ABSTRACT

Title of Document: A STUDY OF TEACHER CONCERNS ON THE INTEGRATION OF TECHNOLOGY WITH MATHEMATICS CONTENT AND PEDAGOGY IN CLASSROOM INSTRUCTION

Sherwin A. Collette
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Directed By: Professor Ann Ryu Edwards
Department of Curriculum and Instruction

The purpose of this research was to study teachers' changes in concerns as they integrate technology with their content and pedagogy. By analyzing the *Stages of Concerns Questionnaire* (SoCQ) at the beginning and end of this professional development cycle, this study analyzed changes in teacher concerns about the integration of technology, pedagogy, and content in their mathematics teaching and learning program as a result of participating in specific professional development.

Results of the t-tests comparing pre and post-survey data indicated that significant differences were found between February and May for Stages 0, 1, 2, 3, 4, and 5. No significant differences were found at Stage 6, the stage where participants have ideas about how to change or alter the reform initiative.

Concern profiles were generated and analyzed for all participants, whole-school implementation participants, and partial-school implementation participants for February and May. Profiles reflected shifts in concerns over time. A major area of concern that

evolved over time was an increase in management concerns. Profiles reflected low concerns about the impact to students.

A STUDY OF TEACHER CONCERNS ON THE INTEGRATION OF TECHNOLOGY WITH MATHEMATICS CONTENT AND PEDAGOGY IN CLASSROOM INSTRUCTION

By

Sherwin A. Collette

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Advisory Committee:

Professor Ann Ryu Edwards, Chair
Professor Daniel Chazan
Professor Lawrence Clark

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

Introduction to the Problem

This study seeks to explore the changes in mathematics teachers' thoughts and concerns over time as they engage in professional development targeted to help them integrate technology into their mathematics teaching and learning program. The focus on concerns acknowledges prior research findings indicating that teachers move through various stages toward deeper understanding and application as they attempt to implement changes or new innovations in their practice. And, in the specific context of integrating technology into mathematics classrooms "teachers are learners who move toward deeper understanding of what it means to use mathematics technology effectively with students" (Zbiek & Hollebrands, 2008, p. 288).

In their manual *Measuring Implementation in Schools: The Stages of Concern Questionnaire* (George, Hall, & Stiegelbauer, 2006), the authors highlight the research that framed the "developmental conceptualization of teachers' concerns… [and situate these concerns as teachers experience change] on a continuum from concerns about self to concerns about the task of teaching to concerns about impact on students" (p. 3). The ability to define where teachers are in the progression of change affords us a better opportunity to understand present concerns and design professional development practices from which teachers at any particular stage may benefit. Like other innovations, improving the teaching of mathematics through the effective integration of technology can be viewed as a developmental process through which mathematics teachers experience the affective dimensions of changing practice.

The integration of these technologies into mathematics teaching and learning is set against the backdrop of more than a century's long debate that has defined and redefined the role of mathematics in curriculum and what mathematics content is to be taught when and to whom. In response to economic and social changes, Stanic (1984) summarizes that "the emergence of mathematics as a school subject in the United States during the early years of the twentieth century was, then, characterized by conflict, continuity, and compromise. [This] conflict was largely a result of changes related to the growth of an industrialized society" (p. 171). Despite research advances and codification of laws assuring access to education, many of these conflicts remain today and have reemerged amid new attempts to reshape national curriculum content standards. The tenor of the debates and challenges to the adoption of the National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics* (NCTM, 2000) and the Common Core State Standards (CCSSO, 2010), for example, illustrate that these debates remain even today.

One key principle of the NCTM *Standards* envisions that "technology is essential in teaching and learning mathematics; [and] it influences the mathematics that is taught and enhances students' learning" (NCTM, 2010, p. 11). Over the past two decades, we have witnessed and participated in the rapid growth of new technologies. Kurzweil (2001) contextualizes this growth in his statement that over the next century, we will not experience 100 years of growth; instead, "it will feel like 20,000 years of progress" (p. 1). He further explains that the "overall technological progress of the 21^{st} century is the equivalent of what would require the past 200 centuries to accomplish" (p.1) and this is about 1000 times greater than the progress we saw in the last century (Kurzweil, 2001).

Researchers (Heid, 2008; Hollenbeck, Wray, & Fey, 2010) have begun to explore the possibilities and potential that the growth and progress in the various information and communication technologies that are "available for teaching and doing mathematics [hold for transforming the] ways that we can engage students in exploring mathematical ideas and solving mathematical problems" (Hollenbeck, Wray, & Fey, 2010, p. 265). As Heid and Blume (2008) state so eloquently "it is the confluence of technological environment, teachers, learners, curriculum, and mathematical activity that sets the stage for changes in the teaching and learning of mathematics in the context of technology" (p. 420) and for inviting and challenging us to revisit what mathematics is emphasized in classrooms.

There are many terms used to classify technology and its use in educational settings. Terms including *educational technologies, learning technologies, instructional technologies, mathematics-specific technologies*, and others bring with them connotations that either inadequately describes the role of technology or limits the possibilities that I believe can be explored with the integration of technology in classrooms, and specifically mathematics classrooms. In this review, I use the term *information and communication technology* (ICT) to describe the range and purpose of different hardware and software applications that could be used in classrooms to change content, pedagogy, instruction, and learning. By definition, ICT includes any information or communication device or application. This could be a radio, television, mobile phone, computer, web cameras, internet resources, online assessments, digital content, and the services and applications associated with each of these, such as videoconferencing, distance learning, wikis, blogs, and other social learning and networking platforms (Kumar, 2008). For the purpose of this review, the specific ICT on which I focus relative to studying changes to teacher practice and requirements for professional development include interactive whiteboards and the accompanying suite of handheld clickers, slates, and software, and web 2.0 learning spaces including wikis, blogs, and online web conferencing.

ICT tools and solutions have become more prevalent, powerful, and portable within mathematics and other classroom communities. Consequently, research indicates that teachers have begun to integrate content, pedagogy, and information and communication technologies in their classroom learning communities (Heid & Blume, 2008; Mishra & Koehler, 2006). Heid & Blume (2008) suggest that “the confluence of technological environment, teachers, learners, curriculum, and mathematical activity sets the stage for changes in the teaching and learning of mathematics in the context of technology” (p. 420). The implications for changes in the teaching and learning of mathematics resulting from the growth of new and innovative technologies used for information sharing and gathering and communication are many. For mathematics content, teaching, and learning, the questions are numerous: *What content is now available for teaching mathematics that was not possible before? How has digital content impacted teaching and learning of mathematics? How has teaching changed as a result of integrating specific technologies? Are there technologies that are specific to mathematics? How do technologies change the ways in which we visualize or represent mathematics? How are the ways in which we know mathematics changed as a result of certain technologies? Is there curriculum that is no longer relevant as a result of these technologies? How might mathematics communities of practice between students, teachers, universities, and mathematicians be facilitated and enhanced using new technologies?*

These questions and more are shaping research studies centered on content, teaching, student learning, assessment, and technology itself. This study seeks to explore changes in teachers' thoughts and concerns as they participate in and experience professional development that models and supports how to meaningfully select and integrate technology into their instructional design and practice. This examination proceeds from a belief that the integration of technology into mathematics teaching and learning programs must appropriately match the selection and use of technology to the findings on the principles of learning outlined in the National Research Council's 2000 report *How People Learn*. As a result, the professional development designed for teachers focused on integrating technology across three important principles: building on and helping to refine the mathematical understandings and resources that students bring to the classroom; inviting students into inquiry and criterial reasoning above procedural problem-solving based on key mathematical concepts; and engaging students in forming metacognitive strategies in solving problems (Fuson, Kalchman, & Bransford, 2005).

Statement of the Problem

Classroom teachers across the country have begun to integrate content, pedagogy, and information and communication technologies in their classroom learning communities. However, while there are many studies and anecdotal reports on the benefits of this integration, there is a need for studies that describe the changes in teacher concerns that support the growth in integration of technology, pedagogy, and content as they participate in professional development experiences.

