greater detail in a later section.

Mr. Moore believed that all of his students wanted to pursue post-secondary education, with over half of his students interested in attending a four-year college. Of Mr. Moore's 62 students, 37 of these students are members of Mu Alpha Theta. Twice a month, THS had club/activity schedule. During this schedule, students reported to their club during the scheduled time period. During Mu Alpha Theta meetings, students discussed their post high school plans and researched different colleges and universities. Additionally, they planned and scheduled college visits and community service projects. Mr. Moore stated that they frequently asked for assistance with college application materials and entrance exam skills. Mr. Moore frequently (6 coded instances) referred to his students as the "cream of the crop."

Mr. Moore's beliefs about THS students during and after the situated professional development. Mr. Moore's beliefs about his students remained unchanged. Prior to the study, Mr. Moore expressed high expectations of his students and praised their efforts in each of his mathematics classes. Mr. Moore continued to express his complete confidence in students' abilities to be successful with each of the lessons planned during the situated professional development. Data analysis of lesson observations, lesson debriefs, departmental meetings, and the final interview revealed no instances of Mr. Moore expressing negative beliefs about students' behavior of mathematics abilities.

Because Mr. Moore initially held positive beliefs related to his student, the study did not change his beliefs about students at THS.

Mr. Moore's belief and practices related to the teaching and learning of mathematics. In this section, Mr. Moore's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs and practices related to the teaching and learning of mathematics prior to the situated professional development, beliefs and practices related to the teaching and learning of mathematics during the situated professional development, and beliefs and practices related to the teaching and learning of mathematics at the end of the situated professional development.

Mr. Moore's initial beliefs and practices related to the teaching and learning of mathematics. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Mr. Moore's pedagogical beliefs and teaching practices were primarily teacher-centered. A data analysis of the section of Mr. Moore's initial interview where he describes a typical mathematics lesson revealed 9 instances of teacher actions in the form of "I" statements. For example, these statements consisted of phrases like, "I like to start with", "I complete", "I work", "I show them", etc. Compared to only 3 coded student actions, this shows a primarily teacher-centered approach. Like Mr. Smith, Mr. Johnson, and Mrs. Brown, Mr. Moore typically began his lessons by introducing key vocabulary and formulas, followed by Mr. Moore working several examples. Students then worked through examples with Mr. Moore. Occasionally, students completed examples in pairs or in small groups. Finally, students were assigned problems to complete individually.

This pattern was observed during the initial observation of Mr. Moore's precalculus class. As students entered the class, Mr. Moore collected students' homework and instructed them to copy the formula for the average rate of change for a function from the promethean board. After students copied the formula, Mr. Moore graphed a quadratic function using TI 84 Smartview on his Smart Board. Mr. Moore had both a Promethean Board and a Smart Board. Next, Mr. Moore began explaining to students how to use the formula to calculate the average rate of change between two chosen points on the function. The values were taken from the table on the TI 84. After working several examples, students were instructed to work two examples with a partner. Because Mr. Moore focused on the procedure with very little explanation of what the formula represented, this led to students developing a misconception of the concept. The following conversation took place during the discussion of the two problems:

Mr. Moore: Ok. Volunteers for the first problem. Jason and Sam.

Jason: All we had to do was put the values in the formula and subtract. Then simplify the fraction.

Sam: Yeah. We got 2.

Mr. Moore: Good. That's correct. Did everyone get 2?

Jason: So, we are pretty much just finding the slope of the function, right?

Mr. Moore: No. Not really.

Sam: Why not? It's the same process. Take two points, subtract the y's and the x's. That's how we find the slope of a line.

Pam: It's not a line though.

Sam: Well, the slope of the curve.

Mr. Moore: It's the slope of the line that passes through the two points you used?

Jason: Is it the same for any two points?

Pam: No. Look at the second one. It's the same equation but we got different answers.

Jason: So, the function has multiple slopes. I'm confused.

Following this conversation, Mr. Moore explained that the formula that they were using was similar to the slope formula and that they were using it to determine the slope of the line that passed through the two points. He also, drew the line that passes through the two points. He then provided another brief explanation of average rate of change. At no point during the discussion did Mr. Moore or his students refer to the line that passed through the two points as the secant line or use the calculated value to find the equation of the secant line. Next, Mr. Moore posted a second formula on the board and asked students to tell him how the formula was different from the first one. Mr. Moore stated that they would use the second formula to find the average rate of change from a given point to x. He worked several examples followed by students working 2 examples in pairs. Several students could be seen using a foldable they created with examples of factoring different types of quadratics. After a discussion of the two examples, students were given 6 problems to work independently. As students worked on their problems, Mr. Moore walked around the class to help students who needed assistance.

Task selection. Although Mr. Moore stated that he believed it was important for students to see how mathematics concepts applied to real world situations, be believed that the students needed to be able to complete the procedures prior to using them in application problems. Data analysis of data collected during Mr. Moore's initial interview, initial observation debriefing, and departmental workshop revealed 8 instances of Mr. Moore expressing this belief. For example, Mr. Moore stated, "I really feel like students need to work their way through the problem-solving examples first before we have to apply it." Additionally, Mr. Moore stated that in the past his students experienced less success with learning and understanding mathematics concepts when he tried to use investigation type problems prior to explaining the procedures needed to solve the problems. Mr. Moore integrates tasks from IMP units. However, he does not implement the units in their entirety and often reviews the concepts needed to complete the tasks prior to the tasks being implemented. As a result, a large percentage of Mr. Moore's lesson plans utilize low-level cognitive demand tasks. Daily lesson plan analysis from August 9th through November 17th revealed that overall 65% of the tasks implemented in Mr. Moore's classes were low-cognitive demand tasks (see Table 15). Lesson plans for Mr. Moore's dual enrollment calculus class were not included due to lessons and pacing being determined by the college. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 15

Moore Lesson Plans Analysis from August 9 to November 17

Subject	Level of Cognitive Demand	Frequency
Precalculus	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	42
	High Level Cognitive Demand Task	20

	(procedures with connections and doing mathematics)	
	Students Use Technology to Explore/Demonstrate Concept	9
	Teacher Uses Technology to Explore/Demonstrate Concept	43
Honors Algebra 2 with Trig	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	37
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	22
	Students Use Technology to Explore/Demonstrate Concept	8
	Teacher Uses Technology to Explore/Demonstrate Concept	39

During the initial observation, Mr. Moore's students completed the two examples below:

Example 1:

Find the average rate of change of the function $f(x) = x^2 - x + 1$ from $x = 0$ to $x = 3$.

Example 2:

Find the average rate of change of the function $f(x) = x^2 - x + 1$ from 2 to x. Simplify and list any restrictions.

These examples are examples of low-level cognitive demand tasks because they focus solely on procedure. The remaining examples used during the lesson followed the same format.

According to Mr. Moore, he planned his lessons by following examples in the textbook. After he believed students were able to complete the procedures required for a particular concept, Mr. Moore integrated application problems and activities from several

Interactive Mathematics Program units, A+ College Ready resources, textbook resources, and the internet.

Collaboration. Mr. Moore believed that collaboration with colleagues was important and that it was beneficial for both students' success and professional growth. Data analysis revealed 5 instances of Mr. Moore referring to collaboration with colleagues in a positive manner. Although he believed collaboration was important, Mr. Moore rarely collaborated with his colleagues regarding mathematics lessons and instruction in the past. He believed that the personalities and the individual beliefs of teachers that he worked with over the years effected the department's ability to collaborate effectively. However, due to his relationship with Mr. Johnson, Mr. Moore has assisted to Mr. Johnson on several occasions.

Mr. Moore's beliefs and practices related to the teaching and learning of mathematics during situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to task selection, teaching practices, and collaboration will be discussed.

Task selection. Daily lesson plans from November 27th through March 23rd revealed a decrease in the percentage of low-level cognitive demand task. Overall, the percentage of low-level cognitive demand tasks decreased from 65% to 52% (see Table 16). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 16

Moore Lesson Plans Analysis from November 27 to March 23

Subject	Level of Cognitive Demand	Frequency
Precalculus	Low Level Cognitive Demand Tasks	27

	(memorization and procedures without connections)	
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	23
	Students Use Technology to Explore/Demonstrate Concept	19
	Teacher Uses Technology to Explore/Demonstrate Concept	37
Honors Algebra 2 with Trig	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	26
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	25
	Students Use Technology to Explore/Demonstrate Concept	17
	Teacher Uses Technology to Explore/Demonstrate Concept	41

The increase in the level of cognitive demand tasks used in Mr. Moore's class was due to the incorporation of more tasks from Interactive Mathematics Program, Illuminations, Desmos, and Texas Instrument. Although he continued to use his textbook as a primary resource for planning, Mr. Moore began to integrate more consecutive days from units in the Interactive Mathematics Program units. Prior to the study, Mr. Moore sporadically implemented activities from the Interactive Mathematics Program Units. Additionally, those activities were implemented after the concepts the units were designed to develop were taught and mastered by the students. Thus, several of the initial activities of the units were often skipped. During the professional development, Mr. Moore was encouraged to allow the Interactive Program Unit activities to introduce and develop the concepts. Mr. Moore agreed to try this with the unit, All About Alice. Because of the success he experienced with this unit, Mr. Moore integrated additional consecutive days from other Interactive Mathematics Units as well.

Teaching practices. Although Mr. Moore's teaching practices remained largely teacher focused, he began to integrate more student-centered teaching practices. According to Mr. Moore, he began asking more questions rather than directly telling students how to solve a problem or complete a procedure prior to students having an opportunity to attempt the problem. During the observation of Mr. Moore's individually planned lesson, this teaching strategy was observed. Prior to students beginning the Desmos activity on circle patterns, Mr. Moore asked students to tell him everything they remember about circles. He had students come to the Promethean Board and list the things they remembered. He did not add or delete any information from the list students created. However, if students listed incorrect information, he pointed out that there was a mistake and asked the students to find and correct the mistake. The Desmos lesson required students to have prior knowledge about the equation of a circle, $(x - h)^2 + (y - k)^2 = r^2$. During the lesson, Mr. Moore was able to share students' responses with the class and have them explain their answers. During the lesson debrief, Mr. Moore stated that he enjoyed seeing and hearing student explain their thinking. Additionally, data analysis of each of the three lesson debriefs completed during the study revealed 5 instances of Mr. Moore referring to adjustments in is teaching style as being difficult but beneficial. For example, Mr. Moore stated that he was "used to being the one doing most of the talking. Letting [students] do most of the talking is hard, but, I get to really hear what they are thinking instead of telling them what to do. It's hard, but, I'm trying it out more."

Collaboration. Throughout the study, Mr. Moore collaborated with Mr. Johnson. The primary focus of their collaboration was for activities and assistance for Mr. Johnson. However, Mr. Moore occasionally asked Mr. Johnson to use his NCTM account to help him find activities on Illuminations. Additionally, as part of the situated professional development, Mr. Moore and Mr. Johnson planned a lesson that required their Algebra 2 with Trigonometry students to use Desmos to explore exponential functions. The original task was presented in *Principles to Action* (NCTM, 2014) and suggested students use graphing calculators to investigate the changes that occur in the graph of $y=a^x$ for different values of a. However, both Mr. Johnson and Mr. Moore decided to use Desmos rather than the graphing calculators. They made this decision because they both believed that their students enjoyed using Desmos and the slider feature of Desmos was more efficient than graphing multiple equations on the graphing calculator. In addition to this lesson, Mr. Moore also planned similar additional lessons for the sine and cosine functions.

In addition to collaborating with Mr. Johnson, Mr. Moore shared activities with Mr. Smith and suggested strategies to assist with behavior management. Additionally, during departmental meetings, Mr. Moore allowed his department to share activities that were successful and brainstorm activities that were not successful. During the first departmental meeting that occurred during the study, Mr. Moore shared the success he had with his students as they completed the activity we planned together. This lesson was also observed by Mr. Smith. The lesson required his Algebra 2 with Trigonometry students to explore the end behavior of polynomials of different degrees using a graphing calculator or graphing apps on their phones. Mr. Johnson shared student work and his thoughts on the activity. He believed the activity was a success because students were able to determine the end behavior of polynomials after completing the activity.

Mr. Moore's final beliefs and practices related to the teaching and learning of mathematics. Mr. Moore stated that he would continue to integrate more student-centered practice and less direct instruction. Although, he stated that this was a difficult practice to change. Additionally, Mr. Moore continued to integrate a lower percentage of low-level cognitive demand tasks than he had prior to the study. Lesson plan analysis of lessons completed after Mr. Moore's final interview revealed an additional increase in overall use of low-level demand tasks from 52% to 59% (see Table 17). However, this percentage was lower than the initial percentage of 65%. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 17

Moore Lesson Plans Analysis from April 2 to May 24

Subject	Level of Cognitive Demand	Frequency
Precalculus	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	20
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	16
	Students Use Technology to Explore/Demonstrate Concept	14
	Teacher Uses Technology to Explore/Demonstrate Concept	24
Honors Algebra 2 with Trig	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	19
	High Level Cognitive Demand Task	11

	(procedures with connections and doing mathematics)	
	Students Use Technology to Explore/Demonstrate Concept	8
	Teacher Uses Technology to Explore/Demonstrate Concept	20

Mr. Moore's beliefs and practices related to the use of technology during mathematics instruction. In this section, Mr. Moore's beliefs and practices related to the use of technology during mathematics instruction are discussed. Beliefs will be discussed based on the following continuum: initial beliefs and practices related to the use of technology during mathematics instruction prior to the situated professional development, beliefs and practices related to the use of technology during mathematics instruction while participating in the situated professional development, and beliefs and practices related to the use of technology during mathematics instruction at the end of the situated professional development.

Mr. Moore's class is equipped with a Promethean Board, Smart Board, 2 mounted LCD projectors, 1 desktop computer, Apple TV, personal iPad, document camera, class sets of calculators (scientific and TI-84), a teacher laptop, and wired and wireless internet. Additionally, Mr. Moore has access to the 3 computer carts stationed in the mathematics commons (stored in the adjoining empty classroom), an iPad cart, and a Chromebook cart.

Mr. Moore's initial beliefs and practices related to the use of technology during mathematics instruction. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to the benefits of technology, barriers to technology integration, and technology integration are discussed.

Benefits. Mr. Moore believed that technology can be beneficial to students learning mathematics concepts. Data analysis of Mr. Moore's initial interview, initial observation, and departmental workshop revealed 16 instances of Mr. Moore referring to the use of technology during mathematics instruction as beneficial. During the departmental workshop, Mr. Moore frequently provided counter examples of his belief that graphing calculators could be beneficial if used effectively when Mr. Smith and Mrs. Brown expressed negative beliefs regarding the use of graphing calculators. For example, the following conversation took place during the departmental workshop:

Mr. Moore: We use the graphing calculators to compare multiple graphs. Instead of spending a lot of time and graph paper graphing all those equations, I can use the graphing calculators to graph them. I can change the numbers in the equations and they can see it instantly.

Mr. Smith: But, they need to know how to do it by hand too. How do you know if they can graph it? What would they do if they didn't have the calculator? I'm old school. I need to see that they can do it.

Mrs. Moore: Yeah. Me too I'm old school. I make sure they can graph it buy hand

Mr. Moore: But that's not what I'm looking for. That takes too much time if all I want them to see is a pattern. You saw how quick that Desmos thing changed the graphs! If I Just want them to see what happens when the coefficient of x^2 changes, why do I have to spend 20 minutes waiting on them to graph a bunch of equations on paper. It saves time, and they get it on the calculator.

Mr. Moore: But they aren't going to always have the something that can graph for them.

Mr. Johnson: Man, they have phones. Most of mine have smart phones and show me graphing apps all of the time. I bet they will have access to that before they have graph paper. When was the last time you saw someone walking around with graph paper?

Mr. Moore: Exactly!

This conversation shows that Mr. Moore held strong beliefs about the benefits of technology and some knowledge of how to use it during mathematics instruction. However, within this dialogue the primary person described using the technology is the teacher and not the students. This is evident in lessons implemented prior to the study which revealed that his students used technology to explore or demonstrate knowledge of mathematics concepts an average of 14% of the lessons. The only technology students used at this time were the TI 84 graphing calculators.

Barriers. The primary barrier impacting Mr. Moore's decision to increase the students' use of technology during instruction was time. Data analysis revealed 6 instances of Mr. Moore mentioning time as a barrier during his initial interview. Because THS changed from a four-period block schedule to seven 50-minute class periods, Mr. Moore often stated that he does not have enough time during the day to integrate a variety of activities. Additionally, Mr. Moore stated that his additional coaching and administrative responsibilities prevent him from learning the new technologies available.

A second barrier impacting Mr. Moore's decision to increase the students' use of technology during instruction was his knowledge of new technologies and how to integrate them into mathematics instruction. Data analysis of Mr. Moore's initial interview, initial observation debriefing, and data collected during the departmental workshop revealed five instances of Mr. Moore referring to this being a barrier. For example, Mr. Moore stated,

> I use technology all the time. But, I don't know how to use any of this new stuff with my students. Like, this summer at A+ training, the instructor mentioned something called Geogebra. I looked it up. It looked cool, but, I don't know how to use it. And, she didn't show us how to use it either.

Although Mr. Moore frequently used technology to demonstrate concepts (TI 84 graphing calculator and free online applets), he stated that he has difficulty creating or locating activities that allow students to use technology to explore concepts. Prior to participating in this study, Mr. Moore had participated in technology professional development. However, none of the professional development sessions focused specifically on integrating technology in mathematics instruction. The technology professional development focused on using Google classroom and another focused on the flipped classroom.

Technology integration. Mr. Moore frequently uses technology to assess student learning. When participants were asked how they have seen technology being used in the mathematics classroom, Mr. Smith, Mr. Johnson, and Mrs. brown that they liked how Mr. Moore used technology to assess student learning. Particularly, they each mentioned Mr. Moore's use of the Promethean Board and Activexpression student response system. Mr. Moore frequently uses these devises to grade students' quizzes, grade short multiple-choice tests, and assess students' knowledge of concepts. He stated that it saves time and paper. Additionally, he likes that he can quickly compare student responses and quickly determine concepts that students did not master.

Mr. Moore's beliefs and practices related to the use of technology during mathematics instruction during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices and technology integration are discussed.

Teaching practices. Mr. Moore reported that during the technology lessons, students seemed to enjoy leading the discussions. In particular, students like using Desmos on the Promethean Board. Additionally, Mr. Moore stated that he enjoyed being able to create and use lessons on teacher.desmos.com because it allowed him to be able to see each of the student's work on his screen. Additionally, he like being able to share students' work with the entire class and control the pace of the activity. For example, during the technology lesson Mr. Moore planned individually, he primarily stood in the back of the class with his iPad as students completed the circle patterns activity on Desmos. Throughout the lesson, Mr. Moore shared student responses and the student, or pair of students, whose response was being displayed was instructed to lead the discussion. Additionally, during the lesson, several students asked if their work could be displayed on the board. Mr. Moore stated that students preferred using Desmos for graphing multiple graphs rather than using the TI-84 graphing calculators. Many of his students downloaded the mobile app on their phone and used it during assignments. Although Mr. Moore did not discourage his students from using Desmos, he encourages students to continue to use the TI-84 graphing calculators in addition to Desmos because students were allowed to use it on the ACT.

Technology integration. Prior to the study, Mr. Moore used technology to demonstrate technology, however his students did not use technology to explore mathematics concepts as often as Mr. Moore. Mr. Moore held positive views related to technology use during mathematics instruction and desired to increase his students' use of technology during instruction. During the study, I assisted Mr. Moore with locating resources and provided him with additional professional development on how to use a variety of new technology resources with his students. As a result of participating in the professional development, Mr. Johnson experienced an increase in TPACK. He was able to select and assess the appropriateness of technology tools and plan activities that utilized those tools effectively. Mr. Moore experienced a significant increase in the percentage of lessons that required students to use technology to explore mathematics concepts. Mr. Moore planned and implemented more than the three technology-based lessons required for the study. Analysis of lesson plans from November 27th to March 23rd revealed an overall increase in student use of technology to explore concepts from 14% to 36% (see Table 12 and Table 13). Many of Mr. Moore's technology lessons were planned from activities presented in *Principles to Actions* (NCTM, 2014), Desmos Classroom Activities, textbook resources, and Texas Instruments.