Purpose of the Study

The purpose of this research is to study teachers' changes in concerns as they work to integrate technology with their content and pedagogy. This study seeks to analyze the changes in teacher concerns about the integration of technology, pedagogy, and content in their mathematics teaching and learning program as a result of participating in a specific professional development initiative in order to better understand how this professional development initiative influences, if at all, changes in teachers' implementation practices.

Research Questions

The following research questions are the focus of this study:

1. Is there a statistically significant difference between how teachers think about integrating technology, content, and pedagogy in their classrooms, as reflected by changes in their concerns about the initiative, at the beginning and after several months of participation in targeted professional development?
2. How do the concern profiles of teachers change after several months of participating in targeted professional development on the integration of technology?
    a. How do the concern profiles of teachers who teach in a whole-school technology integration model change after several months of participating in targeted professional development on the integration of technology?
    b. How do the concern profiles of teachers who teach in a partial-school technology integration model change after several months of participating in targeted professional development on the integration of technology?

CHAPTER TWO: REVIEW OF THE LITERATURE

The first section of this review of the literature includes a description of coherence of reform initiatives in schools as new reform efforts are introduced. The next section outlines several shifts in teaching and learning environments as a result of the growth of technologies. The third section of this chapter outlines emerging research perspectives on the design of teacher professional development, as well as teacher practices as they are modified by the integration of technology. The next section outlines some of the research on teacher knowledge that is required for meaningful integration of technology into the instructional program and what professional development experiences might look like for these teachers. The final section of this literature review outlines the research on teacher concerns and the use of the CBAM to assess these concerns in teachers.

Coherence in School Reform Efforts

In their book, *Tinkering Toward Utopia*, Tyack and Cuban (1995) tell the story of a century-long pattern of reform efforts that find their way into schools, only to fall short and then be replaced by another round of reform efforts. They make the case that no reform effort has yet to live up to its full expectation or potential, and therefore ends up being abandoned and replaced a new promising innovation. However, often the reforms don’t spiral in to schools one at a time. They often converge at the school door as competing priorities and policies to be implemented all at the same time. Darling-Hammond (1990) states, “policies don’t land in a vacuum. They land on top of other policies” (p. 346). When these policies make their way to schools, often they are presented as fragmented, disjointed, and unrelated to a more comprehensive approach to school improvement.

In an attempt to explain this failure to reform, Fullan (2000) states "the main enemies of large-scale reform are overload and extreme fragmentation" (p. 581). Newmann, Smith, Allensworth, and Bryk (2001) explain that in an attempt to overcome poor performance, many schools adopt many school improvement projects and programs. They describe the pattern of implementation that occurs as a result as, "teachers divide themselves among various initiatives and direct a great deal of time and energy to multiple workshops, meetings and conferences" (p. 298). Over time, as gains and changes are not recognized, the efforts fade, and schools soon find themselves in "a large and fragmented circuit of school improvement activity," (Newmann et al, 2000, p. 298).

A focus on greater whole-school coherence is suggested in movements grounded in whole-school reform. These efforts attempt to eliminate the disjointed, piecemeal improvement efforts that currently exist and serve to divide the focus of school staff and splinter what are already limited resources. This whole-school approach to reform is growing more common in today's reform efforts (Newmann et al, 2000, p. 298). The whole school reform movement brings to light the idea that coherence is a critical factor in implementing and sustaining educational reform.

Instructional program coherence is defined as a set of inter-related programs that are guided by a common framework for curriculum, instruction, assessment, and learning climate, and are pursued over a period of time (Newmann, Smith, Allensworth, & Byrk, 2001). This contrasts with a school that adopts a wide variety of programs that are uncoordinated or limited. The need for coherence first surfaced in curriculum improvement initiatives (Cohen & Ball, 1998; Smith, Smith, & Byrk, 1998). Researchers emphasized the importance of building sensible connections between topics and grade levels. This need for program coherence was developed by Newmann et al. as a way to measure how different efforts fit together while being implemented. Madda, Halverson, and Gomez (2007) echo this importance by stating that the "lack of a coherent fit among initiatives at the school level means that local practitioners must make decisions about which conflicting program goals are worth meeting" (p. 1958).

This notion of coherence in implementation of a reform is especially important in the rollout of technology in schools. Across the country, we have seen two different implementation models—whole school implementation models and partial school implementation models. Much of the implementation decision is driven from a financial limitation. However, it is important to better understand the implications of each of these implementation models in order to make decisions about the future rollout of technology in schools.

While the data on whole-school vs. partial-school implementation of technology in schools is limited, early studies have found that schools that were most successful at introducing technology into the curriculum involved many, or most, departments in the school (Treagust & Rennie, 1993). Departments incorporated those aspects of the technology implementation into their curricula which were considered to be most relevant to their subject areas. Further, after a year of participation in the reform, "there was a perception among teachers in all three successful schools that 'this is a Technology School and we are doing something different and important with our programs compared to other schools'. Once the focus on technology in the school was sufficiently clear, and when some teachers other than the coordinator had success with and responsibility for what they were doing, then there was sufficient momentum in the school to ensure that, with monitoring, encouragement and assistance by the coordinator, the implementation process would continue" (Treagust & Rennie, 1993, p. 53).

As there is a move away from aligning technology with the 'trade' or 'technical' subjects and an effort to place it more central to the curriculum (Treagust & Rennie, 1993), there are opportunities to move the integration of technology from a few people in the building to a whole-school effort. In this way, the disjointed and often fragmented effort of integrating technology moves to a position of coherence through a whole-school implementation model.

Shifts in Teaching and Learning

In order to better examine and interpret the research on how the integration of ICT is expanding the conceptualization of what it means to be literate and how we define these new, dynamic learning environments, I believe that it is important to situate these shifts within the scholarly efforts to define quality teaching in reform-minded mathematics classrooms. Understanding the complexity of defining quality teaching is relevant given the possibilities for how the integration of information and communication technologies into teaching may further shift and reshape our notion of quality teaching.

As Franke, Kazemi, and Battey (2007) observe, "Classrooms involve people, the lives of people over time, people who work in social, cultural, and political contexts that shape how they do their work and how that work gets interpreted" (p. 227). Moreover, the intersections and interactions among teachers, students, and the curricular content is dynamic, complex and mediated by many factors. In fact, "the form and role of the content influences and informs how meaning is constructed and student conceptions formed as students and teachers engage in mathematical activities" (Franke et al., 2007, p. 228). These complex, multifaceted, dynamic relationships that comprise classroom practice and the interactions between teaching and learning vary day to day and make it impossible to create a "formula, a set of guidelines, or even a set of practices that all teachers should engage in" (Franke et al., 2007, p. 228).

The New Literacy

It used to be that when people talked about being literate, they meant being able to read and write text. While these goals are still important, and while we continue to emphasize the requirement to read and write through a text-based forum, the definition of literacy has expanded to include many other modes of communication. Richardson (2009) explains that, "It is no longer sufficient in today's world to only be able to read and write in a text-based environment because we no longer live in just a text-based environment" (p. 4). He further states that, "Today, content and information can be created and published across the internet by anyone at anytime from anywhere. Because of this, it is now a requirement for people to learn to be critical analyzers of information. This requires that we teach students how to be thoughtful, active consumers and creators of knowledge instead of passively accepting all content as legitimate" (p. 22).

Today, not only do teachers need to model for students how to write and communicate their ideas using multiple forms of communication styles including video, presentation software, and visual graphics, but they must also model for students how to publish their ideas and potentially define their voice in virtual communities and spaces

(Richardson, 2009). According to Richardson (2009), “There are new communication literacy skills and processes that students must know and be able to use as they learn to effectively navigate in the digital age” (p. 34). With the blending of pictures, video, presentation slides, text, and audio, today’s means for communicating key information and ideas through the creation of a blog, Prezi, or Voicethread presentation is a requirement for teachers to understand and help students learn in order to engage effectively in this new era.

The fast growth of information and communication technologies and their prevalence in today’s world has begun to impact teaching and learning environments. With this growth and integration of technology, we have an opportunity to rethink longstanding assumptions about central components of education, including where content comes from, when teaching and learning occurs, who the teacher is, and how people are able to show what they know and understand. Richardson (2009), in his research on technology and its impact on education, describes several shifts in our assumptions and understanding about schooling that we must consider as we seek to understand what is required of teachers in this new teaching age.