Mr. Moore's final beliefs and practices related to the use of technology during mathematics instruction. Mr. Moore continued to believe that technology was beneficial to students learning mathematics. Mr. Moore attributed his increase in student use of technology during instruction to his participation in this study. During Mr. Moore's final interview, he stated, "this was the first time I was able to see how to use technology with my students. I liked that I could ask questions, and have you watch me do the activities. That helped a lot." Mr. Moore stated that he would continue to use several of the resources presented during the professional development. In particular, he stated that he would continue to use Desmos and Illuminations. Additionally, Mr. Moore stated that he would continue to plan activities with Mr. Johnson following the study. Analysis of lesson plans collected from April 2nd through May 24th revealed that 33% of his lessons included student use of technology to explore mathematics concepts. Although this was slightly lower than the percentage during the study (36%), this percentage was higher than the initial percentage of 14%.

Summary. In all phases of the situated professional development, Mr. Moore expressed high expectations expressed high expectations related to his students' mathematics abilities and behavior. He continued to express these beliefs throughout the study. Because Mr. Moore initially held positive beliefs related to his student, the study did not change his beliefs about students at THS. However, Mr. Moore reported that his students were more excited about mathematics during activities that integrated strategies and activities developed as part of the situated professional development. During the study, Mr. Moore began to integrate more student-centered practices. Additionally, low-level demand tasks decreased overall from 65% prior to the study to 52% during. After the study, the percent of low-level cognitive demand task increased slightly to 59%. Student use of technology also increased as a result of the situated professional development. Prior to the study, the percent of lessons that required students to use technology to explore mathematics content was 14%. This increased to 36% during the study. Following the study, the lessons that required student use of technology decreased slightly to 33%. However, this higher than the initial percent of lessons that required student use of technology. Although Mr. Moore frequently used technology to demonstrate, explore, and explain concepts prior to the study, teacher use of technology during mathematics instruction also increased as a result of the situated professional development. Prior to the study, the percent of lessons that required teacher to use technology to explore mathematics content was 68%. This increased to 77% during the study. Following the study, the lessons that required student use of technology decreased slightly to 67% (see Table 18). Percentages for technology use were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately. Similarly, percentages for the cognitive demand of tasks were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans for each time period.

Table 18

Moore Summary Table

	Before	During	After
Teaching Practices	TC	TC/SC	TC/SC
Student Use of Mathematical Action Technology	14%	36%	33%
Teacher Use of Mathematical Action Technology	68%	77%	67%
Overall Low-Level Cognitive Demand Tasks	65%	52%	59%
Expectations of Students	High	High	High

*TC – Teacher Centered, SC – Student Centered, TC/sc – Primarily Teacher Centered with some student-centered practices, TC/SC nearly equal amount of student and teacher centered practices

Case 5: Mrs. Taylor

Mrs. Taylor was a 34-year-old, white female mathematics teacher at PJHS. She received a bachelor's degree in elementary education from a public, nonprofit university in a neighboring state. While completing the degree and certification requirements for elementary education, Mrs. Taylor completed the mathematics courses required for students majoring in secondary mathematics education. As a result, Mrs. Taylor was granted teacher certification in elementary education for grades kindergarten through sixth grade and teacher certification in mathematics for grades six through twelve. At the time of the study, Mrs. Taylor had 8 years of teaching experience. She began her teaching career as a second grade teacher in a rural, low-income, predominately African America elementary school. She taught at this school for two years. Following this teaching position, Mrs. Taylor began teaching at an alternative high school in the same district as her prior school. Students were placed in this school as a result of negative behavior in the traditional high school. Students typically attended this school for a few weeks and returned back to their zoned high school. While teaching there, Mrs. Taylor was responsible for providing students with assistance on their mathematics assignments. The assignments students completed were provided by the students' teachers at their zoned high school. She remained in this position for two years. Mrs. Taylor returned to the traditional classroom setting in a rural, low-income, predominately African American elementary school in a neighboring school district. Mrs. Taylor taught third grade mathematics and science for 1 year and fifth grade language arts for 1 year. The following year, Mrs. Taylor accepted a teaching position at an alternative school in a neighboring city.

Students were assigned to this school as a result of behavior issues that occurred at their zoned school. This school serviced students in Grades K – 12. Mrs. Taylor's teaching responsibilities included providing mathematics assistance to students in Grades K – 6. Similar to the previous alternative school, Mrs. Taylor did not create the assignments for her students. She remained in this position for 1 year. The following year, Mrs. Taylor's husband received a job in the same state as PJHS. Mrs. Taylor applied for and received elementary teacher certification for Grades K-6. However, she did not receive teacher certification in mathematics for Grades 6 – 12 because she did not meet the state's licensure requirements at that time. She accepted a fifth grade mathematics teacher position at a K – 8 school in a large, urban, predominately African American school district. At the end of the school year, the district's school board chose not to renew the teaching contracts of all non-tenured teachers. This was a common practice within this district (AL.com, 2010; 2012; 2016). Many nontenured teachers were offered their positions back prior to the start of the next school year. However, Mrs. Taylor was not rehired. She decided to seek a teaching position in several school systems and was not extended an offer of employment. The technology coordinator for the school system in which PJHS is located was a friend of Mrs. Taylor's husband. He told Mrs. Taylor about the mathematics teaching position at PJHS. Mrs. Taylor applied and accepted the position. At PJHS, Mrs. Taylor taught eighth grade mathematics and eighth grade Algebra 1. At the time of the study, Mrs. Taylor had been teaching at PJHS for three months. This was her first experience as a full-time, secondary mathematics teacher responsible for planning and facilitating mathematics instruction.

Mrs. Taylor's beliefs about PJHS students. In this section, Mrs. Taylor's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs and practices will be discussed based on the following continuum: initial beliefs and practices related to the teaching and learning of mathematics prior to the situated professional development, beliefs and practices related to the teaching and learning of mathematics during the situated professional development, and beliefs and practices related to the teaching and learning of mathematics at the end of situated professional development.

Mrs. Taylor's initial beliefs about PJHS students. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations of students will be discussed.

Expectations. Mrs. Taylor expressed high expectations for her students. Data analysis of Mrs. Taylor's initial interview, initial observation and debrief, and departmental workshop revealed 12 instances of Mrs. Taylor expressing high expectations and positive beliefs about her students. For example, Mrs. Taylor stated, "my students are hands down the best students I have ever taught as far as being respectful and having good behavior. And, they know I expect them to try their hardest at all times." Although Mrs. Taylor, had high expectations for her students, she also believed that many of her students had low mathematics abilities due to not having a mathematics teacher in pervious grades, mathematics teachers leaving the system during the school year, or students being placed in courses that they were not mathematically prepared to successfully complete. For example, Mrs. Taylor stated that 12 of the 20 students in her eighth-grade algebra 1 class were enrolled in seventh grade mathematics the previous school year instead of seventh grade pre-algebra. Those students were place in her eighth-grade algebra 1 class because they received high scores on the previous year's state assessment and earned either an A or B in seventh grade mathematics.

Mrs. Taylor's beliefs about PJHS students during and after the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations of students will be discussed.

Expectations. Mrs. Taylor continued to express high expectations for her students. Data analysis of Mrs. Taylor's observations, debriefs, and department meetings revealed 10 instances of Mrs. Taylor expressing high expectations and positive beliefs about her students. For example, Mrs. Taylor stated, "I know my students can do well in math if they had the opportunity. Many of my students did not have math teachers in other grades. So that may have set them back a bit." Because Mrs. Taylor did not have low expectations for her students, the study had no impact on changing her beliefs about her students. Any deficiencies in students' mathematics abilities were attributed to students' lack of exposure to effective mathematics teachers and not to characteristics of the students.

Mrs. Taylor's beliefs and practices related to the teaching and learning of mathematics. In this section, Mrs. Taylor's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs and practices will be discussed based on the following continuum: initial beliefs and practices related to the teaching and learning of mathematics prior to the situated professional development, beliefs and practices related to the teaching and learning of mathematics during the situated professional development, and beliefs and practices related to the teaching and learning of mathematics at the end of the situated professional development.

Mrs. Taylor's initial beliefs and practices related to the teaching and learning of mathematics. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Mrs. Taylor's teaching practices were primarily teacher-centered with a procedural focus. Data analysis of data collected during Mrs. Taylors initial interview, initial observation debriefing, and departmental workshop revealed 11 instances of Mrs. Taylor referring to teacher-centered practices and only 3 instances of student-centered practices. For example, Mrs. Taylor stated that she believed students learned best if they "[saw] the problems being worked out." She believed that it was beneficial for students to see her "solve the problems in as many ways as possible." She also believed that it would be beneficial for students to engage in more student led discussions. However, Mrs. Taylor stated that she needed to learn how to facilitate those discussions more effectively. When asked to describe a typical lesson in her classroom, Mrs. Taylor stated that she began her lessons with a bell ringer. Two weeks prior to Mrs. Taylor's initial interview, she decided to change the bell ringer to problems similar to the previous days lesson. Previously, the bell ringer was used to review mathematics skills from prior grades that were not directly connected to the lesson being taught. Following the bell ringer, Mrs. Taylor stated that she worked several examples. She then assigned several similar problems to students for them to work individually or with a partner. While students completed the assignment, Mrs. Taylor stated that she "[called] four or five students to a table to assist them with their assignment." She stated that this "allowed [her] to see exactly how students were working each problem." Working with students in this manner generally lasted for 20 minutes of the 50-minute class period. Mrs. Taylor stated that she decided to integrate this practice after observing a mathematics teacher at a middle school in a neighboring county. Additionally, students were allowed to work on assembling jigsaw puzzles, rather than the assignment, until their group was called to the table with Mrs. Taylor. She believed allowing students to assemble jigsaw puzzles "taught problem-solving skills" and "decreased behavior issues." This pattern was observed during Mrs. Taylor's initial observation of her eighth grade Algebra 1 class. Mrs. Taylor began her lesson with the following bell ringer:

Basic One Step Equations Type #1	Basic One Step Equation Type #2
$x + 9 = 19$	$7x = 63$
$x - 9 = 19$	$\frac{x}{7} = 5$

After solving both equations, Mrs. Taylor informed students that they were going to begin solving two-step equations. The following conversation took place:

Patrick: Why are we still doing this? We already know how to do two-step equations.

Mrs. Taylor: I know some of you know how to do this. But, some don't. I want to be sure you can do this before we get to more complicated equations.

Patrick: Ok, Mrs. Taylor. Can I just do the hard ones?

Mrs. Taylor: No Patrick. I want everyone to be on the same page with this.

Following this exchange, Patrick put his head on the desk until Mrs. Taylor passed out the assignment. This shows that Mrs. Taylor was not meeting the individual needs of her students. Additionally, students were not encouraged to be active participants in the lesson. Mrs. Taylor distributed a handout for the lesson. Next, Mrs. Taylor continued with her explanation of procedures to solve two-step equations. She displayed the equation 5x + 3 = 23 on the Promethean board. She then stated, "look at this equation. Do you see that it is similar to type 1 and type 2? It's just like a combination of both types. To solve it, just do what we did for both types." Mrs. Taylor proceeded to solve the equation and several similar equations. During the lesson, I noticed that no students were writing anything on the handout. During the lesson debrief, Mrs. Taylor stated that she provided students with worked out examples because she "wanted students to focus on what she was saying and not focusing on writing things down." She started this practice a few weeks after the school year began because she believed it was more beneficial for students to see her working the problems rather than "filling in notes." Once Mrs. Taylor completed solving several examples, she passed out a worksheet with several two-step equations and began calling groups of four students to a table in the back of the classroom. While students were working with Mrs. Taylor, many of the remaining students were not completing the assignment. During the debrief, Mrs. Taylor stated that it was common for students to wait until they were called back to the table to begin working on the assignment. She believed that students felt more comfortable attempting assignments when she was "there to walk them through it." This shows that many of Mrs. Taylor's students had become learned helpless. Although, Mrs. Taylor often expressed beliefs coded as high expectations for students, her teaching practices indicated that she did not provide students with opportunities to explore mathematics without tasks being overly scaffolded.

Task selection. The tasks chosen by Mrs. Taylor were primarily low-level cognitive demand tasks that focused on procedures. Analysis of lesson plans from August 9 through

November 17th revealed that overall 84% of the tasks implemented in Mrs. Taylor's class were low-level cognitive demand tasks (see Table 19). Low-level cognitive demand task accounted for 81% of the task in eighth grade mathematics and 86% of the tasks in eighth grade Algebra 1. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 19

Taylor Lesson Plans Analysis from August 9 to November 17

Subject	Level of Cognitive Demand	Frequency
Eighth grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	48
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	11
	Students Use Technology to Explore/Demonstrate Concept	2
	Teacher Uses Technology to Explore/Demonstrate Concept	5
Eighth grade Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	53
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	8
	Students Use Technology to Explore/Demonstrate Concept	3
	Teacher Uses Technology to Explore/Demonstrate Concept	4

According to Mrs. Taylor, she planned lesson for both classes by following a pacing guide developed four years prior to the study by curriculum and instruction administrators at the central office with input from middle school mathematics teachers. She primarily chose her activities from the textbook. Mrs. Taylor stated that she tried to implement lessons found on the state's Learning Exchange and Better Lessons websites. However, she stated that she did not effectively implement those lessons. Additionally, Mrs. Taylor did not participate in the Laying the Foundations training organized by A+ College Ready because she was hired two days after the start of the school year.

Collaboration. Analysis of Mrs. Taylor's initial interview, initial observation debriefing, and departmental workshop revealed 9 references to the benefits of collaborating with colleagues and other mathematics teachers. Mrs. Taylor believed that she learned best by observing and being observed by mathematics teachers. Prior to the participating in the study, Mrs. Taylor used two personal development days to observe a middle school mathematics teacher in a neighboring county. Although the student population was not similar to that of PJHS, Mrs. Taylor believed that the practices she observed would be beneficial to her students. Additionally, Mrs. Taylor occasionally asked Mrs. Wallace, another participant in the study and mathematics teacher at PJHS, to show her different ways to solve mathematics problems and possible misconceptions student might have for lessons that she planned to teach. Mrs. Taylor expressed interest in collaborating on lessons with Mrs. Wallace. However, due to Mrs. Wallace's teaching schedule at that time, collaborating on lessons was not possible.

Mrs. Taylor's beliefs and practices related to the teaching and learning of mathematics during situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, self-efficacy, and collaboration will be discussed.

Task selection. Analysis of lesson plans from November 27th through March 23rd revealed an overall decrease in percent of low-level cognitive demand tasks from 84% to 68% (see Table 20). The percent of low-level cognitive demand tasks decreased from 81% to 65% in Mrs. Taylor's eighth grade mathematics course and decreased from 86% to 71% in her eighth grade Algebra 1 course. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 20

Taylor Lesson Plans Analysis from November 27 to March 23

Subject	Level of Cognitive Demand	Frequency
Eighth grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	39
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	21
	Students Use Technology to Explore/Demonstrate Concept	12
	Teacher Uses Technology to Explore/Demonstrate Concept	15
Eighth grade Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	44
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	18
	Students Use Technology to Explore/Demonstrate Concept	11
	Teacher Uses Technology to Explore/Demonstrate Concept	13

Although Mrs. Taylor continued to plan her lessons primarily from the school's pacing guide, she began to integrate more activities from NCTM's PTA Toolkit, Illuminations, state's Learning Exchange, Better Lessons, Desmos, and Texas Instruments.

Teaching practices. During the situated professional development, Mrs. Taylor implemented more student-centered teaching practiced. Analysis of Mrs. Taylor's planning sessions, observations, observation debriefs, and departmental meetings revealed 17 coded instances of Mrs. Taylor incorporating or referencing student-centered practices. For example, during the planning sessions for Mrs. Taylors first technology lesson, Mrs. Taylor stated, "I want to get to the point where my students can explain their work to the class." She wanted to integrate more student discourse because she believed that she was "dominating the majority of the discussions." She believed her students were not comfortable presenting information to the class. I encouraged her to provide opportunities throughout the lesson for students to present their thinking to the class. During the observation of Mrs. Taylor's first lesson, Mrs. Taylor allowed students to place their group's iPad under the document camera to share their strategies for solving multi-step equations. The lesson required students to use the interactive, virtual Algebra Balance Manipulative. Mrs. Taylor purchased the application with instructional funds for 10 iPads. Mrs. Taylor began to allow students to present their thinking in lessons that were not part of the situated professional development. Additionally, she ended her practice of calling students to the table in the back of the room. She stated that this practice "became overwhelming". She believed that she spent a lot of time repeating information, and she often ended her whole group instruction before she presented all of the material to ensure she had time to call each group to the table. Additionally, she believed that many of her students were not paying attention during the lesson because "they knew [she] was going to reexplain it during the small group meeting." Mrs. Taylor also decreased the number of lessons where she passed out a handout of completed examples. She replaced both of the aforementioned practices with allowing students to complete tasks in small groups followed by each group presenting their solutions to the class. She found that doing this increased student engagement in her lessons.

Self-efficacy. Throughout the situated professional development, Mrs. Taylor expressed concerns about her abilities to teach the content effectively. Analysis of data collected from Mrs. Taylor's planning sessions, observations, observation debriefs, and departmental meeting revealed 12 coded instances of low self-efficacy. For example, Mrs. Taylor stated, "I just want to do a good job, and sometimes I don't think I'm doing as good as I would like. It's hard. But, I'm willing to try new things." Mrs. Taylor often expressed difficulties with creating lessons and teaching the mathematical content. She believed she was having difficulties because this was her first-year teaching middle school mathematics. Prior to this school year, her mathematics teaching experiences included elementary mathematics (2nd, 3rd, and 5th grades) and assisting students placed in alternative school settings. Additionally, she had not participated in any professional development sessions focused on mathematics instruction at the secondary level. Although she received initial teacher certifications from a neighboring state in elementary education (K- 6, all subjects) and secondary mathematics for grades 6 – 12 upon graduation, she was not required to take the secondary education methods courses or complete an internship in a secondary mathematics classroom. She was able to obtain both certification in this state through reciprocity for elementary certification and passing the required Praxis II exams for secondary mathematics.

Collaboration. During the situated professional development, Mrs. Taylor increased the amount of time spent collaborating with Mrs. Wallace. The week following the departmental workshop, Mrs. Taylor and Mrs. Wallace began planning lessons that integrated the resources presented during the workshop. As a part of the situated professional development, Mrs. Taylor was only required to plan one technology-based lesson with Mrs. Wallace. However, Mrs. Taylor and Mrs. Wallace planned an entire unit on rate of change and slope. Lessons within the unit required the use of CBR, Desmos, and the TI 73 Explorer graphing calculators (see page 74). Also, Mrs. Taylor requested additional planning sessions to become more familiar with the features of the TI 73 Explorer graphing calculator and the TI-30XS Multiview Scientific Calculator. As a result, Mrs. Taylor, with assistance from Mrs. Wallace modified and implemented several Laying the Foundation activities that required the use of the more advanced TI 84 graphing calculator.

Mrs. Taylor's final beliefs and practices related to the teaching and learning of mathematics. As a result of the situated professional development, Mrs. Taylor expressed interest in continued collaboration with Mrs. Wallace for the remainder of the school year. Additionally, Mrs. Taylor continued to integrate lessons that utilized student use of technology and integrate less low-level cognitive demand tasks. Lesson plan analysis of lessons completed after Mrs. Taylor's final interview revealed a minimal increase in overall use of low-level cognitive demand tasks from 68% to 69% (see Table 21). However, the overall percent of low-cognitive demand tasks was lower than the initial 84%. In eighth grade mathematics, the percent of low-cognitive demand tasks increased from 65% during the study to 68% after the study. This was still lower than the initial 81%. Additionally, in eighth grade Algebra 1, the percent of low-cognitive demand tasks decreased slightly from 71% during the study to 70% after the study. Similarly, this percentage was lower than the initial 86%. Although Mrs. Taylor stated that she enjoyed teaching the students at PJHS, she planned to return to the elementary setting. At the end of the school year, Mrs. Taylor accepted a full-time, 5th grade teaching position at a rural, predominately white, school in the same county as PJHS. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 21

Taylor Lesson Plans Analysis from April 2 to May 24

Subject	Level of Cognitive Demand	Frequency
Eighth Grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	21
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	10
	Students Use Technology to Explore/Demonstrate Concept	6
	Teacher Uses Technology to Explore/Demonstrate Concept	7
Eighth Grade Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	19
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	8
	Students Use Technology to Explore/Demonstrate Concept	7

Mrs. Taylor's beliefs and practices related to the use of technology during mathematics instruction. In this section, Mrs. Taylor's beliefs and practices related to the use of technology during mathematics instruction are discussed. Beliefs and practices will be discussed based on the following continuum: initial beliefs and practices related to the use of technology during mathematics instruction prior to the situated professional development, beliefs and practices related to the use of technology during mathematics instruction while participating in the situated professional development, and beliefs and practices related to the use of technology during mathematics instruction at the end of the situated professional development.