The first shift that Richardson discusses is related to the role of content. Until recently, school districts and teachers “owned” the content that was taught in school. Curriculum was generated through central office, was transmitted to schools and teachers, and taught by the teacher through a book with additional resources supplied by the teacher (Richardson, 2009). Students had limited access to additional information about the subjects and topics they were studying, and it was not expected that they seek outside sources unless it was part of a school research project. Today, more current and often more accurate information than what appears in printed textbooks and is portrayed in curriculum guides is available with one search on the internet. The breadth and depth of information available on virtually any topic is something that teachers never needed to address or contend with in the history of education, until now. For the first time, teachers and school districts do not own and control the content that students have access to. Richardson (2009) talks of this shift as “changing the once controlled teaching and learning environment to a more open-source type classroom where everyone contributes to the curriculum” (p. 24).

A second closely related shift that Richardson (2009) highlights, is the availability of, and access to information anytime and anywhere. Richardson states, “As access to content increases, so does the access to other teachers – formal and informal” (p. 32). It is now possible to engage and interact with people around the world about the topics that are studied in school. This includes authors of the books that are read in reading class, professionals in the STEM fields that work with the content learned in biology and calculus, and other experts around the world that can provide information that could only be made available in the past through a guest speaker session (Richardson, 2009). Because of this shift, learning can occur at any time and with anyone. Further, the access to diverse cultures, locations, and opinions and expertise that is now available broadens learning opportunities. Students are now able to more readily incorporate multiple viewpoints and perspectives into their thinking and work products as they access different experts from around the world. Richardson concludes that, “Unlike the traditional teacher-student relationship, students are no longer dependent on just the classroom teacher; and are no longer passive consumers of content provided by only their teacher" (p. 36).

What it means to create content and share knowledge is another critical element of teaching that requires a shift in our thinking as a result of new technologies in our daily lives. The typical and current scenario for most students and how they work has been that students work independently to produce work that is then reviewed and graded by the teacher (Richardson, 2009). Once students have finished their work, they are very rarely asked to revisit it and continue to make modifications and changes. Instead, students move to the next assignment that they then complete independently and turn in for grading by the teacher. Today, however, with the integration of information and communication technologies, students have access to technologies where they can post their work to a public forum, receive feedback on their creation, and watch their content undergo modifications and transformations by others. Today, students are content creators on the internet, and through the social collaboration that naturally exists on blogs, discussion boards, email, and other posting sites, students realize that no work is a final product. Instead, they are able to learn and grow from watching others transform their work as they work to transform other's creations. This shift has tremendous impact for teachers who often only seek the final draft in order to generate a report card grade (Richardson, 2009).

With the shift in being content contributors to the internet and the wealth of knowledge and information on the web, another shift that Richardson (2009) identifies is the role of student voice and participation in learning. The changes in communication that have occurred with the growth of ICT have enabled students to actively participate in the design of their own learning. Not only are students able to explore and learn just about any topic they are interested in, they are able to do this at any time of day from their own homes. With the ability to post content and information, students are now able to voice their ideas and opinions to others in very public ways (Richardson, 2009) and then are able to listen to others as they reflect and give feedback on those ideas. Through this forum, students are learning that their ideas count and that they share in the ownership of knowledge creation. This is very different from the traditional classroom where students have little to no voice in shaping the learning environments, and this has tremendous implications for teachers who no longer are able to control the learning and forms of expression of their students.

These shifts in teaching and learning as a result of the growth of information and communication technologies communicate a need for classroom communities of practice to become more reflective of the communities of practice in which students engage outside of school. As Prensky (2001) observed, “Our students have changed radically. Today’s students are no longer the people our educational system was designed to teach” (p. 22). As a result, teachers are being required to examine their practice and respond to these changes in order to remain relevant to students in the classroom. A closer examination of how teacher practices shift with the integration of technology follows in the next section.

Shifts in Teacher Practices

A New Paradigm for Teacher Professional Development

Efforts to implement reform-based curricular and instructional practices have renewed inquiry and research into what constitutes effective professional development.

For example, mathematics reform curricular such as the *Principles and Standards for School Mathematics* (NCTM, 2000) and the *Common Core State Standards for Mathematics* (Common Core State Standards Initiative, 2010) envision changed pedagogical practices and teacher content expertise needed to develop students' mathematical proficiency. In this way, teaching for mathematical proficiency, as contemplated by the process and practice standards of these reforms, require a "new paradigm for professional development" (Stein, Smith, & Silver, 1999, p. 239). Research examining the characteristics of high quality and effective professional development has led to a growing consensus in the research literature that is defining the elements of this new paradigm for professional development. Taken together, the research literature suggest that designing professional development opportunities with these features can have beneficial effects in changing and improving teacher practice and students learning.

In planning the professional development initiative that is the subject of this study, it was important to situate the program design on key professional development research constructs. According to Little (1993) district sponsored staff development typically consists of a menu of training options designed to transmit a specific set of ideas, techniques, or materials. Usually, these training sessions are planned by people other than the teachers themselves (Fullan, 1991) and often result in a disconnected and de-contextualized set of experiences (Stein, et al., 1999). Such approaches tend to encourage tinkering around the edges of practice rather than actually transforming it (Huberman, 1993) and reduce teaching to routine and technical (Little, 1993).

As a result, while teachers may incorporate additive benefits by sprinkling in new skills with what they already know and do this kind of professional development model based on these research findings do not lead to transformation of practice. Based on the work of a number of researchers (Ball & Cohen, 1999; Darling-Hammond & McLaughlin, 1995; Little, 1993; Loucks-Horsley, 1995; Stein, Smith, & Silver, 1999; Whitcomb, Borko, & Liston, 2009; and others) key attributes of effective professional development include: situating the programs directly in the practice of teaching; grounding the professional development in exploring content and student learning; developing teacher communities of professional practice; and considering the organizational context in which teachers work across the district.

Situating professional learning in the practice of teaching builds from the research that has focused on more deeply understanding high quality teaching. For example, Fenstermacher and Richardson (2005) outline three research categories that reflect different perspectives on high quality teaching. The three perspectives include teaching as transmission, or process-product; teaching as cognition, or cognitive science; and teaching as facilitation, or constructivist teaching. Each of these perspectives reflects very different beliefs about what high quality teaching is and is not. Teaching as transmission, according to Fenstermacher and Richardson (2005) is a linear model where effective teachers use certain instructional behaviors to transmit knowledge and skills to students, and effective teaching in this way is measured by student test scores (Fenstermacher & Richardson, 2005, p. 198).

As a result, defining high quality teaching is essential to defining and situating professional development, and engaging in and researching it. Wei, Darling-Hammond, Andree, Richardson, and Orphanos (2009) in their status report on the state of professional development conclude that in order for these teacher learning opportunities to be effective, "the content of [the] professional development is most useful when it focuses on concrete tasks of teaching, assessment, observation, and reflection" (p. 3). Locating the professional development within the context of teacher practice provides more meaningful opportunities to explore instructional practice within the complex interactions among teachers, students, and content.

Focusing professional development on exploring student thinking is another critical aspect to designing effective, high quality professional development that is emerging from the research. As Whitcomb, Borko, and Liston (2009) summarize, "Professional development programs should help teachers learn how to elicit and interpret students' ideas, examine student work, and use what they learn about students' ideas and work to inform their instructional decisions and actions" (p. 209). In alignment with this argument, Hiebert et al. (1992) claim that the single most important principle for improving the teaching of mathematics is to allow the subject of mathematics to be problematic for students. Magdalene Lampert (1990) elaborates this notion of the importance of mathematics teachers' being proficient in examining and diagnosing student thinking through problematic tasks in observing:

> "The most important criterion in picking a problem was that it be the sort of problem that would have the capacity to engage all of the students in the class in making and testing mathematical hypotheses. These hypotheses are embedded in the answers students give to the problem, and so comparing answers engaged the class in a discussion of the relative mathematical merits of various hypotheses, setting the stage for the kind of zig-zag between inductive observation and deductive generalization that Lakatos and Polya see as characteristic of mathematical activity" (p. 39).