Mrs. Taylor's class was equipped with a Promethean Board, mounted LCD projector, 1 desktop computer, document camera, class sets of calculators (4-function, TI-73 Explorer, and TI-30XS), a teacher laptop, and wired and wireless internet. Additionally, Mrs. Taylor had access to the mathematics department's iPad cart and a Chromebook cart.

Mrs. Taylor's initial beliefs and practices related to the use of technology during mathematics instruction. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to the benefits of technology, technology integration, and barriers to technology integration will be discussed.

Benefits. Mrs. Taylor believed that technology use during mathematics instruction was beneficial to students. Analysis of data collected during Mrs. Taylor's initial interview, initial observation and debrief, and departmental workshop revealed 7 references to the positive benefits of technology for students during mathematics instruction. For example, Mrs. Taylor stated, “some technology tools can allow students to see why and how some [mathematics] concepts work.” Although there were 7 coded references to the benefits of technology, 5 of the 7 references were related to assessment after mathematics concepts were taught or managing the classroom. For example, she believed that technology was beneficial in assessing student learning and increase student engagement. She believed her students were more engaged in the mathematics lesson when she used Kahoot! to review concepts prior to a test. Kahoot! is a free, game-based platform that allows teachers to create multiple choice questions (or select from pre-made Kahoots) for students to answer using their electronic device in a competitive manner. Additionally, she stated that programs like Edulastic allowed her to assess students’ mathematical abilities and track their progress. Edulastic is an online assessment system (Edulastic.com, 2018).

Technology integration. Although Mrs. Taylor believed student use of technology during mathematics instruction was beneficial to students’ learning, she did not integrate technology often during mathematics instruction. Analysis of lesson plans from August 9th through November 17th revealed overall student use of technology to explore mathematics concepts occurred in only 4% (2 in eighth grade mathematics and 3 in eighth grade Algebra 1) of the planned lessons (see Table 15). Additionally, only 8% (5 in eighth grade mathematics and 4 in eighth grade Algebra 1) of the planned lessons integrated the teacher’s use of technology to explore or demonstrate mathematics concepts. Mrs. Taylor also used Google Classroom to assign students assessments on Edulastic and provided additional study material from Khan Academy. Additionally, Mrs. Taylor uploaded class notes to Google Classroom.

Barriers. There were many barriers that prevented Mrs. Taylor from incorporating technology to explore mathematics concepts into her teaching practices. The most significant barriers were internal barriers. Unlike other teachers at PJHS, Mrs. Taylor did not experience technical issues regarding internet connectivity or faulty classroom wiring. Analysis of data collected during Mrs. Taylors initial interview, departmental workshop, and initial observation debrief revealed that the most significant barriers were knowledge of technology (8 coded instances) and confidence (5 coded instances). For example, Mrs. Taylor stated that she did not feel comfortable using some of the technology tools because she did not know how to use them. She only had experience using graphing calculators in her high school and undergraduate mathematics courses. Additionally, she was not familiar with current mathematics specific technology program and applications. During Mrs. Taylor's teacher undergraduate teacher education program and during her teaching career, she did not participate in any secondary mathematics specific, technology-based professional development or methods courses. During the departmental workshop, Mrs. Taylor stated that she wanted me to provide her with additional assistance with learning the different features of Desmos, TI-73 Explore graphing calculator, and TI-30XS Multiview scientific calculator (see page 74).

Mrs. Taylor's beliefs and practices related to the use of technology during mathematics instruction during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to the benefits of technology, technology integration, and overcoming barriers to technology integration will be discussed

Benefits. Throughout the study, Mrs. Taylor express positive views regarding the benefits of technology. Analysis of data collected from Mrs. Taylor's observations, observation debriefs, and departmental meetings revealed 10 instances of Mrs. Taylor expressing positive views about teacher and student use of technology during instruction. For example, during the debrief of her second observation, Mrs. Taylor stated, "my students were way more engaged with the lesson. I was impressed that they were using the right words when talking about the properties." The lesson required students to use an interactive pan balance to solve multi step equations with variables on both sides. We decided to develop a technology-based lesson for this concept because Mrs. Taylor stated during her initial interview, "I know technology can be helpful. I just don't know how to use it with a lot of concepts. Like, how do you use it to teach solving equations. I just don't know." During this lesson, students solved multi-step equations with variables on both sides by placing colored tiles on a balance that corresponded with each term in the equations. As students manipulated the tiles on the balance, the scale tilted when the result of their actions caused the equations to be unbalanced. Students completed the activity in pairs or groups of 3. As a result of this activity, students were also able to correct a misconception that many of them had. During the student presentations the following dialogue occurred:

> Students were solving the following equation: $4x - 9 = 7x + 6$. Parker and Ashley were presenters.
>
> Parker: First, we moved these tiles (the tiles representing 4x) to the other side. But that made the scale not be even.
>
> Janay: That's because you can't move the x's first.

Parker: Yes you can! We just did it wrong. We didn't use the zero pair thing like we did with the other problem.

Janay: I thought you always had to do the regular numbers first.

Mrs. Taylor: What are those terms called?

Ashley: Constant terms. We don't have to move those first.

Janay: When we did the other problems the other day, Mrs. Taylor said do the add and subtract terms first.

Parker: Those didn't have the x on both sides.

Janay: Does it matter?

Parker: We got the same answer they (pointing to Jason and Josh) got. They got rid of the constants first, and we didn't.

Mrs. Taylor: Parker finish showing us how you solved it. Then, Jason and Josh can show us how they solved it, and we'll see if it matters.

Mrs. Taylor believed this activity was more beneficial to her students understand of solving equations. In previous lessons, Mrs. Taylor provided students with the steps necessary to solve equations, and there was minimal student discussion and engagement. Similarly, increased student engagement and greater understanding of mathematics concepts were reported benefits from Mrs. Taylor's additional technology-based lessons. Analysis of data from observation debriefs and departmental meetings revealed 7coded references to increased student engagement and 6 coded references to greater understanding of mathematics concepts.

Technology integration. As a result of participating in the professional development, Mrs. Taylor experienced an increase in TPACK. She was able to select and assess the appropriateness of technology tools and plan activities that utilized those tools effectively. As a result, Mrs. Taylor planned and implemented more than the three technology-based lessons required for the study. Analysis of lesson plans from November 27th through March 23rd revealed an increase in use of technology to explore concepts. During the study, overall student use of technology increased from 4% lessons to 19% (see Table16). Mrs. Taylor planned and implemented 12 lessons in eighth grade mathematics and 11 lessons in eighth grade Algebra 1 that required the students' use of technology to explore mathematics. In addition to an increase in students' use of technology, lessons that required the teacher's use of technology increased from 8% to 23%. Mrs. Taylor planned and implemented 15 lessons in eighth grade mathematics and 13 lessons in eighth grade Algebra 1 that required the student use of technology to explore mathematics.

Overcoming Barriers. During the study, Mrs. Taylor believed she was improving her knowledge of technology resources to teach mathematics concepts and becoming more comfortable using them with her students. Analysis of data collected during lesson debriefs and departmental workshops revealed 4 coded references to becoming more confident and 5 coded references to improved knowledge of technology resources. During the study, Mrs. Taylor participate in additional planning sessions with me to improve her knowledge of available technology resources. Additionally, during departmental meetings, Mrs. Taylor discussed resources she found online and activities that she implemented in her classroom with the other mathematics teachers at PJHS. She believed being able to discuss her issues and receive feedback were the most beneficial aspect of her improving her self-efficacy regarding technology implementation and improving her knowledge of technology resources.

Mrs. Taylor's final beliefs and practices related to the use of technology during mathematics instruction. Analysis of Mrs. Taylor's final interview revealed that she planned to continue to integrate technology into her teaching practices. Additionally, she planned to continue to collaborate with Mrs. Wallace on activities to implement with her students. Analysis of Mrs. Taylor's lesson plans from April 2nd through May 24th revealed that she continued to integrate activities that required students to use technology to explore mathematics in all of her classes. The percent of lessons that required students to use technology overall increased slightly from 19% to 22%, which is significantly higher than the percent of student technology prior to the study, which was 4%.

Summary. In all phases of the situated professional development, Mrs. Taylor expressed high expectations related to her students' mathematics abilities and behavior. However, her teaching practices often did not reflect those beliefs. As the study continued, Mrs. Taylor's teaching practices began to align with her expressed beliefs about her students. However, Mrs. Taylor reported that her students were more engaged and developed a deeper understanding of mathematics concepts during activities that integrated strategies and activities developed as part of the situated professional development. During the study, Mrs. Taylor began to integrate more student-centered practices. Additionally, low-level demand tasks decreased overall from 84% prior to the study to 68% during. After the study, the percent of low-level cognitive demand task increased slightly to 69%. Student use of technology also increased as a result of the situated professional development. Prior to the study, the percent of lessons that required students to use technology to explore mathematics content was 4%. This increased to 19% during the study. Following the study, the lessons that required student use of technology increased slightly to 22%. Prior to the study, the percent of Mrs. Taylor's lessons that required the teacher to use technology to explore mathematics content was 8%. This increased to 23% during the study. Following the study, the lessons that required student use of technology increased slightly to 24% (see Table 22). Percentages for technology use were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately. Similarly, percentages for the cognitive demand of tasks were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans for each time period.

Table 22

Taylor Summary Table

	Before	During	After
Teaching Practices	TC	TC/SC	TC/SC
Student Use of Mathematical Action Technology	4%	19%	22%
Teacher Use of Mathematical Action Technology	8%	23%	24%
Overall Low-Level Cognitive Demand Tasks	84%	68%	69%
Expectations of Students	High*	High*	High*

*TC – Teacher Centered, SC – Student Centered, TC/sc – Primarily Teacher Centered with some student-centered practices, TC/SC nearly equal amount of student and teacher centered practices

Case 6: Mrs. Wallace

Mrs. Wallace was a 61-year-old, African American female mathematics teacher at PJHS. She attended elementary, middle, junior high, and high school in the same school system as PJHS. She has a bachelor's degree in mathematics from a private, Christian university in the southern region of the state. Additionally, she has a master's degree in secondary mathematics education from a public university located in the central region of the state and an educational specialist degree in secondary mathematics education from a public university located in the western region of the state. After receiving her bachelor's degree, Mrs. Wallace became a 6th grade assistant computer instructor and mathematics tutor at a middle school in the same school system as PJHS and THS. She continued in this position for eight years. After receiving her master's degree, Mrs. Wallace accepted a full time, mathematics teaching position at PJHS. At the time of the study, Mrs. Wallace had been teaching seventh and eighth grade mathematics courses at PJHS for 26 years. During the study, Mrs. Wallace taught seventh grade mathematics, seventh grade prealgebra, eighth grade mathematics, and eighth grade Algebra 1. As a result of another mathematics teacher leaving after the school year began, Mrs. Wallace taught on an alternating schedule from August 28th until October 13th. This schedule required Mrs. Wallace to alternate the days she provided instruction to her scheduled students and the students of the teacher that left the system. For example, she provided instruction to her students on Monday, Wednesday, and Friday and provided instruction to the other students on Tuesday and Thursday. The following week, the days switched. During the days that she was not providing instruction, students completed assignments based on the previous day's lesson. Additionally, Mrs. Wallace's first period class contained seventh grade and eighth grade students. Because of this, the first half of the class period was used to teach seventh grade mathematics content and the second half of the class period was used to teach eighth grade mathematics content.

Mrs. Wallace decided to become a mathematics teacher because she enjoyed working with the students while employed as an assistant computer instructor and mathematics tutor. Like Mr. Moore and Mr. Johnson, Mrs. Wallace believed that she could have a positive impact on the students from their community. In addition to teaching seventh and eighth grade mathematics courses, Mrs. Wallace served as the mathematics department head, chess lead teacher, assistant archery coach, RTI team leader, and RTI mathematics remediation teacher.

Mrs. Wallace's beliefs about PJHS students. In this section, Mrs. Wallace's beliefs about her students and their ability to learn mathematics are discussed. Beliefs will be discussed based on the following continuum: initial beliefs about students prior to the situated professional development, beliefs about students during the situated professional development, and beliefs about students at the end of the situated professional development.

Mrs. Wallace's initial beliefs about PJHS students. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to student tracking and testing, expectations, and parental support will be discussed.

*Tracking and testing***.** Mrs. Wallace believed that her students were unfairly grouped into mathematics courses. According to Mrs. Wallace, her students were assigned to mathematics courses based primarily on the results of standardized test results from students' sixth grade academic year. Students with the highest test scores were placed in seventh grade pre-algebra. The remaining students were place in seventh grade mathematics. Within the seventh-grade mathematics courses, students were grouped according to their test scores and teacher recommendations. Students with the lowest scores were grouped together. Students generally continued in the same track in the eighth grade. Seventh grade prealgebra students progressed to eighth grade Algebra 1. All others were assigned to eighth grade mathematics. Students enrolled in seventh grade prealgebra and eighth grade Algebra 1 were classified as "advanced students". Analysis of Mrs. Wallace's initial interview and data collected during the departmental workshop revealed 5 instances of Mrs. Wallace stating that this practice has negative effects on her students. She believed that her seventh and eighth grade mathematics students used their placements as an excuse when they were unable to complete a mathematics task. For example, Mrs. Wallace stated that her lower level students often compared themselves to the advanced students with statements such as, "I'm not in your 6th period class." The expression of students' low self-efficacy and comparisons to advanced students was observed during the initial observation. A female student stated, "my sister is in your advanced class, and she couldn't do this. If she can't then I know I can't. This is hard."

Mrs. Wallace believed that the students at PJHS were subjected to an excessive amount of testing. Data analysis revealed 7 instances of Mrs. Wallace expressing this belief. At the end of the previous school year, Mrs. Wallace and two teachers who serve on the school's RTI team calculated the amount of instructional time used for testing. They found that the amount of test time some students experienced was equivalent to the 40 instructional days. The mathematics and English departments administered benchmark exams every four and a half weeks. Students who did not perform well on the benchmarks were pulled from their 3rd period class once or twice a week for 30 minutes to receive remediation. After students received remediation, they were retested using the same benchmark exam. This process continued throughout the school year. Students were also tested twice a year using Scantron's Performance Series. Performance Series is a web-based, computer adaptive assessment platform (Scantron.com, 2018). Additionally, the week prior to the state assessment, all core academic teachers reviewed skills that were going to be tested on the assessment and reviewed test taking strategies.

Expectations. Mrs. Wallace had high expectations for all of her students. Data analysis of Mrs. Wallace's initial interview, initial observation and debrief, and departmental workshop revealed 7 instances of Mrs. Wallace expressing high expectations for her students and only 1 instance of a negative belief about students. For example, Mrs. Wallace stated that she believed most of her students could "think and have excellent minds." She expected all of her students to be active participants in her classroom. The only negative belief expressed by Mrs. Wallace regarding the students was in reference to students completing homework. She believed that her students did not believe studying and completing homework were important. As a result, many of her students did not complete homework assignments or take study materials home prior to a major class assessment.

Mrs. Wallace believed that it was her responsibility to motivate her students and provide them with positive experiences in her mathematics classroom. As a result of this belief, Mrs. Wallace had a variety of positive quotes posted on the wall of her classroom. Additionally, Mr. Wallace posted pictures of her students with positive statements about mathematics. The positive statements about mathematics were written by the students. Each student was required to come up with a positive statement about mathematics or how they have used mathematics. For example, under one female student's picture was the statement, "I can use math to help me figure out how much money I want to make." Another male wrote, "We would not have all this technology without math." Mrs. Moore stated that she had students write positive statements about mathematics because she wanted her students to understand that mathematics was beneficial and to change any negative beliefs students had related to mathematics.

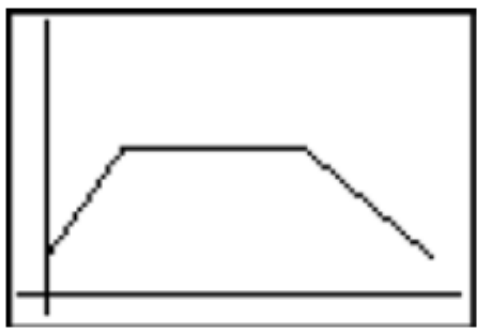
Parental support. Mrs. Wallace believed that parental support was important to students' success in her mathematics classroom. Analysis of Mrs. Wallace's initial interview revealed 4 references to parental support and student success. Mrs. Wallace believed that her relationship with the parents of her students was instrumental in her being able to resolve any issues she experienced with students. Because Mrs. Wallace grew up in the same community as PJHS students, continued to live in the community, and taught many of her students' guardians, parents and grandparents, they were familiar with her expectations of students and were cooperative and supportive when their assistance was requested.

Mrs. Wallace's beliefs about PJHS students during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to expectations of student will be discussed.

Expectations. Throughout the study, Mrs. Wallace continued to express high expectations for her students. Data analysis of data collected during Mrs. Wallace's planning sessions, debrief interviews, and departmental meetings revealed 19 references to positive expectations of students. For example, when planning the first technology lesson with Mrs. Wallace, she stated "I think they will be able to do this. They'll like it too."

Mrs. Wallace was referring to the students being able to successfully complete the probability activity and using the TI 73 Explorer graphing calculators to run probability simulations. Throughout the study, Mrs. Wallace stated that she often encouraged students to "give their best effort" when students became discouraged during class. This was observed several times during the study. For example, during the second technology lesson for this study, a group of students became frustrated because their group was having trouble completing the third graph using their CBR. Students were required to use their CBR to recreate the graph below:

Figure 12. Problem 3: CBR Activity



Mrs. Wallace approached the group and the following conversation took place:

> Mrs. Wallace: Hey. Why are we sitting down? What's going on?
>
> April: We don't get it. We'll just wait until you go over it.
>
> Mrs. Wallace: So, you're just going to give up? What did you try?
>
> April: We tried everything. Nothing worked so we quit.
>
> Mrs. Wallace: You quit! We don't quit in here. If you quit every time something is hard, you'll never get anything done. I know y'all can figure this out. Show me what you tried.
>
> David: (laughing) Mrs. Wallace, we did everything except just stand here.

Mrs. Wallace: Well, how do you think that would affect the graph?

David: I was joking. Don't you have to move for this thing to work?

Mrs. Wallace: That's a good question. Try it and let me know how it works.

This is an example of Mrs. Wallace helping her students persevere. Encouraging students to persevere when presented with a challenge is something that Mrs. Wallace had found to be increasingly more difficult. According to Mrs. Wallace, she has seen an increase in the number of students that stop trying when presented with a nonroutine or challenging task. She attributed this to a high turnover rate of teachers in the earlier grades. Many of her students experienced being without a classroom teacher in core subjects at some point during their prior academic years. For example, during the previous school year, several of her seventh-grade students were without a full-time 6th grade mathematics and science teacher. As a result, students were used to completing simple assignments that required students to perform a specific algorithm to obtain a correct solution. Therefore, Mrs. Wallace believed that encouraging students to persevere was challenging.

Mrs. Wallace's beliefs about students at the end of the situated professional development. Prior to the situated professional development, Mrs. Wallace held positive beliefs about her students. She believed that her students were able to be successful in mathematics with the proper support. Because she had positive beliefs about her students prior to the participating in this study, the situated professional development did not change those beliefs. However, Mrs. Wallace was able to provide her students with opportunities to explore mathematics and challenge themselves in ways many of them had not experienced prior to the situated professional development.

Mrs. Wallace's beliefs and practices related to the teaching and learning of mathematics. In this section, Mrs. Wallace's beliefs and practices related to the teaching and learning of mathematics are discussed. Beliefs and practices will be discussed based on the following continuum: initial beliefs and practices related to the teaching and learning of mathematics prior to the situated professional development, beliefs and practices related to the teaching and learning of mathematics during the situated professional development, and beliefs and practices related to the teaching and learning of mathematics at the situated professional development.