Moreover, because of its use to guide instruction, research findings on teacher knowledge of student thinking, including engaging and analyzing student misconceptions or emerging understandings of mathematical concepts, continues to evolve. Numerous researchers (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Gearhart & Saxe, 2004; Jacobs, Franke, Carpenter, Levi, & Battey, 2007) have illustrated that by focusing on students' thinking, teachers are able to actually strengthen students' mathematical understandings—when students' thinking is used in intentional ways to guide instruction. As a result, mathematics reform efforts as embodied in the NCTM (2000) and Common Core Initiative (2010) have emphasized "helping teachers become more expert at assessing and using student thinking to guide instruction" (Kersting, Givvin, Sotelo, & Stigler, 2010, p. 173).

This emphasis on better engaging, analyzing, and using students' understandings (including misconceptions of mathematical concepts) also has influenced the call for professional development that develops teacher knowledge in the context of teaching and within communities of practice. Lave and Wenger (1992) write about what it means to be a meaningful member of a community of learners and what it means to practice or participate within the community. Their arguments cause us to reflect on the critical role of community and communities of practice relative to learning and as a result, consider the implications for schooling today. The implications for schooling include how schools and classrooms are organized to support and foster the multi-dimensional practice of teaching that considers how identity, communication, and social activity work together to influence student participation in the learning community and impact student learning. Furthermore, Kersting et al. (2010) note that research on the development of teacher knowledge within the context of teaching "reason[s] that teachers' decision making might be improved if they become more capable of sophisticated analyses of student thinking in the context of classroom lessons” (p. 173).

Therefore, an essential part of a teacher’s instructional design, is shaping and enabling mathematical discourse. As a result, constructing classroom communities that support and invite authentic problem solving, communication, and a sense of ownership in the mathematics learning becomes critically important. This implicit acknowledgement of the social nature of learning also is informing the reimaging of the context for teacher professional development. As Whitcomb, Borko, and Liston (2009) observe, “a growing body of literature indicates that professional development experiences are particularly effective when situated in a collegial learning environment, where teachers work collaboratively to inquire and reflect on their teaching” (p. 210). Relatedly, Stein, Smith, and Silver (1999) found that one of its two study districts achieved success in implementing its new mathematics curriculum by establishing and sustaining a professional learning community over a three year period. Moreover, Stein et al. (1999) attribute the success of the learning community to the district having used the new curriculum as the foundation for constructing a shared vision for their students’ mathematical proficiency and teachers’ growth as content experts. Within the new teacher professional development paradigm, the emerging research consensus suggests that learning communities provide opportunities to nurture both teacher individual growth and the development of teams of teachers in reflecting critically on their practice, planning together, and shaping shared understandings for developing students’ mathematical proficiency.

Teacher Shifts with Technology

In his book, *Teachers and Machines: The Classroom Uses of Technology Since 1920*, Cuban (1986) researches and charts the integration of three specific technologies in educational settings, and then asks whether or not and to what extent technology, and specifically computers, should be integrated in classrooms. Cuban (1986) highlights his findings in this study and others that education and classroom instruction has been the "constancy amidst change" (p. 1) and explains that the integration of technology in classrooms epitomizes this "constancy and failure" (p. 2) of impactful reform. He states that, "nowhere is this paradox more apparent than in the interplay between the classroom teacher and technology" (p. 2). From Cuban's perspective, over the decades of trying to implement reform, and specifically reform with technology, there has been little or no shift at all in teaching practice.

One possible explanation for this constancy and lack of impactful transformation that Cuban (1986) points to is the lack of teacher voice, participation, and ownership of the reform itself. Teachers themselves have rarely been the leaders of such reform movements, and instead have practices and technologies imposed upon them by policymakers, administrators, and outside voices seeking efficiency and productivity (p. 5). He suggests that if technology is to be integrated in classrooms, it is through the inclusion of teachers that it is possible to actualize some of the promise of new ways of teaching and learning with technology.

Echoing Cuban's (1986) sentiment on the importance of involving teachers in generating the value and reform movement, Sandholtz, Ringstaff, and Dwyer (1997) conducted a series of case studies within the Apple Classrooms of Tomorrow (ACOT) that were aimed at understanding the process that teachers go through as new technologies are provisioned in their classrooms. In this particular study, the technology was computers. Through their research, they discovered that shifts in teacher practice were nonexistent in the first few years of implementation. Just as Cuban had found, teachers had incorporated the use of technology within their current structures and practices, and implemented the necessary adaptations to their existing lessons in order to accommodate technology but not change the teaching and learning in any noticeable or valuable way. However, as the study continued and the teachers continued to be exposed to the technology and professional development, shifts did occur in teacher practices in a non-linear in fashion (Sandholtz et al., 1997).

In their book, *Teaching with Technology: Creating Student-Centered Classrooms*, Sandholtz et al (1997) describe the process of teachers went through as they worked to integrate technology in their classrooms. As teachers worked to quickly adapt to the new technologies in their classroom, the researchers observed teachers establishing a routine for their classroom practice. This routine included the use of the technology in ways that continued their current and existing practice.

Over time, however, Sandholtz et al. (1997) found that teachers began to experiment in ways that changed their teaching and impacted the kinds of learning that was taking place in the classroom. This experimentation served two purposes. It provided the teacher with the opportunity to teach in new ways that embraced the transformation the technology could provide; and it changed the learning environment, usually toward a more student-centered approach. However, it was during this stage that teachers found undesirable consequences as a result of this experimentation, and they reverted back to their former ways of teaching and structuring class.

Once these teachers returned to their former state, Sandholtz et al. (1997) found that these teachers were no longer satisfied with their former ways of teaching. During the experimental stage, teachers found new desired attributes of their teaching program and experienced student learning environments that they realized they could not achieve within their traditional ways of teaching. It was at this point that the researchers observed teachers re-engaging in experimentation of practice, again embracing the possibilities these technologies could provide in transforming teaching and learning.

It was through this process of stepping forward and then stepping back, only to step forward again did these researchers observe shifts in teacher practice. Had the study only lasted for one or two years of implementation, these researchers would have concluded that no change in teacher practice had occurred. It was only after several years of implementation did this stepping in and stepping out of the reform begin to occur for many teachers.

Teacher Practice Shifts with Interactive White Boards

One specific technology that has seen tremendous growth in education settings is the interactive whiteboard (IWB). In many ways, it is analogous to the computer integration in the classroom. Research that studies changes in teachers' practice as a result of the integration of the IWB are growing. This is an important area of the research on the integration of technology in education today because currently, it is estimated that "one in every seven classrooms in the world features an interactive whiteboard" (Future Source Consulting, 2009, p. 423).

Much of the research during the early stages of IWB adoption focused on the benefits of the technology instead of on how pedagogy and engagement with content might be transformed. This research has supported the claim that use of interactive whiteboards can have positive effects on teaching and learning (British Educational Communications and Technology Agency, 2003). Research has also shown that use of the IWB promotes student interest, sustains longer periods of concentration, and promotes more effective learning when teachers are aware of the ways in which such technology can be used to support a variety of learning styles (Glover & Miller, 2003). Recently, more research that illustrates cases of how teachers integrate these technologies are emerging and showing the connection between methods of integration and how the implementation of technologies influences student learning experiences.

Studies about teacher adoption of these technologies suggest that when implemented in certain ways, technologies have the ability to display material with a variety of representations that have the potential to meet the needs of a wide range of learners (Beeland, 2002). This notion of representation is especially critical in the mathematics classroom. How teachers use this technology to select teaching models, provision opportunities for students to access different models, and create representations of mathematics concepts through the use of the board have begun to be explored, and finding suggest that how teachers choose to implement technologies in mathematics classes is directly related to what they know about mathematics, what they know about technology, and how they integrate the two (Zbiek & Hollebrands, 2008). Further, in their synthesis on technology and the teaching and learning of mathematics, Heid and Blume (2008) argue that through their analysis of the research on the integration of specific technologies within specific mathematics subjects, it is the teacher's knowledge of mathematics and the teacher's knowledge of technology that influences the selection of content, activities, and the use of the technology.