Mrs. Wallace's initial beliefs and practices related to the teaching and learning of mathematics. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to teaching practices, task selection, and collaboration will be discussed.

Teaching practices. Mrs. Wallace used both teacher-centered and student-centered practices. Data analysis of data collected during Mrs. Wallace's initial interview, initial observation debriefing, and departmental workshop revealed 14 instances of Mrs. Wallace referring to student centered practices. For example, Mrs. Wallace stated that she believed students learned best by "participating in cooperative groups", "presenting material to the class", and "working with partners". When asked to describe a typical lesson in her classroom during her initial interview, Mrs. Wallace stated that she typically begins with a bell ringer that is related to a previous lesson, current lesson, or upcoming benchmark. Following the bell ringer, Mrs. Wallace introduced the concept and relevant vocabulary. Then, Mrs. Wallace and her students worked through several examples. Once they worked through examples, Mrs. Wallace assigned problems for students to work in their groups. Sometimes the groups have the same problems and sometimes the problems are different for each group. Once each group has completed its problem, each group presents its solutions to the class. This pattern was also observed during Mrs. Wallace's initial observation. Mrs. Wallace began her lesson with a bell ringer reviewing the simplifying expressions by combining like terms and the distributive property. Students were instructed to simplify the following expressions: 3(6x – 9) and 8x + 10x - 27. As students worked on the problem, Mrs. Wallace walked around and checked their homework for completion. Once all students' homework was checked, Mrs. Wallace completed the example presented during the bell ringer. She asked students if anyone had an answer different from 18x – 27. Two students stated that their answers were different. After the two students shared their answers and identified their mistakes, Mrs. Wallace asked students to compare the resulting expression to the original expression. Students were asked if they could prove that the two expressions were equivalent. Several students suggested substituting a number for x in both expressions. After soliciting possible values to substitute for x, Mrs. Wallace chose to substitute 1 for x. After showing that substituting 1 for x resulted in -9 for both expressions, Mrs. Wallace asked students to write 3 expressions that resulted in -9 if they substituted 1 for the variable. Students completed this task in groups of 3. After each group completed the task, one member from each group presented at least one of the group's expressions to the class. Following this activity, students were assigned problems from their textbook to complete. These problems required students to simplify and evaluate expressions.

Task selection. Although Mrs. Wallace used both teacher-centered and student-centered practices, the tasks chosen in her class were primarily low-cognitive demand tasks that focused on procedures. Analysis of lesson plans from August 9th through November 17th revealed that overall 67% of the tasks implemented in Mrs. Wallace's classes were low-level cognitive demand tasks (see Table 23). The percentage of low-level cognitive demand tasks was higher in her lower-level courses (seventh and eighth grade mathematics) when compared to her advanced courses (seventh grade prealgebra and eighth grade Algebra 1). Low-level cognitive demand tasks accounted for 69% of the tasks implemented in seventh grade mathematics and 80% of the tasks in eighth grade mathematics compared to 60% in seventh grade prealgebra and 57% in eighth grade Algebra 1. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 23

Wallace Lesson Plans Analysis from August 9 to November 17

Subject	Level of Cognitive Demand	Frequency
Seventh grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	42
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	19
	Students Use Technology to Explore/Demonstrate Concept	1
	Teacher Uses Technology to Explore/Demonstrate Concept	3
Seventh grade Pre-Algebra	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	31
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	20
	Students Use Technology to Explore/Demonstrate Concept	2

	Teacher Uses Technology to Explore/Demonstrate Concept	4
Eighth grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	47
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	12
	Students Use Technology to Explore/Demonstrate Concept	2
	Teacher Uses Technology to Explore/Demonstrate Concept	3
Eighth grade Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	32
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	24
	Students Use Technology to Explore/Demonstrate Concept	3
	Teacher Uses Technology to Explore/Demonstrate Concept	3

According to Mrs. Wallace, she planned lessons for seventh and eighth grade mathematics by following a pacing guide developed four years prior to the study by curriculum and instruction administrators at the central office with input from middle school mathematics teachers. Lesson pacing and order was determined based on system and state assessments. Mrs. Wallace primarily chose her activities from the textbook and accompanying resources. Occasionally, Mrs. Wallace implemented tasks obtained from Laying the Foundations. One week prior to the start of the school year, Mrs. Wallace attended Laying the Foundations training organized by A+ College Ready. Following a directive from administrators, lessons obtained as a result of this training were implemented in the advanced courses. Thus, the percent of low-level cognitive demand tasks in seventh grade prealgebra and eighth grade algebra 1 was lower when compared to the tasks in seventh and eighth grade mathematics.

Collaboration. Mrs. Wallace believed collaborating with colleagues was beneficial to professional growth and student achievement. Analysis of data obtained from Mrs. Wallace's initial interview and departmental workshop revealed 6 references to the importance of collaboration. Mrs. Wallace often referred to the teachers at PJHS as being "like a family". In prior years, Mrs. Wallace experienced planning individual lessons and units with the mathematics teachers in her department. Additionally, Mrs. Wallace has planned lessons with teachers in other disciplines. For example, Mrs. Wallace stated that she planned lessons with one of the science teachers at PJHS. The science teacher was beginning a lesson on balancing equations. The two planned lessons that involved equivalent expressions, factors and multiples of numbers, and the distributive property. She believed that this allowed her students to see these concepts applied in other academic areas.

Although, Mrs. Wallace believed collaboration with colleagues was important, collaboration with colleagues was challenging for Mrs. Wallace for the past two school years due to teacher turnover. The mathematics department at PJHS typically consisted of three full-time teachers. However, the year prior to the study, the school year began with two mathematics teachers. Two weeks after school started, a third teacher was hired. During the school year, the two mathematics teachers isolated themselves in the classroom and rarely expressed interest in collaborating. At the end of the school year, two of the teachers left the system, leaving Mrs. Wallace as the only teacher remaining in the department. Similarly, the following year, the school year began with two teachers. Two days after the start of the school year, Mrs. Taylor was hired. Unfortunately, two weeks after school started, the third mathematics teacher left the school. Mrs. Wallace expressed interest in collaborating with Mrs. Taylor in the future. However, due to her compact schedule as a result of teaching both her students and the students of the teacher that left, Mrs. Wallace did not have time to collaborate with Mrs. Taylor at that time.

Mrs. Wallace's beliefs and practices related to the teaching and learning of mathematics during situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related task selection and collaboration will be discussed.

Task selection. Analysis of lesson plans from November 27th through March 23rd revealed an overall decrease in percent of low-level cognitive demand tasks from 67% to 60% (see Table 24). Although the percent of low-level cognitive demand task remained unchanged in Mrs. Wallace's eighth grade Algebra 1 course, significant change was seen in Mrs. Wallace's eighth grade mathematics course. The percent of low-level cognitive demand tasks decreased from 80% to 64%. Additionally, a slight decrease was seen in seventh grade mathematics (69% to 65%) and seventh grade prealgebra (60% to 54%). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 24

Wallace Lesson Plans Analysis from November 27 to March 23

Subject	Level of Cognitive Demand	Frequency
Seventh grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	39
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	21
	Students Use Technology to Explore/Demonstrate Concept	5
	Teacher Uses Technology to Explore/Demonstrate Concept	7
Seventh grade Pre-Algebra	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	33
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	28
	Students Use Technology to Explore/Demonstrate Concept	14
	Teacher Uses Technology to Explore/Demonstrate Concept	15
Eighth grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	39
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	22
	Students Use Technology to Explore/Demonstrate Concept	7
	Teacher Uses Technology to Explore/Demonstrate Concept	10
Eighth grade Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	36
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	27
	Students Use Technology to Explore/Demonstrate Concept	12

Although Mrs. Wallace continued to plan lessons for her lower-level courses based on the school system's pacing guide for seventh and eighth grade mathematics, she began to integrate activities found on NCTM's website, Illuminations, Laying the Foundations, and activities presented at the TEAM Math and AMSTI PMLC quarterly meeting. Although the percent of low-level cognitive demand tasks did not decrease in Mrs. Wallace's Algebra 1 course, there was an increase in the percent of lessons that required the student use of technology from 5% to 19%.

Collaboration. During the situated professional development, Mrs. Wallace increased the amount of time spent collaborating with Mrs. Taylor. The week following the departmental workshop, Mrs. Wallace and Mrs. Taylor began planning lessons that integrated the resources presented during the workshop. Mrs. Wallace decided to focus on improving instruction in her eighth grade mathematics course and increasing both her use of technology and her students use of technology in all classes. As part of the situated professional development, Mrs. Wallace was required to plan one technology-based lesson with a colleague. However, Mrs. Wallace and Mrs. Taylor planned an entire unit on rate of change and slope. Lessons within the unit required the use of CBR, Desmos, and the TI 73 Explorer graphing calculators. Also, Mrs. Wallace and Mrs. Taylor requested additional planning sessions to become more familiar with the features of their TI 73 Explorer graphing calculators. As a result, Mrs. Wallace and Mrs. Taylor modified and implemented several Laying the Foundation activities that required the use of the more advanced TI 84 graphing calculator.

Mrs. Wallace's final beliefs and practices related to the teaching and learning of mathematics. As a result of the situated professional development, Mrs. Wallace expressed interest in continued collaboration with Mrs. Taylor. Additionally, Mrs. Wallace stated that she would like to collaborate with high school algebra 1 teachers in the future. Additionally, Mrs. Wallace continued to integrate lessons that utilized student use of technology and integrate less low-level cognitive demand tasks. Lesson plan analysis of lessons completed after Mrs. Wallace's final interview revealed an additional decrease in overall use of low -level cognitive demand tasks from 60% to 57% (see Table 25). Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans.

Table 25

Wallace Lesson Plans Analysis from April 2nd to May 24th

Subject	Level of Cognitive Demand	Frequency
Seventh grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	21
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	11
	Students Use Technology to Explore/Demonstrate Concept	6
	Teacher Uses Technology to Explore/Demonstrate Concept	7
Seventh grade Pre-Algebra	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	17
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	13

	Students Use Technology to Explore/Demonstrate Concept	5
	Teacher Uses Technology to Explore/Demonstrate Concept	5
Eighth grade Mathematics	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	20
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	14
	Students Use Technology to Explore/Demonstrate Concept	8
	Teacher Uses Technology to Explore/Demonstrate Concept	8
Eighth grade Algebra 1	Low Level Cognitive Demand Tasks (memorization and procedures without connections)	17
	High Level Cognitive Demand Task (procedures with connections and doing mathematics)	17
	Students Use Technology to Explore/Demonstrate Concept	5
	Teacher Uses Technology to Explore/Demonstrate Concept	7

Mrs. Wallace's beliefs and practices related to the use of technology during mathematics instruction. In this section, Mrs. Wallace's beliefs and practices related to the use of technology during mathematics instruction are discussed. Beliefs and practices will be discussed based on the following continuum: initial beliefs and practices related to the use of technology during mathematics instruction prior to the situated professional development, beliefs and practices related to the use of technology during mathematics instruction while participating in the situated professional development, and beliefs and practices related to the use of technology during mathematics instruction at the end of the situated professional development.

Mrs. Wallace's class was equipped with a Promethean Board, mounted LCD projector, 1 desktop computer, document camera, class sets of calculators (4-function and TI-73 Explorer), a teacher laptop, and wired and wireless internet. Additionally, Mrs. Wallace had access to the mathematics department's iPad cart and a Chromebook cart.

Mrs. Wallace's initial beliefs and practices related to the use of technology during mathematics instruction. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to benefits of technology integration, technology integration, and barriers to technology integration will be discussed.

Benefits. Mrs. Wallace believed that technology use during mathematics instruction was beneficial to students. Analysis of data collected during Mrs. Wallace's initial interview and departmental workshop revealed 9 references to the positive benefits of technology for student during mathematics instruction. For example, Mrs. Wallace stated, "Every student should have a device that they can use in class. It would be very helpful. They can use it to research and explore concepts." Additionally, she would like to see more students using technology in their mathematics classes. Mrs. Wallace stated, that she has observed teachers at PJHS using technology in their classrooms. However, those teachers primarily used technology for reviewing concepts. For example, Mrs. Wallace stated she observed Mrs. Taylor using the Kahoot! to review before tests. Additionally, several teachers at PJHS create Quizlets to review vocabulary. Mrs. Wallace stated she believed that technology should be integrated in all phases of learning to achieve the greatest benefit for students.

Technology integration. Although Mrs. Wallace believed incorporating technology during mathematics instruction was beneficial to student learning, Mrs. Wallace did not integrate technology often during mathematics instruction. Analysis of lesson plans from August 8th through November 17 revealed overall student use of technology to explore or demonstrate knowledge of mathematics concepts occurred in only 4% of the lessons (see Table 18). Prior to the study, Mrs. Wallace's students completed 1 technology-based activity in seventh grade mathematics, 2 technology-based lessons in eighth grade mathematics, 2 technology-based lessons in seventh grade prealgebra, and 3 technology-based lessons in algebra 1.

Barriers. There were many barriers that prevented Mrs. Wallace from incorporating technology in her classroom. Analysis of data collected during Mrs. Wallace's initial interview, departmental workshop, and initial observation debrief revealed the most significant barriers were time (12 coded instances), knowledge of technology (7 coded instances), and technical/hardware issues (9 coded instances). Time constraints were the most significant barrier for Mrs. Wallace. Because Mrs. Wallace was teaching twice her normal number of students from August 28th until October 1, she stated that she did not have time to plan and implement activities that used technology. Mrs. Wallace's additional responsibilities with RTI utilized a significant portion her planning time. Additionally, due to the amount of instructional time devoted to testing in previous years, Mrs. Wallace believed that she did not have time instructional days to integrate additional activities.

Mrs. Wallace frequently stated that she did not feel comfortable incorporating technology because of her lack of knowledge of how to use the available technology. Although Mrs. Wallace participated in a variety of professional development sessions during her 26 years as a full-time mathematics instructor, none of the sessions were devoted to technology use in the mathematics classroom. During the summer, Mrs. Wallace participated in a professional development session that focused on the flipped classroom. However, no information was presented that was specific to the mathematics classroom or technology specific to the mathematics classroom. Mrs. Wallace stated that she wanted to learn the features of the TI 73 Explorer graphing calculator because those were the calculators to which she had access. Additionally, the technology activities Mrs. Wallace had access to through Laying the Foundation lesson plans were designed from the TI-84 and TI Nspire graphing calculators. Mrs. Moore did not implement any of those activities because she was not familiar with those calculators nor did she have access to them. Her request for a classroom set of TI 84 calculators was denied due to the cost of the calculators.

The final major barrier that prevented Mrs. Wallace from implementing technology was technical or hardware issues. Although PJHS had wireless internet connections, Mrs. Wallace's classroom was one of four classrooms where the wireless connections were not functioning properly. In an attempt to resolve this issue, a second wireless router was installed in the opposite corner of the classroom during the summer. However, this did not fix the connection issue. It was later determined that the wiring in Mrs. Wallace's classroom needed to be updated. Additionally, the wired internet connection was only functional from only 1 of the 3 access points in Mrs. Wallace's classroom. In addition to internet access issues, the Promethean Board was damaged from water leaking onto it from a pipe above the classroom. The promethean board was replaced after the Thanksgiving break with the Promethean board from the classroom of the mathematics teacher that left. Although system administrators and PJHS administrators encouraged faculty to integrate technology into their teaching practices these barriers prevented Mrs. Wallace from doing so.

Mrs. Wallace's beliefs and practices related to the use of technology during mathematics instruction during the situated professional development. Subheadings for each of the sections below were developed from themes that emerged from the data during analysis. Findings related to benefits of technology integration, technology integration, and overcoming barriers to technology integration will be discussed.

Benefits. Throughout the study, Mrs. Wallace continued to express positive views regarding the benefits of technology. Analysis of data collected from Mrs. Wallace's observations, observation debriefs, and departmental meetings revealed 13 instances of Mrs. Wallace expressing positive views about teacher and student use of technology during instruction. Mrs. Wallace believed that using technology during instruction increased student engagement and decreased management issues. During the debrief of Mrs. Wallace's first technology lesson, she stated that using the probability simulator to flip the coins "was more effective than in past years." She believed students were more engaged with the lesson and were excited to see additional features of their TI 73 Explorer graphing calculators. Students were able to perform a greater number of trials and determine how increasing the number of trials impacted experimental probability. In prior years, Mrs. Wallace required students to manually flipped a coin, which often created classroom management issue. Some of the issues that Mrs. Wallace had to address in previous years were related to students being off task when flipping the coin. Some students played a popular coin flipping game instead of completing the assignment. The excessive noise created from flipping the coins was distracting to some students. Additionally, the amount of time needed to perform larger trials was an issue because class periods were only 53 minutes. Using the simulator on the graphing calculator prevented these issues from occurring during this lesson.

Similar findings were observed during Mrs. Wallace's second and third observation. During Mrs. Wallace's second observation, students were required to use the CBRs to explore and interpret the meaning of the shapes of graphs. Students used the CBRs to recreate graphs depicting distance-time relationships. Mrs. Wallace stated that having students create the graphs using the CBRs gave them a better understanding of the meanings of the graphs. She also believed that students were able to understand rate of change in lessons following the activity better than students in previous years. The third lesson required students to use the TI73 Explorer graphing calculator to compare sets of data. Students represented data as scatter plots, box-and-whisker plots, and histograms measures of center and measures of variability. Mrs. Wallace stated that her students were more engaged with this lesson than in previous years.

Technology integration. As a result of participating in the professional development, Mrs. Wallace experienced an increase in TPACK. She was able to select and assess the appropriateness of technology tools and plan activities that utilized those tools effectively. As a result, Mrs. Wallace planned and implemented more than the three technology-based lessons required for the study. Analysis of lesson plans from November 27th through March 23rd revealed an increase in student use of technology to explore concepts. During the study, student use of technology increased overall from 4% to 16% (see Table 19). Mrs. Wallace's students completed 5 technology-based activity in seventh grade mathematics, 7 technology-based lessons in eighth grade mathematics, 14 technology-based lessons in seventh grade prealgebra, and 12 technology-based lessons in algebra 1.

Overcoming Barriers. Prior to the study Mrs. Wallace expressed three primary barriers that prevented her from implementing technology in her classroom: time, knowledge of technology, and technical and hardware issues. Administrators were able to hire a long-term substitute teacher to replace the mathematics teacher that quit. The substitute worked from October 17th until the end of the semester. A second long-term substitute was hired in January. This substitute was an undergraduate mathematics education student from a public university located in the northeastern region of the state PJHS is located. As a result, Mrs. Wallace was no longer teaching both groups of students. This allowed Mrs. Wallace to have time to devote to learning how to use the available technology and planning activities to implement with her students. During the study, Mrs. Wallace participated in additional planning sessions with me as the facilitator to strengthen her knowledge of the available technology. Additionally, Mrs. Wallace devoted a portion of three mathematics department meetings to discussing technology tools and activities that they used or planned to use in their classroom. Technical and hardware issues remained throughout the study. After several failed requests to resolve the internet connectivity issue, the problem remained. Due to the nature of the repairs needed to resolve the wiring issues, Mrs. Wallace's classroom would did not receive the necessary repairs. Those repairs were scheduled to be completed during the summer following the completion of the study. During the study, Mrs. Wallace used her cellular phone's hotspot capabilities to access videos or online tools when necessary. However, students were not allowed to connect to her personal hotspot. As a result, Mrs. Wallace submitted a request for the

Desmos app to be installed on the iPads assigned to the mathematics department. Once installed, internet access was not needed for students to be able to use the program.

Mrs. Wallace's final beliefs and practices related to the use of technology during mathematics instruction. Analysis of Mrs. Wallace's final interview revealed that she planned to continue to integrate technology into her teaching practices. Additionally, she planned to continue to collaborate with Mrs. Taylor on activities to implement with her students. Mrs. Wallace believed that having someone available to provide feedback regarding her instructional practices was beneficial. Mrs. Wallace stated,

> Having you here to show me how to use the [technology] I have was the best part. They don't give us [professional development] to show us how to do this, but, they want us to use it with our students. I didn't know that little calculator could do all those things. I wish you could be here next year.

Analysis of Mrs. Wallace's lesson plans from April 2nd through May 24th revealed that she continued to integrate activities that required students to use technology to explore mathematics in all of her classes. The percent of lessons that required students to use technology increased slightly from 16% to 18%, which is significantly higher than the percent of student technology prior to the study, 4% (see Table 25).

Summary. In all phases of the situated professional development, Mrs. Wallace expressed high expectations related to her students' mathematics abilities, and behavior. Although Mrs. Wallace integrated some student-centered teaching practices prior to the professional development, Mrs. Wallace increased the use of student led discussions and cooperative groups during the professional development. Additionally, low-level demand tasks decreased overall from 67% prior to the study to 60% during the study. After the study, the percent of low-level cognitive demand task increased slightly to 58%. Student use of technology also increased as a result of the situated professional development. Prior to the study, the percent of lessons that required students to use technology to explore mathematics content was 4%. This increased to 16% during the study. Following the study, the lessons that required student use of technology increased slightly to 18%. Prior to the study, the percent of Mrs. Wallace's lessons that required teacher use of technology to explore mathematics content was 6%. This increased to 19% during the study. Following the study, the lessons that required student use of technology increased slightly to 21% (see Table 22). Percentages were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately.

Table 26

Wallace Summary Table

	Before	During	After
Teaching Practices	TC/sc	TC/SC	TC/SC
Overall Student Technology Use During instruction	4%	16%	18%
Overall Teacher Technology Use During instruction	6%	19%	21%
Overall Low-Level Cognitive Demand Tasks	67%	60%	58%
Expectations of Students	High	High	High

*TC – Teacher Centered, SC – Student Centered, TC/sc – Primarily Teacher Centered with some student-centered practices, TC/SC nearly equal amount of student and teacher centered practices

Cross Case Analysis

As participants progressed through the study, they made meaningful changes with respect to increasing the use of mathematical action technology during instruction and task selection. These changes were influence by participants' beliefs related to students and their beliefs related to the teaching and learning of mathematics. These findings will be discussed in detail in the sections that follow.

Beliefs related to students. Although each of the teachers experienced an increase in student engagement and a decrease in behavior issues during lessons developed as a part of the situated professional development, the study had little overall impact on changing teachers' prior beliefs about THS students. Each of the six participants held strong beliefs about their students' mathematics abilities and expectations they had for their students. Prior to the study, Mrs. Brown and Mr. Smith expressed extremely low expectations for their students. Mrs. Brown and Mr. Smith accounted for 96% of the negative expressions of initial beliefs related to students. They believed that their students possessed inadequate mathematics skills that made it difficult for them to achieve in mathematics. Mrs. Brown and Mr. Smith attributed this skill deficiency largely to factors related to the students' community and social factors. Although Mr. Moore, Mr. Johnson, Mrs. Taylor, and Mrs. Wallace acknowledged that some of their students experienced difficulties with mathematics, they did not attribute those deficiencies to societal factors nor did they lower their expectations for students.

There were no significant changes in beliefs and expectations related to students as a result of the situated professional development. However, placement of students within higher or lower track courses impacted several teachers' beliefs regarding students' mathematics abilities. Mr. Smith and Mrs. Brown continued to have low expectations regarding their students' mathematics abilities and behaviors. He often compared his students' mathematics achievement to students in more advanced courses. Similarly, Mr.

Moore referred to his students as the "cream of the crop" and held high expectations for his students. All of his students were on the advanced track at THS. Although Mrs. Brown experienced a slight increase in her expectations for her students, she continued to hold higher expectations for her honors Algebra 1 students than for her non-honors Algebra 1 students. One factor that contributed to this change was Mrs. Brown observing her students experience success with mathematics tasks that were more challenging and engaging than they previously experienced in her class. Mr. Johnson, Mrs. Taylor, and Mrs. Wallace taught students on the advanced and standard track. Each of these participants held high expectations and positive beliefs about their students throughout the study and did not make comparisons between the different levels of students.

Beliefs and practices related to the teaching and learning of mathematics. Prior to the study, each of the participants primarily utilized teacher-centered teaching practices. Lessons in each of their classes followed a similar format: teacher presented examples, teacher and students work examples together, and independent practice. Of the participants in the study, only 2 participants (Mrs. Brown and Mr. Moore) completed a secondary mathematics education undergraduate degree. Mr. Smith, Mr. Johnson, Mr. Moore, and Mrs. Wallace completed their initial undergraduate degree in mathematics, and Mrs. Taylor completed her initial undergraduate degree in elementary. Additionally, 5 of the 6 the participants' initial careers following their undergraduate were not in secondary mathematics. Moreover, only two participants (Mrs. Wallace and Mr. Moore) had recently participated in professional development specific to teaching mathematics. This shows that as a whole, participants in the study had little formal training and pedagogical knowledge of effective mathematics teaching practices prior to the study.

Cross case analysis revealed that each of the teachers experienced a change in their practices by increasing their use of student-centered practices and decreasing the percentage of low-level cognitive demand tasks used during instruction. Overall, the participants decreased their use of low-level cognitive demand tasks in all lessons planned for the 2017 – 2018 from an average of 77% (maximum 89%, minimum 65%) prior to the study to 62% (maximum 73%, minimum 52%) during the study and 63% (maximum 78%, minimum 54%) after the study. Percentages were calculated by dividing the number of lesson plans that only included low-level cognitive demand tasks by the total number of lesson plans for each time period. The decrease in low-level cognitive demand tasks used in lesson plans resulted from participants including a variety of sources in their lesson planning process and increased collaboration with colleagues. Prior to the study, the primary resource for planning lessons was the textbook or system curriculum guides. As a result of the situated professional development, participants collaborated to plan lessons and included tasks from resources introduced during the study from the National Council of Teachers of Mathematics, Interactive Mathematics Program, Texas Instrument, state's Learning Exchange, and A+ College Ready.

Beliefs and practices related to the use of technology during mathematics instruction. Prior to the study, each of the participants held strong beliefs related to the use of technology during mathematics instruction. Of the participants, only Mrs. Brown and Mr. Smith expressed negative beliefs related to the benefits of technology use during mathematics instruction. Both believed that student use of technology during mathematics instruction did not add meaningful values to students being able to gain understanding of mathematics concepts. However, both participants, as well as other participants, believed that technology could provide some benefits for assessing student's learning after a concept was taught. On the contrary, each of the remaining participants held strong positive beliefs related to the student use of technology during mathematics instructions. However, their practices did not reflect this belief.

Analysis of all data sources across the cases before, during, and after participants' participation in the professional development revealed that the four most common barriers to technology implementation were: (1) pedagogical and technical knowledge of available technology and TPACK, (2) time, (3) hardware issues, and (4) perceived negative student issues. Each of the 6 participants stated that they had not participated in any professional development activities that were specific to technology use during mathematics instruction. Additionally, none of their completed teacher education programs included a specific methods course involving mathematics specific technology use. However, Mr. Johnson was scheduled to complete a mathematics and technology course within his current degree program after the completion of the study. As such, each of the participants had little to no formal training in how to effectively implement mathematical action technology within their teaching practices. Although student use of mathematical action technology was low for all participants prior to the study, both Mr. Moore and Mr. Johnson actively used both conveyance and mathematical action technology during instruction. Each of the 6 participants stated that time was a key factor in their decisions to integrate technology into their teaching practices. Participants stated that they did not have enough time outside of their normal school hours and additional responsibilities to participate in professional development that focused on learning how to effectively integrate technology into their teaching practices. To remedy this issue, all activities related to the study were conducted during their school schedule.

Additionally, several participants sought to improve their teaching practices outside of their regular teaching hours. Mrs. Wallace participated in a Saturday professional development activity that focused on effective teaching practices. This professional development session was hosted by one of the state's large, public, research universities. I was one of the presenters for one of the sessions at this professional development. Furthermore, several participants utilized online tutorials to gain a deeper understanding of the technologies presented during this study.

Overcoming external barriers such as faulty wiring and non-functioning hardware were addressed during this study. I assisted several participants with troubleshooting hardware issues they were experiencing. Additionally, some faulty hardware was able to be replaced. However, remedying wiring issues experienced by Mrs. Wallace was beyond the scope of the study. To overcome this issue, Mrs. Wallace focused on using technology that did not require the use of the internet.

Two participants expressed major concern with possible negative student behavior issues related to the use of technology during instruction in all phases of the situated professional development. Mr. Smith and Mrs. Brown believed that allowing students to use technology during instruction could lead to an increase in negative student behaviors. As such, they did not trust students, nor did they believe they could effectively manage students' behavior while using technology. This greatly impacted their decisions to allow students to use technology to explore mathematics concepts.

Although all participants reported an increase in positive student behavior and academic performance while using technology, Mr. Smith and Mrs. Brown attributed this positive outcome to factors other than the activity and technology use. Mr. Smith believed that the presence of the researcher or other observer resulted in increased student engagement and positive student behavior. Similarly, Mrs. Brown believed that the maturity and high mathematics abilities of her honors students compared to her non-honors students was key her students increased student engagement and positive student behavior.

Analysis of data across the cases revealed that each of the teachers experienced an increase in the student use and teacher use of mathematical action technology during mathematics instruction. Percentages were calculated by dividing the number of lessons that required the use of mathematical action technology by the total number of lessons planned. Percentages for student use of mathematical action technology and teacher use of mathematical action technology were done separately. Student use of mathematical action technology in all lessons planned for the 2017 – 2018 increased from an average of 6% (maximum 14%, minimum 0%) prior to the study to 23% (maximum 35%, minimum 16%) during the study and 22% (maximum 35%, minimum 8%) after the study. Additionally, teacher use of mathematical action technology in all lessons planned for the 2017 – 2018 increased from an average of 20% (maximum 68%, minimum 0%) prior to the study to 35% (maximum 77%, minimum 18%) during the study and 32% (maximum 67%, minimum 8%) after the study.

Table 27

Technology Use Summary by School

	Before	During	After
THS			
Student Use of Mathematical Action Technology	7%	28%	24%
Teacher Use of Mathematical Action Technology	32%	48%	41%
PJHS			
Student Use of Mathematical Action Technology	4%	18%	20%
Teacher Use of Mathematical Action Technology	7%	21%	23%
Combined			
Student Use of Mathematical Action Technology	6%	23%	22%
Teacher Use of Mathematical Action Technology	20%	35%	32%

Summary of Chapter

The purpose of this study was to explore the impact of providing secondary mathematics teachers in a school with a high African American, low-income student population with situated professional development that focuses on integrating mathematical action technology within teaching practices. To examine this, a collective case study design was used. Each participant of the six participants completed an initial interview, observation, and debrief prior to participating in a departmental workshop. After the departmental workshop, each participant participated in several additional planning sessions to further increase their knowledge of and ability to effectively implement mathematical action technology tools within their teaching practices. Additionally, each participant planned and implemented at least one technology-based lesson with the researcher, with a colleague, and individually. Following the observation of lessons, each participant was provided with an opportunity to reflect on the lesson during the observation debrief. Participants were encouraged to increase collaboration and reflection during departmental meetings. Additionally, participants lesson plans for the school year were examined for task selection and technology implementation. Lastly, each participant participated in a final interview. Data collected from each of these components was examined to determine the how and why the participants changed their beliefs and practices related to the use of mathematical action technology, if at all.

The results of this study revealed that the situated professional development influenced change in participants' implementation of mathematical action technology and their selection of mathematics tacks. However, there was little to no change in participants' beliefs. A discussion of the results of this study and implications are discussed in the next chapter.

Chapter 5: Discussion and Implications

In this study, I set out to explore the impact of situated professional development for integrating technology in mathematics instruction on the pedagogical beliefs and teaching practices of secondary mathematics teachers in a school with a high African American, Low-Income Student Population. In this chapter, I discuss the results, limitations and conclusions of the study, as well as implications of the study.

Discussion of Results and Conclusions

The research questions guiding this study were: In a school with a high African American, low-income student population, how does participation in situated professional development focusing on integrating technology in secondary mathematics instruction impact teachers': (1) pedagogical beliefs about technology use during instruction? and (2) decisions to integrate technology within their instructional practices? Additional findings that emerged from the study will also be discussed. These findings included cognitive demand of tasks used in lessons planned during the school year, participants' beliefs about students, and participants' self-efficacy.

Impact on pedagogical beliefs about technology use during instruction. Teachers' pedagogical beliefs have considerable influence on their decisions related to how lessons are planned, and the selection of tools and materials used during the lesson (Applefield, Huber, & Moallem, 2001; Ertmer, 2012; Kim et al., 2013). In this study, participants' positive or negative beliefs about technology use during mathematics instruction remained unchanged. Two of the participants' beliefs about student use of technology were influenced by characteristics of the students as well. Mr. Smith and Mrs. Brown both believed that students from the community that students from THS lived would not appreciate or benefit from using technology during mathematics instruction. Additionally, they believed their students behavior would prevent any meaningful learning with technology from occurring. Participants with positive beliefs related to both student and teacher use of technology during mathematics instruction continued to express those beliefs throughout the study. Four of the six participants believed that the effective use of technology could be beneficial to their students and did not believe that their students were less capable of benefiting from technology because of characteristics related to the demographics of their students. For example, each of these four participants stated that technology could help their students explore mathematics concepts and gain a deep understanding of the mathematics.

Similarly, participants with negative beliefs related to both student and teacher use of technology during mathematics instruction continued to express those beliefs throughout the study. Participation in this study had little to no impact on changing their negative beliefs related to technology use during mathematics instruction. For these two participants, their beliefs about technology use were strongly connected to their overall beliefs related to effective teaching practices and their experiences as a learner of mathematics. Beliefs that have multiple connections to other beliefs and life experiences are considered to be “core” or central beliefs (Ertmer & Ottenbriet-Leftwhich, 2010). Additionally, “the more a given belief is functionally connected or in communication with other beliefs, the more implications and consequences it has for other beliefs, and therefore the more central the belief” (Rokeach, 1968, p. 5). These beliefs are the most difficult to change, as their connections to other beliefs need to be addressed as well (Richardson, 1996).

Although participants did not change their overall beliefs about technology use in the classroom, several participants' beliefs regarding the nature of the use of technology changed from focusing on their use as primarily tools of assessment, as a quick means to complete computation, and as tools to convey information to their use as a tool to explore mathematics concepts. Mr. Smith frequently expressed that technology was not needed in lower level mathematics courses, however, he initially expressed a desire to include technology in his instructional practices as an assessment tool. Throughout his participation in the professional development, Mr. Smith was able to gain a better understanding of how technology could serve as a benefit to his students with understanding the content. As a result, Mr. Smith planned and implemented multiple lessons that utilized Excel spreadsheets. Similarly, Mrs. Brown and Mrs. Taylor's initial focus on technology use during mathematics instruction was primarily assisting with computations and assessing student learning rather than exploring mathematics concepts. Both participants planned and implemented multiple lessons, in excess of the required lessons for the study, that allowed students to explore mathematics concepts.

Decisions to integrate technology within their instructional practices. Access to technology in schools does not always result in use, nor does use always result in enhanced instructional practices or learning outcomes (Mardis, Hoffman, & Marshall, 2008). In schools with a high African American, low-income student population, technology often remain unused or integrated into instructional practices in unproductive ways (NCTM, 2014; Jackson et al., 2006; Reinhart et al., 2011). Although the majority of the participants in this study held strong positive beliefs related to technology use during mathematics instruction, their practices often did not reflect those beliefs. Extrinsic and intrinsic barriers often prevent teachers from using technology during instruction (Ertmer, 2012). However, when teachers believe in technology's effectiveness, they are more likely to embrace it as an instructional tool (Ertmer et al., 2012; Swan & Dixon, 2006; Okeke, 2014; Koszalka, 2001; Stols & Kriek, 2011). If convinced of the value and appropriateness of using technology and provided with proper support, teachers may be motivated to incorporate technology in their practice and work to overcome barriers (Ertmer et al., 2012). As a result of participating in the situated professional development provided during this study, all participant's decisions to integrate technology into their teaching practice increased. The increase in technology use by participants and their students continued to be greater upon completion of the professional development than what was found prior to the study (see Table 27). This increase in technology use can be attributed to several factors: (1) increased Technological Pedagogical Content Knowledge (TPACK), (2) support and collaboration, and (3) overcoming barriers.

TPACK is the basis of effective teaching with technology (Koehler & Mishra, 2009; Mishra & Koehler, 2006). Teachers who demonstrate TPACK are able to integrate their subject with technology to develop students understanding (Koehler & Mishra, 2009). Teachers with TPACK are also able to identify and select technological instruments that are best used to develop and represent specific criteria they are teaching (Koehler & Mishra, 2009). Teachers using TPACK are able to identify, evaluate, and use student thinking, understanding, and learning using technology to promote learning. Prior to participating in this study, participants had little to no formal training related to effective technology implementation with mathematics instruction. As such, improving participants' TPACK could increase the likelihood that they would increase both student and teacher use of technology. In alignment with Mathematics TPACK Framework developed by the Association of Mathematics Teacher Educators (AMTE) (2009), participants were provided with several opportunities to enhance their technological pedagogical content knowledge, design and develop technology-enhanced mathematics learning, facilitate mathematics instruction with technology as an integrated tool, and assess and evaluate technology-enriched mathematics teaching and learning. Although no formal instrument was used to measure TPACK improvement of participants, participants stated that they gained additional knowledge of the technology tools they had access to within the school as a result of the situated professional development. Additionally, participants were able to assess the usefulness of technology tools that they had not previously used to teach mathematics content, which afforded their students the opportunity to explore mathematics concepts. Being able to assess the effectiveness of a tool and effectively incorporate it into their teaching practices is a key component of the Mathematics TPACK framework (AMTE, 2009). Prior to the professional development, participants indicated that they did not engage in this practice.

Professional isolation severely undermines attempts to increase collaboration among colleagues, both between teaching peers internally in the school and among teachers, mathematicians, and mathematics educators externally (National Council of Teachers of Mathematics (NCTM), 2014). This type of isolation stands as an obstacle to ensuring mathematical success for all students as well as teachers' continual growth (NCTM, 2014). Schmoker (2006) noted that "professional learning communities have emerged as arguably the best, most agreed-upon means by which to continuously improve instruction and student performance. Teachers' co-planning of lessons provides one of the greatest opportunities for making a positive difference on student learning (Hattie 2012; Morris, Hiebert, and Spitzer 2009). Participants in this study collaborated with their colleagues as well as the researcher to create and implement lessons that utilized reform-based practices. Most of the participants found that collaborating with the researcher and their colleagues was beneficial and expressed that they would continue to collaborate with colleagues following the study.

According to Rebora (2016), practicing teachers stated that professional development that allowed idea sharing with other teachers, collaborative planning time, and job-embedded training or coaching would be beneficial in helping them better effectively integrate technology into their instruction. All mathematics teachers can benefit from in content-focused instructional coaching (NCTM, 2014). Additionally, situated professional development provides teachers with an opportunity to acquire skills in real-life contexts (Lave & Wenger, 1991). Situated professional development has been shown to be successful in fostering technology integration into teachers' instructional practice because it links learning about technology. This study allowed participants to experience collaboration with colleagues, job-embedded coaching, individual reflection, and participation within a community of practice. All situated professional development activities occurred in an authentic setting, primarily their classroom with resources in which they had regular access (Rebora, 2016, Lave & Wenger 1991). During the study, my role could be compared to an instructional coach. During the departmental workshop, I modeled the implementation of technology and allowed participants to engage with the technology from both a student and teacher perspective. During the workshops, participants were able to discuss their beliefs, practices, and the activities with their colleagues. Their colleagues served as a community of practice, a major component of situated learning theory and situated professional development (Lave & Wenger, 1991). Another key component in situated professional development is reflection (Lave & Wenger, 1991). Participants had multiple opportunities to reflect on their instructional practices as well as the instructional practices of their colleagues. Each participant was asked to reflect on their teaching practices during the initial interview, planning sessions with me as well as with colleagues, observation debriefs, departmental meetings, and departmental workshop. Encouraging and allowing participants to reflect within their community of practice increased likelihood that participants improved their practice and develop and implement learning activities using new technology, strategies, and resources (Glazer et al., 2005; Glazer & Hannafin, 2008; Rebora, 2016).