Research has shown that as teachers become more competent and confident in the use of the IWB technology, they seek ways in which they can use the technology to change their practice (Beeland, 2002; BECTA, 2003, 2004). Changes occur as teachers move through using the board primarily as a glorified overhead projector and screen to more of an interactive device capable of being a window to interactive digital content, opening up multi-modal instructional pathways, and inviting the world community into the classroom through web conferencing on a big screen where all students can easily participate. Further, researchers (Beauchamp & Parkinson, 2005; Tanner, 2002) have studied the link between effective questioning techniques that promote higher level thinking among students with the use of the IWB as a means for examining interactivity. Studies specific to teacher pedagogy within mathematics classrooms emphasize the need for teachers to move from didactic, teacher-centered approaches to a more experiential environment that capitalizes on both the teaching and learning value of the technology (Damcott et al., 2000; Robison, 2000) and emphasize that as teachers do this, the affordances of the new innovative technology become real.

Researchers have noted the transition that teachers undergo in using technology in the classroom. Studies and observations on the use of teachers using the IWB in early stages note that in most cases, the board promotes the teacher in front of the classroom, tethered to the board, delivering a traditional lesson (BECTA, 2007). In this way, using the interactive whiteboard to support and enhance current practice parallels the findings from Sandoltz et al. (1997). In an attempt to better understand the transition teachers move through in using the board in more interactive ways, Glover et al. (2007), building from the research from Beauchamp (2004) and Haldane (2007), created three levels of progression for teacher use of the IWB in mathematics classrooms as a result of his observations.

The first level of use that Glover (2007) observed is what he categorizes as "Supported Didactic." In this stage, teachers use the IWB primarily as a visual support to the lesson and not as an integral strategy for conceptual development. For example, a teacher using the board to demonstrate equivalent fractions showed the students visuals of fraction on the IWB. Another teacher, teaching mathematics vocabulary, had the words displayed on the board but asked the students to copy them in their journals. In this stage, teachers are the focus as they follow traditional approaches with minimal student activity except in response to teacher questioning. This stage mirrors the first stage of establishing routines that was established by Sandholtz et al. (1997).

The second stage that Glover et al. (2007) identify in teachers' shifts toward meaningful use of technology is the interactive stage. This stage of the linear progression has the teacher using the IWB to challenge student thinking by using a variety of verbal, visual, and kinesthetic cues and prompts that begin to capitalize on what the board has to offer. In this stage, teachers begin to interact with the technology as they explore the potential of the IWB tools. This stage is similar to the exploration stage of Sandholtz et al. (1997). In this phase, the technology, and in this case the board becomes a focal point of the students' attention while it is used to illustrate, develop, and model mathematics concepts. At this stage, the IWB is no longer a novelty to teachers and students as it is integrated into the teaching and learning, but the full potential of the technology has not yet been developed.

The final stage that Glover et al. (2007) identified that teachers evolve to is what he calls enhanced interactivity. This stage can be described as teachers using the IWB as an integral part of most teaching and learning and when the technology is used for integrating concepts and learning in a way that explicitly and intentionally capitalizes on the interactive capacity of the technology. At this stage, teachers are fluent in technology use and also flexible in the use of their pedagogical knowledge around structuring lessons. It is in this final phase that teachers provide opportunities for students to work as individuals, pairs, and small groups to enhance active learning and interact in dynamic ways with the technology in order to foster deeper understanding of mathematics concepts. At this stage, Glover (2007) found that the board was used to “prompt discussion, explain processes, develop hypotheses, construct models, and test theories through different applications; and students were able to represent their knowledge in ways they could not without the integration of this technology,” p. 34.

The final stage of Glover et al.’s (2007) differs from the pathway that Sandholtz et al. (1997) outline from their observations. Where Glover’s research suggests an arrival of teachers’ practice at the ideal state of interactivity and transformational use of technology in teaching, Sandholtz suggests that teachers really never arrive at a desired state. Instead, they move from experimenting to sometimes retreating back to a former state to moving forward with experimenting again. It is this flexible movement that allows for teachers to find useful and authentic teaching and learning experiences that they support, embrace, and continue to build from.

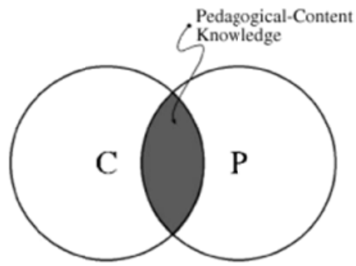
Teacher Knowledge and Professional Development

Technological Pedagogical Content Knowledge

With the introduction and growing integration of technology in classroom settings, implications for teacher knowledge and how that knowledge is cultivated have surfaced within the research literature. Two prominent researchers leading this new and quickly developing field of research are Mishra and Koehler, two professors from Michigan State University. Mishra and Koehler (2006), after spending five years working on a design study that focused on teacher professional development on the integration of technology, developed a theoretical framework for the kinds of teacher knowledge that are necessary for transforming classroom practice through the integration of technology with content and pedagogy.

Building from Shulman’s (1987) concept of pedagogical content knowledge, Mishra and Koehler (2006) found that the complexities of overlapping areas of teacher knowledge could only be explained by extending Schulman’s pedagogical content knowledge (PCK) framework. According to Mishra and Koehler (2006), “PCK represents the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organized, adapted, and represented for instruction” (p. 1021).

Figure 1: Pedagogical Content Knowledge

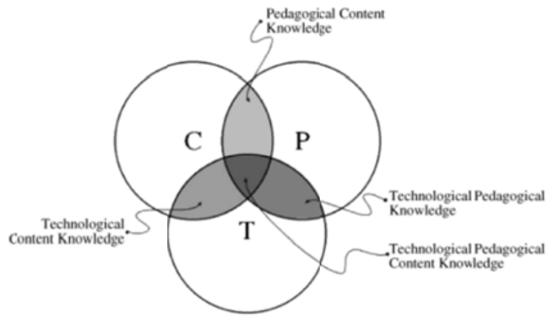


Source: Mishra, P. and Koehler, M. (2006). "Technological pedagogical content knowledge: A framework for teacher knowledge." *Teachers College Record* Volume 108, Number 6, p. 1021.

The PCK framework brings together discrete bodies of knowledge (content and pedagogy) and Schulman illustrates that it is the content for teaching that teachers need to know and be able to teach – know the content and how to teach it.

Mishra and Koehler (2006), based on their design studies of teachers working to integrate technologies, extended the framework that Schulman (1986) built to describe the ways in which we currently think, and need to think, about knowledge of technology and how this knowledge is interwoven with content and pedagogy in complex and important ways. Their theoretical model, which they call technological pedagogical content knowledge (TPCK) stemmed from observations of teachers working with technological knowledge that was separate from their content and teaching knowledge. From their model, as seen in Figure 2, Mishra and Koehler (2006) set themselves apart from other researchers claiming the necessary blending by articulating the distinct bodies of knowledge that grow from the intersections of the three circles of knowledge.

Figure 2: Technological Pedagogical Content Knowledge



Source: Mishra, P. and Koehler, M. (2006). "Technological pedagogical content knowledge: A framework for teacher knowledge." *Teachers College Record* Volume 108, Number 6, p. 1025.

Further, Mishra & Koehler (2006) have extended their framework to support the kinds of professional development that helps to cultivate TPCK in teachers. While many models of professional development differ in terms of the details about how such experiences should look and take place, Mishra and Koehler's ideas of teachers' knowledge being situated in complex contextual spaces are echoed in other research related to professional development and teacher knowledge in teaching with technology (Heid & Blume, 2008; Zbeik & Hollebrands, 2008).

Heid and Blume (2008), in their compilation of the most current research on the integration of technology within mathematics teaching and learning environments, clearly articulate that "it is the confluence of technological environment, teachers, learners, curriculum, and mathematical activity that sets the stage for changes in teaching and learning mathematics in the context of technology" (p. 420). They further state that the "promise of technology is accompanied by a corresponding challenge of implementation"

(p. 421). Zbiek and Hollebrands (2008) elaborate on this claim by stating that "how teachers believe learning occurs and how they envision teaching related to learning influence greatly their concerns and modes as they work to teach mathematics with technology" (p. 322). Specifically, they have found that "the ways in which technology is integrated into teachers' classrooms is influenced by their conceptions of technology, mathematics, learning, and teaching. And, teachers conceptions of technology, mathematics, and teaching influence the ways in which technology is integrated into their practices" (p. 309). It is this co-dependent relationship of knowledge and beliefs across these domains that create the complexity of changing teacher knowledge and practice. Heid and Blume (2008) echo this in their claim that "the ways in which technology is used in the mathematics classroom is determined by choices the teacher makes in engaging students in technology-supported mathematics. Choices teachers make include emphasizing procedures or concepts and electing to use one representation over another" (p. 420).

Features of Professional Development Experiences

As a result of this complex inter-connectedness of knowledge and beliefs about mathematics, teaching, learning, and technology, it is critical that professional development experiences provide opportunities for teachers to learn mathematics, learn technology, learn how to do mathematics with technology, and learn how to teach students how to use technology to learn mathematics (Zbiek & Hollebrands, 2008). In addition to having explicit opportunities for learning in each of these areas, Zbiek and Hollebrands (2008) suggest several additional experiences that seem to be helpful in fostering teacher knowledge and competency in teaching mathematics with technology.

They advocate for incorporating unexpected events within collaborative learning sessions. Building from the work of Bowers and Doerr (2001) and Zbiek and Glass (2001), they argue that teachers' "reactions to these technology-based surprises led them to deeper understanding of [mathematics content] and their enhanced ability to reason in other explorations" (p. 320).

Zbiek and Hollebrands (2008) also advocate for the opportunity for teachers to do mathematics with technology. It is in the doing of this mathematics that teachers unlearn and relearn mathematics in new ways. It is also through this process that teachers learn different representations for mathematics that are possible with technology that may not have been possible before. Zbiek and Hollebrands make reference to this as "privileging of representation that affects what representations students choose to use, and privileging of subject matter that affects what students learn" (p. 319). In this way, Heid and Blume (2008) argue that "technology has the potential for affecting the content of school mathematics because of its capacity for changing the mathematical activities in which students engage" (p. 422). By providing opportunities for teachers to learn with each other and learn mathematics with technology, teachers are able to explore different ways of representing mathematical concepts, generate deeper understanding of the mathematics, and design a broader range of learning experiences with students when using technology.

Teacher Change and Stages of Concern

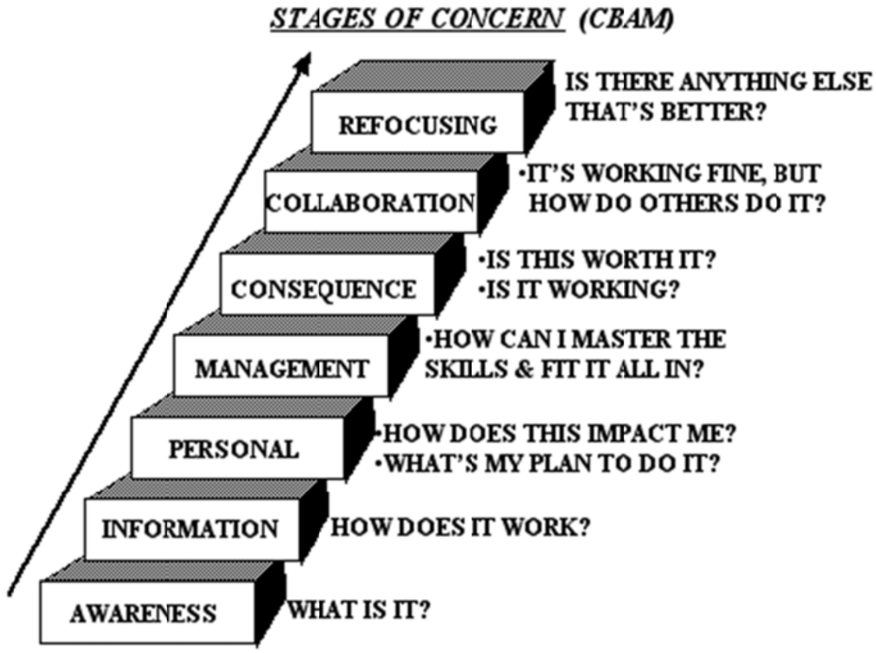
According to Horsley and Horsley (1998), "When most people think of "change," they have in mind a new program or practice: cooperative learning, standards-based science and math, or restructuring schools, for example. No doubt about it, these represent significant examples of change. But to be more precise, these are examples of the content of change. The Concerns-Based Adoption Model is about the parallel process of change, the natural and developmental process that each of us goes through whenever we engage in something new or different" (p. 27). Each of the components has been designed to help professional developers and other leaders understand where people are in the change process and support them in their continuation through the process.

There are three components of the CBAM framework that together comprise a set of tools for understanding and managing change in people (Horsley & Horsley, 1998): Stages of Concern; Levels of Use; and Innovation Configuration. The Stages of Concern component, which consists of a 35-item questionnaire, focuses on assessing the affective dimension of change—that is, how participants who are undergoing a change experience feel about doing something new or different, as well as their concerns as they engage in a new innovation or practice. This component of the CBAM framework is often used in conjunction with designing professional development experiences and therefore is the focus for this study.

Stages of Concern

There are seven stages of concern through which participants move as they work to implement a new initiative or reform. This continuum, as shown below in Figure 3, begins with the Awareness stage and ends with the Refocusing stage. During each of these stages, a person's focus shifts as he or she reaches new understandings of the initiative.

Figure 3: Stages of Concern Continuum



Source: Hall, G., Hord, S., Rutherford, W. (1987).*Taking charge of change.* Reston, VA: Association for Supervision and Curriculum Development.

The seven stages can be clustered into three categories. The first three stages reflect concerns that are focused on self. The Awareness, Information, and Personal stages all reflect a participant's concern with what the initiative is, what is being required, and what is the impact to the individual in terms of work, thought, and change. The middle category, Management focuses on mastering the initiative. It is in this phase that participants set about implementing the initiative. The third category, which consists of the last three stages (Consequence, Collaboration, and Refocusing) all focus on how participants might evaluate the impact of the initiative being implemented. It is across these stages that value statements are made about whether or not this is good for student learning, how we might improve the initiative or the process, and how we might work together to make it better.

To assess where individuals or groups of individuals are in the change process using the CBAM framework, a 35-item questionnaire is administered to participants. From that data, a profile can be developed that graphically displays how individuals or groups are moving through this change continuum. Using this profile, it is then possible to construct professional development experiences that better meet the needs of the participants at any given level of the change process. It is through this analysis and matching of experiences that we can better support teachers in implementing new initiatives and change their practice. Consequently, this study seeks to understand teachers' concerns as they move through the implementation of integrating technology into their mathematics teaching and learning program as a way of helping to think about and design appropriately differentiated professional development experiences.

While there is an emerging body of research on the integration of technology and what that means for teacher practice, teacher knowledge, and professional development, there is still much to learn and explore about how these new technologies can potentially change teaching and learning environments. One of the limitations of the existing research is related to the availability of studies representing a range of methodologies that analyze this integration. Most studies that have been conducted thus far have been case studies that serve to illustrate how teaching has or has not changed over time, but do not shed light on teacher concerns as they work on the integration of technology in their practice. Further, there are no studies to date that represent changes in teacher concerns on a large scale as they move through implementing this type of practice. As this relatively new field continues to emerge, studies filling this gap in the research will be beneficial in helping us further understand the kinds of knowledge and professional learning experiences teachers need to integrate technology in mathematics environments.

An additional limitation for research in this field deals with the availability of literature that spans across mathematics content. To date, most of the research on the integration of technology in mathematics is focused on specific technologies in specific mathematics classes. Heid & Blume (2008) started to synthesize these studies to find themes across these specific studies in order to make more global conjectures about teacher knowledge and practice. As the field continues to emerge, more syntheses that seek to find themes in the integration of technology in mathematics classrooms will be created. This study seeks to add to the literature by looking at teacher concerns as they move through the change process of integrating technology into their teaching and learning practices.

CHAPTER THREE: METHODOLOGY

The purpose of this research was to study teachers' changes in concerns as they work to integrate technology with their content and pedagogy. This study seeks to analyze the changes in teacher concerns about the integration of technology, pedagogy, and content in their mathematics teaching and learning program as a result of participating in a specific professional development initiative in order to better understand how this professional development initiative influences, if at all, changes in teachers' implementation practices.