Participants in this study expressed several intrinsic and extrinsic barriers. Intrinsic barriers included participants' self-efficacy regarding implementing technology and reform-based practices, perceived ability to manage student behavior during technology use, beliefs related to the benefits of technology use during instruction, and knowledge of available technology. When teachers believe in technology's effectiveness, they are more likely to embrace it as an instructional tool (Ertmer et al., 2012; Swan & Dixon, 2006; Okeke, 2014; Koszalka, 2001; Stols & Kriek, 2011). Overcoming intrinsic barriers requires changes in teachers' thinking and behavior (Ertmer & Ottenbriet-Leftwhich, 2010; Ertmer, Ottenbriet-Leftwhich, Sadik, Sendurur, & Sendurur, 2012). This study provided participants with support to assist with addressing intrinsic barriers. Participants collaborated with their colleagues as well as the researcher to improve their instructional practices, which helped many of the participants overcome some of their intrinsic barriers.

Additionally, by participating in the departmental workshop, collaborating with colleagues, and participating in additional individual planning sessions, participants were able to increase their knowledge of available technologies. This increase in knowledge improved their self-efficacy and motivated them to incorporate technology within their teaching practices. Ertmer (2012) suggested that teachers' beliefs about the role of technology are very powerful, often affecting teachers' abilities to overcome extrinsic obstacles. For example, Mr. Smith and Mrs. Brown experienced technical issues with technology that was present in their classrooms. Both participants had hardware that did not function properly. Mr. Smith and Mrs. Brown expressed negative beliefs regarding technology use during mathematics instruction and were not motivated to address those issues prior to the study. As a result, they did not seek assistance with fixing the non-functioning hardware in their classroom. However, during the study, both participants were able to alleviate the technical issues they were facing in order to implement technology during their instructional practices. A third participant, Mrs. Wallace, also experienced technical and hardware issues that affected her decision to implement technology during instruction. Although her technical issues regarding internet access and wiring issues were not alleviated during the study, she was motivated to find solutions to incorporate technology within her teaching practices that did not require the internet.

Additional findings impacting participants beliefs and practices. In addition to the study's impact on participants' pedagogical beliefs about technology use during instruction and their decisions to integrate technology within their instructional practices, findings related to the cognitive demand of tasks used in lessons planned participants during the school year, participants' beliefs about students, and participants' self-efficacy also emerged from the data. Each of these findings will be discussed in the sections that follow.

Task selection. Mathematical tasks play a critical role in the teaching and learning of mathematics. Worthwhile tasks give students the chance to solidify and extend what they know and to stimulate mathematics learning (NCTM, 2000, 2009, 2014; Dick & Hollerbrands, 2011; Smith, Steele, & Raith, 2017; Koestler, Felton, Bieda, & Otten, 2013). Prior research has shown that mathematics students in schools with a high African American, low-income student population are often not provided with opportunities to engage in mathematics tasks that promote reasoning and problem solving (Gutiérrez, 2000; Flores, 2007, Strutchens & Silver, 2000; NCTM, 2014; Lubienski & Stilwell, 2011). Participants in this study were secondary mathematics teachers in schools with a high African American, low-income student population. While decreasing participants' use of low-level cognitive demand tasks was not a goal of the study, each participant experienced a decrease in the percent low-level cognitive demand tasks included in lesson plans for the school year. While analyzing participants' lesson plans for student and teacher mathematical action technology use, I began to notice a change in the types of tasks participants began including in their lesson plans. I decided to include a comparison of the percent of tasks in their lesson plans that used low-level and high-level cognitive demand tasks. Prior to the study, participants indicated that their primary source for tasks was the textbook. During the study, participants were introduced to a variety of resources that provided them with high-level cognitive demand tasks. By exposing participants to resources that contained meaningful, high-level cognitive demand tasks, participants began to incorporate those into their practices. Implementing high-level cognitive demand tasks that promote reasoning and problem-solving supports equity within the mathematics classroom by providing all students with access to high-quality mathematics curriculum and effective teaching and learning (Smith, Steele, & Raith, 2017; NCTM, 2014; NCTM, 2018).

Beliefs related to African American students. Learning environments for African American students led by teachers that care about their students and promote positive teacher-student relationships have been shown to have favorable outcomes on students' academic achievement. Participants in this study believed that their students would benefit from learning mathematics from a teacher that cared about them and their success. Three participants, Mr. Johnson, Mrs. Wallace, and Mr. Moore were members of the community and attended the same schools as their students. Mrs. Brown grew up in the same county as her students. She also attended the local historically black university. Participants also believed their students needed positive role models to increase their students' success. Mr. Smith, Mr. Johnson, and Mr. Moore believed that they were positive role models for African American students. This belief was a primary factor in their decision to become mathematics teachers and teach at THS.

Beliefs about students influence teachers' instructional practices (Diemer, Marchand, McKellar, and Malanchuk, 2016; Wang & Eccles, 2014). Curriculum and instruction should be presented using practices that do not view African American students as having deficits (Ladson-Billings, 1999; Oaks, 1992). In many cases, these teachers tend to implement strategies and practices that emphasize repetition, speed, and procedures rather than meaning and understanding (Bakari, 2003; Furgason, 2003). Although four of the six participants expressed high expectations for their students, their instructional practices were initially dominated by teacher-centered practices. Participants often emphasized teaching practices and strategies that focused on performing procedures correctly. However, during and after professional development, each participant increased their use of student-centered teaching practices. Mr. Smith and Mrs. Brown believed that their students' mathematics deficiencies were a result of their environment. They believed that because students were from a community with a low socioeconomic status, they were not motivated to achieve academically. Other participants attributed students' mathematics deficiencies to students' not having the opportunities to be taught by effective mathematics teachers in prior grades. Many of the participants' students experienced academic years without a mathematics teacher due to the teacher leaving during the school year or the administrators being unable to hire a mathematics teacher. It is not uncommon in schools with a high African American, low-income student population for students to experience learning mathematics from uncertified teachers, teachers with weaker mathematics background, or teachers with less professional experience (NCTM, 2014; Darling-Hammond, 2007; Flores, 2007.)

Not only do these beliefs influence the teachers' instructional practices, but they also affect disciplinary procedures and students' academic beliefs, values, and achievement particularly with students of color (Diemer, Marchand, McKellar, and Malanchuk, 2016; Wang & Eccles, 2014). Discipline issues were prevalent in Mr. Smith's classes. These discipline issues were directly related to his expressed negative beliefs about the students at THS. Mr. Smith's students showed little respect towards Mr. Smith as a result of him not effectively showing students that he cared about their academic success. The behavior issues that occurred in his classroom during instruction, in addition to unproductive teaching practices, often resulted in missed opportunities for meaningful learning to take place.

***Participants' self-efficacy*.** Research on teacher beliefs suggests that many teachers lack confidence about their abilities to teach African American students effectively (Ladson-Billings, 1994; Lynn, Bacon, Totten, Bridges, & Jennings, 2010). Teacher beliefs about teaching African American students are also greatly influenced by their perceptions of students' prior academic performance, socioeconomic status, and race (Lynn et al., 2010; Bakari, 2003; Furgason, 2003). In many cases, these teachers tend to implement strategies and practices that emphasize repetition, speed, and procedures rather than meaning and understanding (Bakari, 2003; Furgason, 2003). Participants in this study often used instructional practices that focused on procedures and followed the instructional pattern of "I do, we do, you do". Participants felt comfortable with this method of instruction and often stated that following this pattern was most comfortable for them. Additionally, some participants expressed concerns about their abilities to teach their students effectively using reform-based teaching practices. In particular, Mr. Johnson stated that he was not confident in his ability to effectively implement lessons that utilized reform-based practices. He attributed this lack of confidence to not completing a traditional teacher preparation program. Mrs. Brown also expressed concern about her ability to incorporate reform-based teaching strategies into her instructional practices. However, unlike Mr. Johnson, Mrs. Brown attributed her low self-efficacy to her content knowledge. She often expressed feeling intimidated by her colleagues because she was the only mathematics teacher at THS without an undergraduate degree in mathematics. She believed that her colleagues' mathematics background made them more effective teachers. Participants also expressed low self-efficacy with regard to their use of technology (mathematical action and conveyance) during instruction. Feeling overwhelmed with learning new technology was often reported by Mrs. Wallace and Mrs. Brown. They were not certain that they would be able to effectively integrate technology into their instructional practices. Although both Mrs. Wallace and Mrs. Brown expressed similar concerns regarding their ability to integrate technology, Mrs. Brown also attributed her concern to her beliefs about students. Similarly, Mr. Smith expressed concerns about his ability to incorporate technology as a result of his beliefs about students. Both Mr. Smith and Mrs. Brown believed that they would experience difficulties integrating technology into their instructional practices because they assumed negative student behavior would increase and student engagement in the lesson would decrease. However, all participants noticed an increase in student engagement during lessons that were developed as part of the situated professional development. Additionally, Mr. Smith and Mrs. Brown reported a decrease in negative student behavior during the lessons that were developed as part of the situated professional development.

Conclusion

Data collected during the study, led to the conclusion that the participants in this study, mathematics teachers in schools with a high African American, low income student population, experienced positive benefits as a result of participating in situated professional development that focused on integrating technology within their teaching practices. Each participant increased both the student and teacher use of mathematical action technology used during instruction. Additionally, each participant teacher incorporated more student-centered practices and decreased the percent of low-level cognitive demand tasks in planned lessons. Thus, participants' participation in similar situated professional development activities that focused on integrating technology within their teaching practices is one possible avenue that teachers in schools with a high African American, low income student population may explore to increase their effective use of technology and improve their instructional practices. Furthermore, the results from this study inform current professional development and professional learning community practices, which is crucial given the need to improve mathematics teaching in the U.S. (Hiebert et al. 2005; NCTM, 2014; Stigler & Hiebert, 1999).

Limitations

There were two main limitations to this study. The first limitation of the study was that the analysis of participants' lesson plans does not imply that the level-of cognitive demand for tasks was maintained during the lessons' implementation. Similarly, actual implementation of additional lesson plans that included student and teacher use of mathematical action technologies could not be validated. This was due to not being able to observe each and every lesson planned by teachers during the school year. A second limitation of the study was that student data related to the effectiveness of the technology lessons implemented was not collected. Impact on students was self-reported data from participants regarding the perceived impact the lessons had on their students as well as from observation notes detailing student conversations and engagement in the lessons.

Implications

This study has implications for professional development, instructional coaches for secondary mathematics teachers, and detracking. Further, this study adds to the literature base on teachers transitioning to reform-oriented practices as well as the effectiveness of situated professional development. According to NCTM (2000, 2014), the primary focus of professional development should be to help teachers to facilitate the learning of their students by using methods that improve students' reasoning and problem solving skills. Situated learning theorists suggest that this can occur as teachers have the opportunity to develop tools that shape their identity in such a way that members are able to transfer forms of participation to applicable settings (Lave & Wenger, 1991). In many cases, teachers attempt to implement practices from written documents on their own or attend professional development programs instead of participating in collaborative communities at the school level (Wei et al., 2010). Therefore, professional development leaders should create additional programs situated within the context of the teachers' environment to aid teachers in learning about new reforms including the use of technology during mathematics instruction. These professional development opportunities should consider teachers' attitudes and beliefs regarding technology as an important factor related to the effective use of technology during instruction (Yushau, 2006). Due to the lack of training and experience, even when technology is available, some mathematics teachers rarely use it in their educational practice (Kadijevich, 2002; NCTM, 2014). This was definitely the case for participants within this study. Therefore, this study provides insight into the benefits of using professional development situated in the teachers' teaching environment to improve their instructional practices.

Another implication from this study is the potential positive impact of having a mathematics instructional coach for secondary mathematics teachers at a school with a high African American, low income student population. Instructional coaches can serve as a resource and provide teachers with the support needed to improve their instructional practice (NCTM, 2014). According to NCTM (2014), “Instructional coaching is a critical component in supporting the implementation of effective teaching practices” (p. 106). Instructional coaches should not be viewed as luxuries. Instead, schools should view instructional coaches as a crucial component in improving and supporting the mathematics learning for all students (NCTM, 2014). Participants in this study were open to working collaboratively with me, in my role similar to an instructional coach. As a result, participants experienced positive gains in their instructional practices, including the integration of technology.

As revealed in Chapter 4, some of the participants had unproductive beliefs related to students’ mathematics abilities akin to the unproductive beliefs presented in NCTM (2014) listed below:

1. “Students living in poverty lack the cognitive, emotional, and behavioral characteristics to participate and achieve in mathematics” (NCTM, 2014, p. 63).
2. “Mathematics learning is independent of students’ culture, conditions, and language and teachers do not need to consider any of these factors to be effective” (NCTM, 2014, p. 63).
3. “Only high-achieving or gifted students can reason about, make sense of, and persevere in solving challenging mathematics problems” (NCTM, 2014, p. 64).

These beliefs are contradictory to Gutierrez’s (2002, 2007) definition of equity; Equity means, “being unable to predict students’ mathematics achievement and participation based solely upon characteristics such as race, class, ethnicity, sex, beliefs, and proficiency in the dominant language" (Gutierrez, 2007, p.3; 2002, p. 153).

The teachers' unproductive beliefs have implications for the need for professional development related to microaggressions teachers may send to students. In addition, these beliefs are confounded by tracking in school. Therefore, NCTM's (2018) recommendation to detrack mathematics courses is timely and important.

Future Areas of Research

This study focused on the impact of six mathematics teachers' beliefs and instructional practices as they participated in situated professional development that focused on integrating technology within their teaching practices. Although studying the impact of the professional development on the teachers' beliefs and instructional practices is beneficial, additional research is needed to determine if the changes in their practices are sustainable overtime. Research is also needed to determine if the change in the teachers' practices has an impact on their students' mathematics achievement. This research would provide school officials with effective methods of providing teachers with beneficial professional development.

The next steps needed to determine if the changes in participants' practices are sustainable over time would be to conduct a follow-up study with the participants. During the follow-up study, participants' beliefs and practices related to technology integration and collaboration efforts might be evaluated for one or more consecutive years. Similar to this study, participants' practices would be observed, and lesson plans evaluated for technology integration. Interviews will also be conducted to determine if participants' expressed beliefs corresponded with their teaching practices. Additionally, student assessment data could be collected during the follow-up study to determine the impact of participants' practices on students' mathematics achievement. Note, however, that teacher turnover is a factor that may affect the feasibility of completing a follow-up study with participants.

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Appendix A

Initial Teacher Interview Protocol

Time of interview: ______________________________
Date: ____
Place: _______________________________________
Participant: ___________________________________ Pseudonym: _____________

Introduction and Description of Project

I want to thank you for taking the time to talk with me today. As stated in the recruitment letter, this study will explore the impact of providing secondary mathematics teachers in a school with a high African American, low-income student population with situated professional development that focuses on integrating technology within teaching practices. This study will focus on how the professional development affects the teachers' pedagogical beliefs and integration of technology.

All answers will be kept confidential. Based on your permission, I will audio record the interview as well as take notes during our discussion. Audiotapes will be transcribed in their entirety for review and analysis. At the conclusion of this interview, I will ask you for a pseudonym that you would like me to use to protect your identity when referencing you in the study. Are you ready to start?

Great! During the first set of questions, you will tell me about your educational and teaching background.

1. Why did you decide to become a math teacher?
2. What teaching certifications and education degrees do you currently hold?
    a. Where did you obtain your degree(s) and what year did you obtain it (them)?
3. Tell me about your teaching experience? *(Follow up questions below if necessary)*
    a. What grade level(s) and subject(s) do you currently teach?
    b. What other grade levels and subjects do you have experience teaching?
    c. How long have you been teaching at this school?
    d. What other schools have you taught mathematics?
    e. Why did you choose to teach at this school?
4. Do you have any other roles at this school (department head/new teacher mentor/instructional coach/Intervention Team/coach/sponsor)?
    a. What are your responsibilities in this (those) role?
    b. How does this impact your responsibilities as a mathematics teacher?

Thank you for that information. Now, let's talk about teaching mathematics.

5. Tell me about your students. *(Follow up questions below if necessary)*
    a. How do you think they feel about math? Why do you think they feel this way?
    b. How are your current students different/similar to students in other schools where you've taught?

6. How do you think your students best learn mathematics?
   a. Why do you believe this to be true?
   b. How do you assess their learning?
7. Describe a typical mathematics lesson in your class?
8. Explain your lesson planning process?
   a. How do you choose the activities to do with your students?
   b. Have you ever planned a lesson with a colleague?
      i. If so, describe that experience and the results.
      ii. If not, what has kept you from doing this?
9. (**Ask if teacher if the teacher has taught in another school)** Have your teaching practices changed since you began teaching mathematics in this school?
   a. If so, what contributed to this change?
   b. If not, do you feel you need to change your current teaching practices?
      i. Explain why or why not.
      ii. (If yes) What would you change and why?

(Ask if teacher does not discuss how they think students best learn mathematics)

Now, lets talk about using technology in the mathematics classroom.

10. If you were to observe a mathematics classroom, how would you like to see technology being used?
11. How have you seen technology being utilized in the mathematics classrooms at your school?
12. What technology resources are available for you to use at your school?
    a. How often are you able to access these resources?
    b. (If the time is not often) Why?
    c. What technology would you like to have available for you to use with your mathematics students?
    d. Do you know how to find out what technology is available for you to use?
13. What technologies are you and your students using in your classroom and how are you(they) using them?
14. How often do you use technology during your instruction?
    a. How often do your students use technology during instruction?
15. How are your students using technology during instruction? How often?
16. Have you ever taught a concept and afterwards thought it would be better if you had used technology during the lesson?
    a. What contributed to you feeling this way?
17. Are there any things that make it difficult for you to use technology with your students?
    a. How do you overcome those issues?
18. Does your administration encourage faculty to integrate technology into their instructional practices?
    a. If so, what support do they provide?
    b. If not, what support would you like?
19. How do you use technology outside of the classroom?
    a. Have you used any of these in your classroom? If so, how? If not, why?

20. What types of technology do your students have access to outside of the classroom?

Alright. Let's talk about your professional development experiences.

21. Throughout the school year (including summer), how often do you participate in professional development?
    a. (If a first -year teacher or first year teaching at this school) What professional development have you participated in since you were hired to teach mathematics at this school?
22. Have you participated in any professional development activities that focused on technology integration?
    a. If so, were any specific to mathematics?
    b. Did you implement any of the strategies from those professional development activities? Why or why not?
        i. (If a first- year teacher) Do you plan to implement any of the strategies from those professional development activities? Why or why not?

23. What type of professional development and support do you believe will be the most beneficial to you with regards to integrating technology into your teaching practices?

Thank you for those answers. Now I'm going to give you a handout that contains a few statements about technology use in mathematics and the students' abilities to learn mathematics. Refer participant to Handout 1.

24. Take a moment to read each statement on side one. Then tell me your thoughts on each statement.

After participant has read and discussed the statements on side 1, repeat procedure for side 2. Refer participant to Handout 2

25. Take a moment to read each statement on side one. Then tell me your thoughts on each statement.

After participant had finished discussing the statements on side 2. Proceed with closing.

Closing:

Thank you for taking time out of your busy schedule to talk with me today. As stated earlier, your answers will remain confidential. Once all individual interviews have been completed, there will be an opportunity for you to participate in a workshop and subsequent activities designed to support you throughout the semester with integrating technology into your mathematics classroom. If you would like more information about them, I'm happy to provide that to you at this time.

Again, thank you for your participation in this interview.

Initial Interview Protocol Handout – Side 1

Please read each of the following statements to yourself. After you have finished reading, state whether you **agree or disagree** and discuss your thoughts on each statement with the interviewer.

1. Calculators and other tools are a crutch that keeps students from learning mathematics. Students should use these tools only after they have learned how to do procedures with paper and pencil.
2. School mathematics is static (content does not change). What students need to know about mathematics is unchanged by the presence of technology.
3. Students at all grade levels can benefit from the use of physical and virtual manipulative materials to provide visual models of a range of mathematical ideas.
4. Technology should be used primarily as a quick way to get correct answers to computations.
5. All students should have access to technology and other tools that support the teaching and learning of mathematics.
6. Using technology and other tools to teach is easy. Just launch the app or website, or hand out the manipulatives, and let the students work on their own.
7. Online instructional videos can replace classroom instruction.

National Council of Teachers of Mathematics. (2014). *Principles to action: Ensuring for all.* Reston, VA: Author.

Initial Interview Protocol Handout – Side 2

Please read each of the following statements to yourself. After you have finished reading, state whether you **agree or disagree** and discuss your thoughts on each statement with the interviewer.

1. Students possess different innate levels of ability in mathematics, and these can not be changed by instruction. Certain groups or individuals have it while others do not.
2. All students need to receive the same learning opportunities so that they can achieve the same academic outcomes.
3. Equity—ensuring that all students have access to high-quality curriculum, instruction, and the supports that they need to be successful—applies to all settings.
4. Students who are not fluent in English can learn the language of mathematics at grade level or beyond at the same time that they are learning English when appropriate instructional strategies are used.
5. Mathematics learning is independent of students' culture, conditions, and language, and teachers do not need to consider any of these factors to be effective.
6. Students living in poverty lack the cognitive, emotional, and behavioral characteristics to participate and achieve in mathematics.
7. The practice of isolating low-achieving students in low-level or slower-paced mathematics groups should be eliminated.
8. Only high-achieving or gifted students can reason about, make sense of, and persevere in solving challenging mathematics problems.

National Council of Teachers of Mathematics. (2014). *Principles to action: Ensuring for all.* Reston, VA: Author.

Appendix B
Initial Interview Protocol Matrix

	Background Information	RQ1 Instructional Beliefs Including planning, & assessment	RQ1 Beliefs about technology and instruction	RQ1 Beliefs about AA and/ LI students	RQ2 Barriers	RQ2 Support, Collaborati on, & PD	RQ2 Decision to integrate technology
IQ1	X						
IQ2	X						
IQ3	X						
IQ4	X						
IQ5	X						
IQ6		X					
IQ7		X				X	
IQ8		X		X			
IQ9		X		X			
IQ10			X				
IQ11			X				
IQ12							X
IQ13							X
IQ14							X
IQ15			X	X			X
IQ16		X	X				X
IQ17					X	X	X
IQ18						X	
IQ19			X				
IQ20				X			
IQ21						X	
IQ22						X	
IQ23		X	X	X			X
IQ24		X					

Appendix C

Final Teacher Interview Protocol

Time of interview: ______________________________
Date: ____
Place: _______________________________________
Participant: ___________________________________ Pseudonym: _____________

Introduction and Description of Project

I want to thank you for taking the time out of your schedule to participate in my study. As will all other interviews, your answers will be kept confidential. Based on your permission, I will audio record the interview as well as take notes during our discussion. Audiotapes will be transcribed in their entirety for review and analysis. At the conclusion of this interview, I will ask you for a pseudonym that you would like me to use to protect your identity when referencing you in the study. Are you ready to start?

1. After participating in this study, what do you believe is the role of technology in the mathematics classroom?
   a. How is this belief similar or different to your beliefs prior to participating in this study? Explain.
   b. What specifically impacted this belief?
2. During your participation in this research study, what activities do you feel were the most beneficial to assisting you with incorporating technology within your instructional practices? Explain. *(Follow questions below if not addressed if not addressed)*
   a. Tell me your thought on collaborating with your colleagues during co-planning technology lessons and/or department meetings?
   b. Do you plan to continue collaborating with your colleagues in this manner? Why or why not?
   c. How did the activity or activities impact your views on teaching mathematics to your current students?
3. Do you plan to continue (or increase) the incorporation of technology into your instructional practices? Why or why not?
   a. What made you come to that decision?
   b. What support do you feel you need?
   c. What impact, if any, do you believe technology has on your students' learning of mathematics concepts? Why do you believe this to be true?
4. Prior to implementing your first technology lessons during this study, what expectations did you have of your students?
   a. How did the actions and outcomes of your students compare to your initial expectations?
   b. How did your expectations change or not change as you prepared to implement subsequent technology lessons? Why do you think this was to be true?

    c. How did the actions and outcomes of your students compare to those expectations during subsequent technology lessons? Why do you think this was to be true?
5. Overall, how do you believe students responded to the technology based lessons?
    a. How does their response influence your decision to integrate technology into your instructional practices? Explain.
6. Was there anything that made it difficult for you to integrate technology in your instructional practices? Explain.
    a. How did you address the issue(s)?
7. Have you participated in any other technology professional development this semester? If so, describe the professional development and its impact on your teaching practices.
    a. Why did you choose to participate in that professional development?
8. Do you plan to participate in any technology focused professional development prior to the start of the next school year? Why or why not?
9. Have you received feedback from any other individual regarding your teaching practices this past semester?
    a. What kind of feedback did you receive?
    b. What impact, if any, did the feedback have on your teaching practices? Explain.
    c. If not, would you have liked to receive additional feed back and from who? Explain.
10. Is there anything else, you would like to tell me regarding technology use and mathematics instruction with your students?

Again, thank you for your participation.

Appendix D
Final Interview Protocol Matrix

	RQ1 Instructional Beliefs Including planning, & assessment	RQ1 Beliefs about technology and instruction	RQ1 Beliefs about AA and/ LI students	RQ2 Barriers	RQ2 Support, Collaborati on, & PD	RQ2 Decision to integrate technology
IQ1	X	X				
IQ2	X	X			X	X
IQ3		X	X			X
IQ4			X			
IQ5			X			X
IQ6				X		
IQ7					X	
IQ8					X	
IQ9					X	
IQ10	X	X	X			

Appendix E

Observation Debrief Questions

Additional questions will be asked based on what occurs in the lesson.

Time of interview: ___________________________
Date: ____________________________________
Place: ___________________________________
Participant: ________________________________ Pseudonym: ____________

I want to thank you for taking the time out of your schedule to participate in my study. As will all other interviews, your answers will be kept confidential. Based on your permission, I will audio record the interview as well as take notes during our discussion. Audiotapes will be transcribed in their entirety for review and analysis. At the conclusion of this interview, I will ask you for a pseudonym that you would like me to use to protect your identity when referencing you in the study. Are you ready to start?

1st observed lesson (may or may not be technology based)

1. When planning this lesson,
    a. How did you decide on the content to include for this lesson?
    b. How and why did you choose the activity?
    c. What were your expectations of your students?
    d. What issues, if any, did you foresee when implementing this lesson?
        i. Why did you think that would be an issue?
        ii. What did you do to prepare for those issues?
2. Have you taught this lesson before?
    a. How has this lesson been beneficial in promoting learning for all students in the past?
    b. Did you change anything from the last time you taught the lesson? Why or why not?
3. During the lesson, how would you describe the level of student engagement?
4. I noticed that you did [INSERT ACTION]. Why did you choose to do this? (can have multiple examples)
5. How were you able to assess student learning throughout the lesson?
6. How well do you believe this lesson prepared your students for the next lesson or concept? Explain.
7. If you could change anything about the lesson, what would it be? Why?

Co-planned/Co-taught technology lesson with Researcher & Co-planned lesson with colleague

1. During the co-planning session, what did you find most beneficial? Least beneficial?
    a. How did you decide on the content to include for this lesson?

   b. How and why did you choose the activity?
   c. What were your expectations of your students?
   d. What issues, if any, did you foresee when implementing this lesson?
      i. Why did you think that would be an issue?
      ii. What did you do to prepare for those issues?
2. Is this the first time you used this technology tool during mathematics instruction?
3. Did you have ample time to practice using the tool prior to teaching the lesson?
4. Have you taught this concept before?
   a. Did you use technology the last time you taught this concept? Why or why not?
5. During the lesson, how would you describe the level of student engagement?
   a. How is this different/similar to student engagement with this concept in the past?
6. I noticed that you did [INSERT ACTION]. Why did you choose to do this? (can have multiple examples)
7. How were you able to assess student learning throughout the lesson?
8. How well do you believe this lesson prepared your students for the next lesson or concept?
9. If you could change anything about the lesson, what would it be? Why?
10. *(For co-planned with colleague)* Will (did) you and your colleague discuss this lesson or student work after the lesson was taught? Why or why not?

Individually planned technology lesson

1. When planning this lesson,
   a. How did you decide on the content to include for this lesson?
   b. How and why did you choose the activity?
   c. How did you decide on the technology to use during this lesson? Why?
   d. What were your expectations of your students?
   e. What issues, if any, did you foresee when implementing this lesson?
      i. Why did you think that would be an issue?
      ii. What did you do to address those issues?

2. Have you taught this concept before?
   a. If so, did you use technology the last time you taught this concept? Why or why not?
   b. How has this lesson been beneficial in promoting learning for all students in the past?
   c. Did you change anything from the last time you taught the lesson? Why or why not?
3. During the lesson, how would you describe the level of student engagement?
4. I noticed that you did [INSERT ACTION]. Why did you choose to do this? (can have multiple examples)
5. How were you able to assess student learning throughout the lesson?
6. How well do you believe this lesson prepared your students for the next lesson or concept? Explain.
7. If you could change anything about the lesson, what would it be? Why?

Appendix F

Departmental Workshop Outline and Mathematics Activities

Departmental Workshop Outline

Overview

Time Allotment	5 hours
Audience	All participants
Overview of Big Ideas	• Productive and Unproductive Beliefs Related to Technology • Productive and Unproductive Beliefs Related to Equity • Defining Equity • Growth vs. Fixed Mindset • Standards for Mathematical Practice • Mathematics Teaching Practices
Materials	• *Principals to Action: Ensuring Mathematics for All* (PtA)(NCTM, 2014) • Nearpod Presentation (including NCTM's Principles to Action Professional Learning Toolkit – Equity and Access embedded) • Handouts: ○ Productive and Unproductive Quiz & Key Handouts ▪ Tools and Technology ▪ Equity and Access ○ Standards for Mathematical Practice Look Fors ○ Tremendous Triangles - Geogebra ○ Interactive Slope Activity ○ Statistics Activity – TI 84 ○ Linear and Quadratic Functions Activity - Desmos • Dr. Carol Dweck on Fixed vs. Growth Mindsets https://www.youtube.com/watch?v=MTsF2TaEaJA

Outline/Plans	What Might Happen/Dialog
Quiz on beliefs related to tools and technology	Participants will respond to the quiz questions by selecting agree, disagree, and undecided in the NearPod presentation. This is to be done without consulting anyone.

Handout Tools and Technology Productive and Unproductive Answer Key	What does it mean for students if teachers ascribe to any of the aforementioned beliefs? Choose one belief to discus with your tablemates or elbow partner. Share with whole group
Tools and Technology (PTA)	
Show slide with NCTM's statement regarding an effective mathematics program, mathematical tools, and technology.	Instruct participants to discuss with their elbow partners the key ideas that stood out from the statement (and why). Share with whole group
Divide participants into 2 groups. Group 1 will read the first part of the Tools and Technology section (p. 78-79), making not of the key ideas from this section to share and discuss with the whole group. Group 2 will read the "obstacles" portion of the Tools and Technology section (p. 80-81), making not of the key ideas from this section to share and discuss with the whole group.	What are the potential benefits to allowing students to use mathematics tools and technology in the mathematics classroom? What tools and technology have you used in your teaching practices? What are some of the obstacle that teachers are faced with when incorporating technology into their teaching practices? Do you have similar/different obstacles? Explain. What steps have you (or administration) taken to overcome these obstacles?
Define mathematical action technology (MAT) (slide and p. 84)	How is MAT different/similar from other types of technology? What are the benefits? What types of MAT have you and your students used? How did you use them?
Equity (from NCTM's Principles to Action Professional Learning Toolkit – Equity and Access)	
<u>Productive and Unproductive Beliefs Quiz</u>	

Show the slide with the four statements.	Instruct participants to write down whether they believe each statement is productive or unproductive.
Quiz on beliefs related to equity issues. Show the quiz on the PowerPoint. Give the participants time to write down their responses.	"Write your response without consulting with anyone! This is your gut level reaction, and no one will know how you responded."
Hand out the Productive and Unproductive Quiz Key. Ask participants to discuss one of the statements with their elbow partners	"What does it mean for students if teachers and/or administrators ascribe to any of the aforementioned beliefs?" "Pick one to discuss with your elbow partners."
Bring participants back together.	Ask them to briefly share what they discussed in their pairs.
<u>**Defining Equity**</u> Go over the different definitions for equity in a conversational style.	Ask the following questions: "What is equity?" "What does bidirectional mean?" "Why is it important not to be able to predict what students from different backgrounds can do?
<u>**Mindsets Video**</u> Show Dr. Carol Dweck on Fixed vs. Growth Mindsets video. Ask participants to discuss the video and its implications for teaching and learning mathematics.	Ask participants the following questions: 1. What can be done to change a student's fixed mindset toward mathematics? 2. What are the implications for the teaching and learning of mathematics? What can be done to change a teacher's fixed mindset toward mathematics?
<u>**Standards for Mathematical Practice**</u> Hand out the Standards for Mathematical Practice Look Fors. Go over the Standards.	Go through the slides for the Standards for Mathematical Practice to refresh everyone's memory of the standards. If participants appear not to know them, ask participants to read through the Look Fors.
<u>**Looking for Squares Problem**</u> Go through the launch of the looking for squares problem. Then ask participants to find a square with 10 square units on the 5x5 Dot Paper.	Ask the following questions: What is the area of the unit square? What is the area of the 2 x 2 square? What are other upright squares that can be found in a 5 x 5 grid? What is the area of the tilted square? How do you know?

	Ask participants to find a square with an area of 10 square units. Ask participants to share their solutions. Next ask participants the following questions: 1. What mathematics did you use to solve the problem? What standards for mathematical practice were utilized?
Next, show the short version of the **<u>Looking for Squares Video</u>**.	Ask the following questions: 1. What productive beliefs are supported by the instruction in the video? 2. What shifts in teaching and learning need to occur in most classrooms in order to meet the needs of more students? What standards of mathematical practice did you notice?
<u>Effective Mathematics Teaching Practices</u> Distribute handout and discuss the effective teaching practices.	Discuss the teaching practices with the participants. Talk about how the teaching practices can help teachers to help students to develop the standards for mathematical practice. Ask participants to look at their handout. Ask participants which mathematics teaching practices were visible in the video? Ask participants to discuss how using the mathematics teaching practices can help the mathematics classroom to be more equitable.
Technology Activities	
How can incorporating technology into your teaching practices aid in ensuring all students are learning the mathematics concepts?	Share ideas with group
Activity 1: Interactive Slope Activity	Compare and contrast the 3 activities on the handout. Discuss the three activities.

	How is technology being used in each activity? What are the benefits/disadvantages of each tool? Which tool do you believe is more beneficial for students begin introduced to slope for the first time? What SMPs were used?
Activity 2: Statistics Activity – TI84 Engage in activity and record data. Additional scores will be given to participants to include with their results.	How do you usually teach statistics concepts in your classroom? What types of activities do you usually include? What technology have you and your students used? Why did you choose those tools? What types of activities would you like to do with your students? Discuss results with tablemates and whole group? How was this activity similar/different from the types of statistics activities you usually do in your classroom? How will this activity promote learning for all students? What SMPs were used?

Activity 3: Linear and Quadratic Functions Introduce Desmos and explore components Complete activity and discuss	How have you usually teach concepts related to linear and quadratic functions? What technology have you and your students used? Why did you choose those tools? Discuss results with tablemates and whole group? How was this activity similar/different from the types of statistics activities you usually do in your classroom? How will this activity promote learning for all students? What SMPs were used?
Activity 4: Tremendous Triangles Introduce Geogebra and explore components Complete activity and discuss	How have you usually teach geometry concepts related to triangles and other geometric shapes? What technology have you and your students used? Why did you choose those tools? Discuss results with tablemates and whole group? How was this activity similar/different from the types of statistics activities you usually do in your classroom? How will this activity promote learning for all students? What SMPs were used?

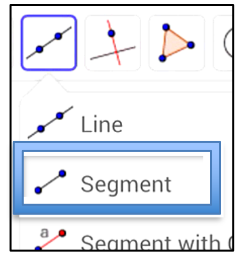
Resource Web Search	Search the internet for other mathematical action technology resources. Share what you found with other participants. How can you use the resources you found to promote mathematics learning for all students?
Reflection Responses will be recorded in NearPod	How will you use the information you learned today to enhance your instructional practices? If you do not plan to use any of the information, please explain why. What part of the workshop did you find most beneficial? Least beneficial? What additional support do you need in order to integrate technology into your mathematics teaching practices?

Tremendous Triangles - Geogebra

INVESTIGATION 0: Getting Started

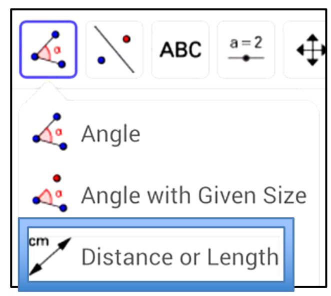
1. Open the Geogebra app, and tap on "Sign in." Then tap on "Create account" and follow the directions.
2. When you return to the "Create your own" screen, choose Geometry.
   a. Play around a little to see what the app can do.
   b. Hit the three vertical bars in the upper right, select New, choose whether you want to save your work, then open a new Geometry window.

INVESTIGATION 1: Tremendous Triangles



1. Let's first draw a triangle.
   a. Use the segment tool from the toolbar at the left to draw a triangle. (See picture to the right.) Make sure the three segments are connected!
   b. Use the "pointer" from the toolbar at the left to move your triangle around. What happens when you drag a point? What happens when you drag a segment?

   Notes: (1) Press and hold an object to delete it. Or use the "undo" icon at the top right. (2) Use the axis icon to the left of the tool bar to adjust the window. (See picture below.)



2. Make your triangle into an isosceles triangle.
   a. Drag the vertices so that the triangle is isosceles.
   b. Is your triangle *exactly* isosceles? Let's add some measurements to see:
      - Tap on the angle icon, then choose Distance or Length (see left)
      - Tap on each segment to see its length.
   c. When you have successfully drawn an isosceles triangle, move one of the vertices and note what happens. Did it remain isosceles?

3. Let's make a *better* isosceles triangle, based on design rather than tweaking measurements. If done correctly, it will remain isosceles, even if one of its vertices is moved.
   a. Here is a hint: You will need to use a circle: What is the definition of a circle? How might that help?
   b. Check the measures to be sure it works. Again, move one of the vertices and note what happens.
   c. Note — To be tidy, you can make the circle less prominent. Press and hold, then choose Object Properties.
      Go to the Style pane. You can also change its color!

4. Once you have completed your improved isosceles triangle, take a look at the measures of the angles.

a. Tap on the angle tool. Then tap on three points (in clockwise order) to find its measure!
b. Continue for the other two angles. What do you notice about the measures? (Are you truly surprised?)

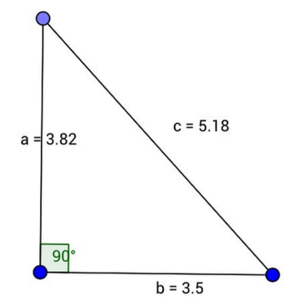
5. Now let's construct a *good* equilateral triangle that will retain its shape even when dragged.
   a. Here's a hint: Use *two* circles. Think about where the centers of the two circles should be…
   b. Add in angle measures and see what you notice.
   c. How are equilateral and isosceles triangles related? To answer this question, consider:
      - Can your isosceles triangle sketch be used to make (all, some, or no) equilateral triangles?
      - Can your equilateral triangle sketch be used to make (all, some, or no) isosceles triangles?

6. We will conclude our investigation of triangles by looking at *right* triangles.
   a. Here's a hint: Draw a segment, then use the "perpendicular line" tool.
   b. Find the measures of its angles, and make observations.
   c. Advanced fun: Add calculations to create the figure to the right. Directions at: www.bit.ly/5040PT

$a^2 = 14.57$

$b^2 = 12.25$

$c^2 = 26.82$



7. Draw an isosceles right triangle. Measure its sides and angles, and draw *several* conclusions.

Interactive Slope Activity

Compare and contrast these activities addressing slope-intercept form.
NOTE: Assume you do not already know about slope-intercept form!

1. Mahalo.com -------- http://x.co/mwnc

   *alternate link for video http://bit.ly/slope5040

2. Khan Academy---- www.bit.ly/slope-int1

3. Shodor.org ---- http://x.co/mwjU (see directions following)

   1. What does changing the black slider do?
   2. Consider the purple slider:
      a. How does changing its value change the line? The equation?
      b. What happens when the number is large? A negative number? Zero?
   3. Consider the green slider:
      a. How does changing its value change the line? The equation?
      b. What happens when the number is large? A negative number? Zero?
   4. In the equation, y = mx + b, summarize what "m" tells you and what "b" tells you.