In order to answer the questions of this study, the Stages of Concerns Questionnaire (SoCQ), as part of the Concerns-Based Adoption Model was administered twice (once at the start of the project and once after four months of participation) to all teachers participating in the targeted professional development initiative aimed at developing teachers' ability to integrate technology, pedagogy, and content. The Stages of Concerns Questionnaire attempts to measure levels of specific teacher concerns related to the implementation of a new reform or practice. The ways in which teachers' concerns are expressed reflect and correspond to where they are in the implementation cycle of the reform. By better understanding these concerns, researchers and professional developers can make decisions about future experiences and can measure teacher change over time.

This chapter outlines the research methodology used for this study. The first section of this chapter details the setting of the study. What follows is a detailed description of the participants, data collection procedures, and data analysis techniques. Table 1 summarizes the data collection and data analysis for each research question.

Table 1: Summary of Data Collection and Analysis

Research Question	Data Collection	Data Analysis
1. Is there a statistically significant difference between how teachers think about integrating technology, content, and pedagogy in their classrooms as reflected by changes in their concerns about the initiative at the beginning and after several months of participation in targeted professional development?	Stages of Concerns Questionnaire (SoCQ), given twice – pre-test/post-test	• Compile data • Run t-tests to determine significant changes in concerns from the pre and post survey data
2. How do the concern profiles of teachers change after several months of participating in targeted professional development on the integration of technology? a. How do the concern profiles of teachers who teach in a whole-school technology integration model change after several months of participating in targeted professional development on the integration of technology? b. How do the concern profiles of teachers who teach in a partial-school technology integration model change after several months of participating in targeted professional development on the integration of technology?	Stages of Concerns Questionnaire (SoCQ), given twice – pre-test/post-test	• Compile data • Use SoCQ scoring tool to generate and interpret pre and post profiles of all participants, those who come from whole-school implementation models, and those who come from partial-school implementation models • Use SoCQ interpretation guide to analyze patterns and changes in concerns profiles

Setting

This project was conducted within a large school district located outside a major metropolitan area. Jackson County Public Schools is comprised of nearly 200 schools with approximately 144,000 students. District-wide, approximately 37% of the students are white, 23% are African American, 23% are Hispanic, and 16% are Asian. More than 164 countries are represented within the school district's student population with more than 184 languages spoken. About 31% of the students attending schools in this district currently participate in the Free and Reduced Meals Services program, and almost 41% have ever received these services.

For the last three years, the Jackson School District has been engaged in transforming teaching and learning through the meaningful introduction and integration of content, pedagogy, and technology in pre-K to grade 12 classrooms across the county. The school district has not only been providing interactive technologies to schools across the county, but also has engaged teachers in professional development on developing inquiry-based lessons that provide access to rich digital content and facilitate the purposeful use of technology so that all students are empowered to participate as full citizens in meaningful learning communities.

The district has been working to create and strengthen inclusive, diverse community-centered classrooms that foster a culture of inquiry, respect, and risk-taking. Providing access, opportunity, and support for a diverse range of learners, these multi-modal, universally-designed classrooms provide access to learning through rigorous instruction, powerful interactive content, and resources that incorporate multiple representations and entry points into learning, along with various means for demonstrating and expressing knowledge.

This work has been centered on supporting the transformation of teaching and learning in creating interactive classrooms that nurture critically explorative adult and student learners, strengthening inquiry-based practices and the use of formative assessment as learning, and improving access to learning for all students. To this end, the purpose of the work of the school district has been to facilitate the creation of meaningful learning environments that engage students in transformative learning across every subject area in every classroom and at every grade level, while enhancing technology-enabled interactive learning communities through the establishment of learning environments that showcase student work and progress reporting. To support this effort, targeted professional development, grounded in teacher practice and focusing on creating teacher learning communities where teachers engage in creating, sharing, and reflecting on lessons and teaching and learning experiences that integrate technology with their mathematics content and pedagogy.

Description of the Professional Development

In her article on designing teacher education programs, Linda Darling-Hammond (1990) asks the question, “Given what we know about how teachers learn and develop, how can we create teacher education programs that are effective in enabling teachers to acquire knowledge, skills, and dispositions that will allow them to succeed?” (p. 390). This study seeks to design, deploy, and study a professional development model that responds to this challenge. It aims to engage mathematics teachers in professional development that supports the creation of interactive mathematics lessons and instructional experiences that integrate technology with mathematics content and pedagogy.

The purpose of the Multi-Modal Universally Designed Learning Environments (MMUDL) professional development initiative was to create opportunities for teachers to study their own teaching as they seek to integrate content, pedagogy, and information and communication technologies, and to provide opportunities for teachers to learn from one another and from the instructional technology specialists that help to lead the initiative as they study use of technology, changes in content and pedagogy as a result of this integration, and plan together.

For the past five years, the technology office within this school district has been provisioning interactive technologies in classrooms across the district. With these technologies has come some initial training on how to use them – turn them on, get them synced, and operate them within the classroom instructional time. What has not been as much as a focus, until this project, has been a concentrated effort on linking the use of these technologies closely with teacher practice. Specifically, this effort was focused on fostering a link for teachers between their planning, teaching, and assessing for student learning. In addition, with a particular focus on student inquiry and building active and engaged learning environments through inquiry, this project sought to actually transform the ways in which teachers planned and implemented their lessons.

To this end, teachers in schools across the district who have these interactive technologies in their classrooms were invited to participate in this professional development experience. Sponsored, planned, and organized by the technology office, this professional development project included close to 300 teachers ranging from kindergarten to grade 12. These mathematics teachers volunteered to participate in this project, and in exchange, received four substitute days in order to attend four whole-day sessions with training on creating interactive learning environments that effectively and purposefully integrate content, technology, and pedagogy. Through these professional development experiences, teachers brought current lesson plans and curricular materials, had access to the technologies, and planned together to develop interactive, inquiry-based lessons that integrate the rich content they teach with inquiry-based pedagogy and interactive technologies. The project, which ran from February through June, was centered on the creation of lessons, instructional materials, and assessments that integrate technology in meaningful ways, using an inquiry framework.

As a result of this work, we designed the professional development components, foci, and experiences around these key themes. First, we planned for a variety of forums and venues to accommodate teacher learning and support. Four (one-day) pull-out professional development sessions were delivered (one in February, March, April, and May). In addition to the pull-out sessions, each school was assigned an instructional technology specialist who was charged with helping during grade-level team planning times and providing job-embedded coaching and support for teachers participating in this project. This support ranged from meeting with teachers, helping teachers create materials for lessons, team-teaching, and modeling a lesson. In each of these forums, the focus of the work was centered on developing, enhancing, or studying teaching artifacts – either planning for them and creating them or reviewing them and modifying them. Teacher artifacts include lesson plans, flipcharts for the Promethean Board, assessment items, learning tasks, and student work products. During these face to face sessions, teachers worked in job-alike collaborative groups to generate lessons that reflected an inquiry stance and integrated technology with their pedagogy and with the mathematics content they were teaching.

Job-embedded coaching was a staple for this professional development effort. Between once and twice a week, a technology instructional specialist visited participated teachers' classrooms. During these visits, the specialist helped to plan lessons that integrate technology, shared resources such as digital content and interesting links that would support the teaching of the current unit, provided tips and tricks for using the interactive technologies, and often co-taught lessons with these participating teachers. These times were co-coordinated and planned so the specific activities differed from teacher to teacher. Most teachers, however, asked for lesson development help, finding resources, and help in thinking through how to implement the lesson. This close connection between technology and the content that teachers were teaching and the context in which they are teaching was a big theme in this shoulder-to-shoulder component.

A focus on teachers' individual content and how they teach that content was a central theme throughout the initiative. Because this project was grounded in teacher practice, the artifacts from which the work occurred are grounded in content. How content was changed, enhanced, or modified as a result of the integration of inquiry and technology was a key focal point of the project. To this end, teachers were able to choose break-out sessions during these face to face meetings where they could work with content-alike colleagues. In addition, the trainers themselves had expertise in mathematics content and pedagogy and were able to lead the different conversations, ask probing questions, provide resources, and help further the thinking of the group.