Statistics Activity –TI -84

A. Engage in the class activity conducted by your instructor. Record your before and after scores. Additional scores will be provided, if needed.
B. Enter your data into the TI-83 graphing calculator:
    1. Press the STAT key, select "1:EDIT.." and hit ENTER.
    2. If there is already data in a column, highlight the column heading, hit CLEAR, then hit ENTER.
    3. Now put the "before" scores for the class in L1 and the corresponding "after" scores in L2.
C. Let's draw a histogram of your "before" values.
    1. Clear out existing graphs:
        a. Hit the "Y=" button.
        b. If there are any equations entered, either move the cursor to the equation and hit CLEAR, or move the cursor to the "=" sign in the definition and hit ENTER so that it is no longer highlighted.
        c. Go to STAT PLOT (2^{nd} + Y=) and select "4: PlotsOff" and hit ENTER.
    2. Go to STAT PLOT again, choose 1, and hit ENTER.
        a. Hit the down arrow and turn the plot On by hitting ENTER. (To turn it back off, hit the right arrow so that Off is highlighted and hit ENTER.)
        b. Hit the down arrow, use the right arrow to select the histogram icon, and hit ENTER.
        c. Arrow down again to select the list you want to plot: Choose L1 by hitting 2^{nd}+1, then ENTER.
    3. Hit Graph to see your histogram.
        a. If you can't see the graph – set ZoomStat (ZOOM key, then 9:ZoomStat.)
        b. Hit the TRACE button and move the arrow to the left. Look at the values it gives you.
        c. To adjust the "bin width" go to WINDOW and change Xscl to a more appropriate value.
    4. What can you conclude about the before values?
    5. Now repeat the process to graph the "after" values.
        a. You will need to turn off your first PLOT.
        b. You may also need to readjust the window!
    6. What can you conclude about the data based on this information? How does it compare to your first plot?
D. Let's try a different view of the data.
    1. Go back to STAT PLOT. (You may want to look at Plot 2 first.)
        a. Change the plot type to "box and whiskers" – use down arrow to get to the type, then hit the right arrow to get to the first icon in the second row.
        b. Hit GRAPH. You may need to use ZoomStat to get a good picture.
        c. Use TRACE to explore this graph. What does it tell you?
    2. Change your other plot to box and whiskers and plot both plots at the same

time.

3. What can you conclude about the two sets of values?

E. We can get statistics for the two lists.
   1. Hit STAT, then right arrow to highlight CALC. Choose 1:1-Var Stats and hit ENTER.
   2. What information does this give you? Which scores are these statistics for?
   3. To set the statistics for the other set of values, follow the same directions, but enter L2 (2^{nd}+2) before hitting ENTER.
   4. What can you conclude from this data?

F. But are they really different? Let's look at the differences of the before and after scores.
   1. Go to STAT, EDIT..
   2. Move to the top of the third column, L3.
   3. Enter the formula L2-L1.
   4. Use the methods described above to explore the differences by looking at the statistics and various graphs. What does this data suggest?

G. Now let's test the differences.
   1. Go to STAT, right-arrow to TESTS, and select 2:T-Test…
   2. Arrow down and set List: to be L3, the differences between your means.
   3. Arrow down and hit Calculate and ENTER.
   4. Then go back and hit Draw and ENTER.
   5. What does this information tell you?

H. Let's take one more look at the data.
   1. Turn off the Stat Plots, then go to Stat Plot 1 and turn it on.
   2. Set the graph type to Scatterplot, the first icon in the first row.
   3. Make sure Xlist is set to L1, and Ylist is set of L2.
   4. Draw the graph, adjusting the window as needed.
   5. What does this representation show you?

I. Let's find an equation that matches the data.
   1. Hit STAT and move the cursor to highlight CALC. Select "4:LinReg(ax+b)" and hit ENTER.
   2. This is the line that best fits the data you have entered.
   3. Make one or more observations about the equation.

J. Now let's graph that equation along with our data.
   1. Hit "Y=" and place the cursor at "Y1"
   2. Hit "VARS", then select "5:Statistics". Highlight "EQ" and hit ENTER.
   3. Now hit GRAPH again.

K. Last of all, let's look at statistics that go with the scatterplot and equation.
   1. Go to CATALOG (2^{nd}+0), scroll down to DiagnosticsOn, and hit enter.
   2. Repeat Part (I) above. What new information is given here?

L. Look over all the previous parts, and draw final conclusions about this investigation.

Linear and Quadratic Function Activity - Desmos

INVESTIGATION 1: Graphing Linear Functions

A. Getting Started
   a. In safari, go to [www.desmos.com/calculator.](http://www.desmos.com/calculator) Or, you may use the app.
   b. Create an account or log in with Google + (this will allow you to save work).

B. Making Linear Graphs
   a. In the left pane, type y = mx + b
   b. You should see: 

   c. Select "all"
   d. Changing the slope
      i. Move the slider for "m" only.
         1. Observe the behavior of your graph.
         2. Be sure to look at both positive and negative values.
         3. You may also press the button.
      ii. What happens for very large or small values of "m"?
         1. Click on the the value at the beginning or end of the slider.
         2. Enter your new slider range. Press Enter.
      iii. What happens as "m" gets very close to 0?
         1. Click on the the value at the beginning or end of the slider.
         2. Enter you new step size, say 0.001. Press Enter. (You may also need to adjust your starting and ending values). What happens?
      iv. What is your conclusion about "m"?
   e. Changing the constant
      i. Next, move the slider for "b" only.
         1. Observe the behavior of your graph.
         2. Be sure to look at both positive and negative values.
         3. You may also press the button.
      ii. What is your conclusion about "b"?
   f. Note – Just for fun, change the color of your line by holding your mouse on the , just to the left of your equation.

C. Special Lines
   a. Can you make your line exactly horizontal? Is it possible? What do you notice?
   b. Can you make your line exactly vertical? What do you notice?

D. Putting it all Together: Can you predict the behavior for a graph given any "m" and "b"?

E. Systems of linear equations
   a. In a blank line, type in "y = mx + b" again. What happens? Why? Clicking on the by one of the equations may help to see what is happening!
   b. Type in "y = nx + c". What happens? Why is this different from (a)?
   c. Try to make a set of parallel lines.

        i. When will the lines be parallel?
        ii. How do you know the lines are parallel?
        iii. Try some other examples to see if your conjecture is correct.
    d. Try to make a set of perpendicular lines.
        i. When will the lines be perpendicular?
        ii. How do you know the lines are perpendicular?
        iii. Try some other examples to see if your conjecture is correct.
    e. Solve the equation 2x-3=-5x+1.

INVESTIGATION 2: Exploring Quadratic Functions $ax^2 + bx + c$

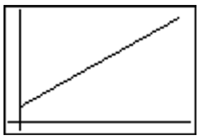
A. Let's explore the different parts of a quadratic equation written in standard form.
    a. In the left pane, enter "$y = ax^2 + bx + c$"
    b. Select "all" when the option to add sliders appear.
B. Changing the coefficient of the quadratic term
    a. Set the value for sliders b and c to 0.
        i. Be sure to look at both positive and negative values.
        ii. You may also press the play button.
    b. Base on your observation, what happens to the graph as you change the values of the number multiplied by x^2?
    c. What happens when a = 0? Why?
C. Changing the constant
    a. Move the slider for "a" back to a = 1.
    b. Move the slider for "c" only and observe the behavior of the graph.
        i. Be sure to look at both positive and negative values.
        ii. You may also press the play button.
    c. Based on your observation, what happens to the graph as you change the values of the constant?
D. Exploring the linear term
    a. Move the slider for "c" back to 0.
    b. Move slider "b" and observe what happens to the vertex of the graph.
        i. To help keep track, use the "+" sign to add a table and add in the coordinates for various positions of the vertex.
        ii. What do you notice? Can you find a rule?
    c. Now adjust "a" to a different value and repeat (b). Do you think you see a pattern?
    d. Now adjust "c" to a different value and repeat (b). Do you think you see a pattern?
    e. Base on this exploration, what is the impact of "b" on the graph? How could you better specify its impact?
E. Putting it all together – predict what the graph will look like for any a, b, and c.

Introductory CBR Activity

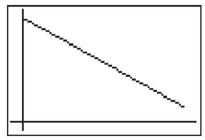
Sheet 1

Each of the following graphs depicts a distance-time relationship. Experiment with the CBR and a graphing calculator to create each graph. Answer the questions as you create the graphs.

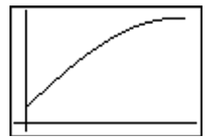
A.



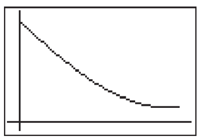
B.



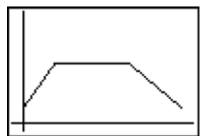
C.



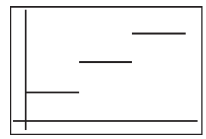
D.



E.



F.



1. Walk a path that results in a shape like that shown in graph A. Use the Trace feature of your calculator to pick two points on your graph and calculate the slope of the line. Also find the y-intercept. Use this information to write the equation of the graph in slope-intercept form $(y = mx + b)$ of the line you have walked.

2. How would you walk a path to create a graph that has the same y-intercept as that of graph A but a steeper slope?

3. Walk a path that results in a shape like that shown in graph B. Use the trace feature of your calculator to pick two points on your graph and calculate the slope. Also find the y-intercept. Use this information to write the equation of the graph in slope-intercept form $(y = mx + b)$ of the line you have walked.

4. Describe some similarities and differences in the motion depicted in graph A compared with the motion depicted in graph B. Consider your starting position, the direction in which you walked, and the speed at which you walked.

5. What does the *slope* of an equation represent with respect to the motion depicted in the graph of the equation? In your answer, describe the difference between positive and negative slope.

6. What does the *y-intercept* of an equation represent with respect to the motion depicted in the graph of the equation?

7. Walk a path that results in a shape like that shown in graph C and then like that shown in graph D. Describe some similarities and differences in the motion depicted in graphs A and B compared with the motion depicted in graphs C and D. Consider your starting position, the direction in which you walked, and the speed at which you walked.

8. Walk a path that results in a shape like that shown in graph E. How does the speed and direction depicted at the beginning of graph E compare with the speed and direction at the end?

9. What type of motion causes the horizontal segment in graph E?

10. Walk a path that results in a shape like that shown in graph F. What did you do to best match the motion depicted in graph F? If three people were in front of the CBR, what would you instruct them to do to create graph F?

From the December 2008/January 2009 issue of **MATHEMATICS teacher**

Appendix G

Timeline for Research

Description	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Participant Recruitment	X							
Initial Teacher Interview	X							
Departmental Workshop	X							
First Observation	X							
Co-Planning, Observation, and Debrief	X	X	X	X				
Individually Planned Lesson, Observations, and debrief		X	X	X	X			
Department Meeting		X	X	X	X			
Lesson Plan Collection	X	X	X	X	X	X	X	
Finial Interview					X			
Data Analysis	X	X	X	X	X	X	X	X

Appendix H
Participant Recruitment Letter

Dear Potential Research Participant,

I am writing to invite you to participate in a research study entitled "An Exploratory Study of the Impact of Situated Professional Development for Integrating Technology in Mathematics Instruction on Pedagogical Beliefs and Teaching Practices of Secondary Mathematics Teachers in a School with a High African American, Low-Income Student Population." The purpose of this study will be to explore the impact of providing secondary mathematics teachers in a school with a high African American, low-income student population with situated professional development that focuses on integrating technology within teaching practices. This study will focus on how the professional development affects the teachers' pedagogical beliefs and integration of technology. You have been purposefully selected to participate in this study because you are a full-time, secondary mathematics teacher in a school with a high African American, low-income student population.

The timeframe for this study is October 2017 through February 2018. You are invited to participate in one face-to-face, audio-recorded interview in which you will be asked a series of open-ended questions. Additionally, you will participate in a five-hour workshop that focus on technology integration and teacher beliefs. You will also be provided with one co-planning session to develop a technology-based lesson to be implemented in your classroom. You will plan two additional technology based lessons on your own. Each of these lessons will be observed by the researcher and a debriefing session will follow. Following the conclusions of all observations, you will again participate in a final interview. Finally, you will be asked to submit lesson plans from the prior school year, if available, and the current semester. All interviews, observations, and the workshop will be audio recorded and transcribed for data analysis purposes.

Every precaution will be taken to ensure your confidentiality. To protect your confidentiality, you will be asked to choose a pseudonym for use in descriptions and reporting results. Your participation in this study is completely voluntary, and you will not receive any compensation for your participation. You have the right to withdraw at any time without penalty.

If you have any questions regarding this research project or would like additional information, please feel free to contact any member of the researcher listed below:

Ruby L. Ellis (205) 886-6430 rze0005@auburn.edu
Dr. Marilyn Strutchens (334) 844-6838 strutme@auburn.edu

If you have questions about your rights as a research participant, concerns, or complaints about the research, you may contact the Office of Research Compliance at (334) 844-35966. Thank you for time and we look forward to hearing from you.

Sincerely,

Ruby Ellis, rze0005@aubun.edu

Appendix I
Consent Form

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMED CONSENT
for a Research Study entitled
"An Exploratory Study of the Impact of Situated Professional Development for Integrating Technology in Mathematics Instruction on Pedagogical Beliefs and Teaching Practices of Secondary Mathematics Teachers in a School with a High African American, Low-Income Student Population"

You are invited to participate in a research study to explore the impact of providing secondary mathematics teachers in a school with a high African American, low-income student population with situated professional development that focuses on integrating technology within teaching practices. This study will focus on how the professional development affects the teachers' pedagogical beliefs and integration of technology. The study is being conducted by Ruby Ellis, Auburn University Graduate Student, under the direction of Dr. Marilyn Strutchens, Professor in the Auburn University Department of Curriculum and Teaching. You were selected as a possible participant because you are a full-time, secondary mathematics teacher in a school with a high African American, low-income student population and are age 19 or older.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to participate in one face-to-face, audio-recorded interview in which you will be asked a series of open-ended questions. Additionally, you will participate in a five-hour workshop that focus on technology integration and teacher beliefs. You will also be provided with one co-planning session to develop a technology-based lesson to be implemented in your classroom. You will plan two additional technology based lessons on your own. Each of these lessons will be observed by the researcher and a debriefing session will follow. Following the conclusions of all observations, you will again participate in a final interview. Your total time commitment will be approximately 18 weeks.

Are there any risks or discomforts? The risks associated with participating in this study are breach of confidentiality. To minimize these risks, we will ask you to choose a pseudonym for use in descriptions and reporting results

Are there any benefits to yourself or others? If you participate in this study, you can expect to receive professional development designed to help you integrate technology within your current mathematics teaching practices. We/I cannot promise you that you will receive any or all of the benefits described.

Will you receive compensation for participating? You will not receive any compensation.

Are there any costs? If you decide to participate, you will not have any additional costs.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Curriculum and Teaching or Talladega City Schools.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation may be used to fulfill an educational requirement, published in a professional journal, and/or presented at a professional meeting.

If you have questions about this study, please ask them now or contact Ruby Ellis at 205-886-6430 or Dr. Marilyn Strutchens at 334-844-6838. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

______________________________	______________________________
Participant's signature Date	Investigator obtaining consent Date
____________________	____________________
Printed Name	Printed Name
	______________________________
	Co-Investigator Date
	____________________
	Printed Name

Appendix J

Code	Code Type	Description
Background Information	A-priori	Information pertaining to participants background information. This includes demographic, education, work experience, etc.
Current Teaching Experience	A-priori	Information related to teaching position at the time of the study
Education	A-priori	Related to specific education, training, degrees, and certifications
Previous Teaching Experience	A-priori	Related to teaching experiences prior to teaching position at the time of the study.
Beliefs about Students	A-priori	Related to participants beliefs about students and their behavior, mathematics abilities, learning, etc.
Discipline Problems	Emergent	Related to students' discipline issues
Do Not Care About Education	Emergent	Related to participants' perception of students' feelings towards education and mathematics
Low Expectations	Emergent	Participants mathematical expectations of students being low
Low Mathematical Ability	Emergent	Participants perceived mathematical ability of students being low
Unprepared for College	Emergent	Participant's belief that students are not prepared to succeed in college mathematics courses
Tracking Students	Emergent	Referred to tracking when discussing beliefs about students and their abilities
Parental Support	Emergent	Referred to parental support when discussing beliefs about students
Beliefs and Practices Related to Teaching and Learning	A-priori	Participants beliefs about the teaching and learning of mathematics
Assessing Student Learning	Emergent	Participant's views on assessing student learning
Obstacles	Emergent	Obstacles encountered by participant during the teaching and learning process
Administration	Emergent	Administration issues that interfere with teaching and learning

Discipline	Emergent	Discipline issues that interfere with teaching and learning
Planning Lessons	A priori	Information pertaining to how participants plan lessons and select activities
Choosing Content	Emergent	
Test Prep	Emergent	Participant indicated test preparation as a reason for choosing tasks
Textbook	Emergent	Tasks were taken from textbook
Collaboration	A priori	Collaboration with colleagues during the lesson planning process
Desire	Emergent	Desire to collaborate with colleagues to plan lesson
No Desire	Emergent	No desire to collaborate with colleagues to plan lessons
Old Fashioned Traditional	Emergent	Participant indicated that they view themselves as old fashioned or traditional meaning they prefer using older teaching strategies as opposed to newer teaching strategies.
Real World Connection	Emergent	Participant indicated that activities should have a real world connection
Teacher-Centered	Emergent	Instruction centered around teacher's thinking
Desire to Teach	A-priori	Information pertaining to why they chose to become a math teacher
No Desire	Emergent	No initial desire to teach math
Role Model	Emergent	Participant views themselves as a role model for students
Saw a Need	Emergent	Participant indicated that there was a need that they could fill
Professional Development	A priori	Information related to the professional development opportunities available to participants
Needed PD for Technology Integration in Teaching Practices	A priori	Additional PD participants specified they needed to assist with technology integration into their teaching practices
Participation	A priori	PD participants have participated
Specific to Technology	A priori	Related to PD participants have had specific to technology

Specific to Technology Integration In Mathematics	A priori	Related to PD participants have had specific to integrating technology into their mathematics teaching practices
Technology Use During Instruction	A priori	Related to using technology during mathematics teaching practices
Access to Technology	A priori	Participants access to technology for instructional purposes
Administrative Support	A priori	Administrative support assist participants with using technology in their classroom
Beliefs About Technology in the Mathematics Classroom	A priori	Participants initial beliefs about technology use in the classroom
Crutch	Emergent	Belief that calculators hinders student learning of mathematics or that students become too dependent on the technology
Distraction	Emergent	Belief that technology causes a distraction during instruction
For Upper Level Mathematics	Emergent	Belief that technology is only beneficial for advanced mathematics courses
Less Technology	Emergent	Desire to see less technology use in the mathematics classroom
Real World Applications	Emergent	Belief that students can benefit from seeing technology and mathematics being used in the real world
Desire to Use	Emergent	Participant indicated a desire to use technology during instruction
As Reward	Emergent	Participant indicated that technology should be a reward
Assessment Purposes	Emergent	Participant indicated that they would like to use technology to assist with assessing student learning
Games	Emergent	Participant statements related to math-based games use during instruction
Willingness to Try	Emergent	Participant indicated a willingness to integrate technology into instructional practices
Obstacles	Emergent	Things that prevent participant from using technology during instruction
Comfort	Emergent	Participant indicated comfortability was an

		issue
Overwhelmed	Emergent	Indicated feeling overwhelmed
Student Behavior	Emergent	Student behavior prevents technology use
Student Needs		Unaware of student needs to provide effective mathematics instruction
Technical and Hardware issues		Technical and hardware issues prevent technology use during instruction
Time		Indicated time or lack of time as an obstacle for technology use during instruction
Training		Lack of training to effectively use the available technology during instruction
Technology Use Outside of Classroom	A-priori	Participants' use of technology outside of the classroom

Appendix K
Participant Situated Professional Development Activities Facilitated by Researcher (not including discussions and reflections during observation debrief interviews)

Participant	Departmental Workshop (7 hours)	Planning Sessions (approximately 1 hour each)	Total Hours
Mr. Smith	1	4	11
Mr. Johnson	1	6	13
Mrs. Brown	1	4	11
Mr. Moore	1	5	12
Mrs. Taylor	1	9	15
Mrs. Wallace	1	7	14