The development of teacher communities, both face to face and virtual was another focus for this project. To this end, the trainers developed an online collaboration website for teachers where they could access materials, share materials, post discussion items, and share their learning. It was here that teachers engaged in online community with similar grade level and content-specific teachers across the county in lesson creation and sharing of resources – particularly between the face to face sessions. In addition, through the use of web-conferencing technology, level-alike and content-alike groups worked together to collaborate on the creation and modification of lesson materials, watch video of teaching and provide feedback, and learn from one another the tips and tricks in integrating some of the technology tools. As a result of participating in this project, it was the hope that teachers would be better able to plan for, create, and implement engaging and interactive lessons; design lessons that promote inquiry-based learning and pedagogical practices that purposefully integrate interactive technologies with the curriculum content; analyze student work resulting from these interactive lessons to assess student learning and to strengthen planning and teaching practices; reflect on and critique their teaching practices and lessons; increase their technological, pedagogical, and content knowledge; explore new instructional practices and use of assessments as learning; build, nurture, reflect, and refine classroom communities that are learner-centered, assessment-centered, and knowledge-centered; participate in school, content, and/or grade-level collaborative communities that support professional growth; and participate in research, reflection, and feedback sessions.

Participants

The participants of this study were elementary and secondary mathematics teachers who are currently teaching in the school district and are participating in the Multi-Modal Universally-Designed Classrooms professional development initiative. All of the teachers who were participating in the professional development project were invited to participate in the survey. By agreeing to participate in this study, teachers committed to completing the Stages of Concerns Questionnaire and relevant demographic data. Teachers who chose not to participate in the survey continued to participate in the professional development.

Data Collection Procedures

The Stages of Concern Questionnaire (SoCQ), which is part of the Concerns-Based Adoption Model developed by Hord and Hall (1987) and published by Southwest Education Regional Laboratory, was administered twice throughout the professional development experience, once at the beginning of the initiative and once after about four months of participation. The questionnaire consists of thirty-five questions, all on an eight-point Likert scale. The scale ranges from zero to seven, with zero being “irrelevant” and seven being “very true of me now.” Each of the questions corresponds to one of the seven stages of concern: Unconcerned, Informational, Personal, Management, Consequence, Collaboration, and Refocusing. For each participant, an average total survey score was calculated in addition to the average score within each stage of concern for the pre and post survey data. In addition to calculating seven stages of concern averages and a total average for each participant’s pre and post questionnaire, the average scores of participants by school were calculated, The questionnaire was administered through a web-based survey forum. Time was provided within the professional development session for the teachers to complete the survey. It took participants about fifteen minutes to complete.

Teacher participation in the questionnaire was completely voluntary. Participants could have withdrawn from participating in the questionnaire at any point during the completion of the questionnaire or even after completing the questionnaire. Teachers' names were not linked to their responses.

At no time will individual responses be made available to any personnel from a school, including the principal, or personnel from the school system. Data from the questionnaire will only be used for the purposes of this study, and will not be used to determine teacher quality, performance, or any other indicator of a teacher's fulfillment of a contract.

Data Analysis

Quantitative

In order to analyze changes in teachers' concerns about the integration of content, pedagogy, and information and communication technologies in classroom practice, teacher responses to the Stages of Concern Questionnaire, along with teacher demographic data, and what school the teacher works in were collected and organized. Data was organized in an Excel spreadsheet for February and May. Each participant was assigned a random participant number that linked their February data with their May data. For each participant, the data consisted of their school name, how many years they had been teaching, and their responses to each of the 35 questions on the survey. This data was moved to SPSS where frequencies and descriptive statistics were on the data set in order to identify and eliminate any outliers or problem areas in the data.

Once the descriptive statistics were calculated, I was able to then run statistical analyses on the overall means and the means at each stage of concern. Eight t-tests were conducted in order to determine significant differences between the February and May data. Specifically, the pre-test means from February for the overall survey, Stage 0, Stage 1, Stage 2, Stage 3, Stage 4, Stage 5, and Stage 6 were compared with the post-test means for each of these categories using the t-test statistical method. Significant differences were calculated at the .05 alpha level.

In order to calculate the means for each Stage of Concern, the procedures outlined in the Stages of Concern scoring guide, as part of the CBAM program, were followed. For each stage, there are five questions on the survey that correspond to that specific level of concern. An average score for each stage for each participant was calculated. This resulted in a total of 295 pre-test and post-test averages for each stage of concern and an overall survey average. For question one of this study, t-tests were run to compare corresponding pre- and post-test means.

Qualitative

Qualitative data analysis consisted of examining, categorizing, tabulating, and interpreting data from the Stages of Concern Questionnaire. Data from the Stages of Concern Questionnaire was compiled based on the directions in the Concerns-Based Adoption Model handbook to generate group pre and post profiles. These profiles are graphical depictions of teachers' concerns across categories of concerns. The pattern of the graph was interpreted as a representation of where teachers were in the implementation cycle of the given initiative in February and in May. By studying the change in profile from the beginning to the end of the initiative, I was able to study changes that have occurred over time.

For this study, I analyzed the change in teachers' concerns at three levels. First, I created pre and post concerns profiles for the entire group of teachers. In order to look more closely at different implementation models, I also generated pre and post concerns profiles for two different kinds of implementation groups – those coming from a whole-school implementation model and those coming from a partial-school implementation model. This was defined by how many interactive classrooms as school has. Partial-implementation schools were defined as having fewer than ten interactive classrooms. Whole-school implementation schools have more than ten interactive classrooms.

In order to generate the concerns profiles, directions provided in the Stages of Concern Questionnaire scoring guide were followed. Five questions on the survey correspond with each stage of concern. Each participant's raw score was calculated for each stage. This was done by adding up the total points for each of the five corresponding questions for each stage. The scoring guide recommends that when generating group profiles, the average of the group's raw scores for each stage be found, and then matched with the percentile score from the table they provide. To this end, average raw scores were generated for the total group for pre and post survey data, and for the sub groups – whole school implementers and partial-school implementers – for each stage of concern. Average raw scores were then matched with their equivalent percentile score, provided by the CBAM authors in the scoring guide. Profiles were charted using Excel, and patterns in the profiles were then analyzed using the scoring guide.

Interpreting the profiles consisted of understanding the patterns in the charted concerns as they relate to each stage of concern. For example, Stage 0 indicates a lack of awareness about the initiative. If concerns at this stage were to be high for pre and post survey data, this could potentially be problematic because it would indicate that after four months of the project, participants were expressing concern with not knowing with the project was about. Similarly, if concerns were to increase, this could potentially indicate that over time in the project, participants grew more confused about the initiative and what is was about. Ideally, we would hope for a decrease in concerns at Stage 0 over time. In this way, the profiles were interpreted for the entire group and for each of the two sub-groups.

CHAPTER FOUR: RESULTS

The purpose of this research was to study teachers' changes in concerns as they work to integrate technology with their content and pedagogy. Through the analysis of the Stages of Concerns Questionnaire (SoCQ), as part of the Concerns-Based Adoption Model (CBAM) given at the beginning and end of this professional development cycle, this study sought to analyze the changes in teacher concerns about the integration of technology, pedagogy, and content in their mathematics teaching and learning program as a result of participating in a specific professional development initiative in order to better understand how this professional development initiative influenced, if at all, changes in teachers' implementation practices.

This chapter outlines the findings as related to each of the research questions. The first section of this chapter details the descriptive data of the participants and the variables. Next, the results for each research question are presented under each of the questions. The final section of this chapter includes a summary of the data.

Descriptive Statistics

The first step in the data analysis and generating descriptions about the participants was to first determine what the criteria was in order to be included in the data set to be analyzed. Because it was important to me for a participant to have two sets of questionnaire data (one in February and one in May), I eliminated any participant who did not have two sets of survey data. Also, in order to be included in the data analysis, a participant must have completed the entire survey. Therefore, any participant that did not complete the survey was eliminated from the data set. This left 295 teachers as the population of my study.

The first step in my analysis of their data was to better understand these participants. One of the first questions found on the questionnaire asked teachers to identify how many years they had been teaching. Participants were asked to check the response that best applied to them. The data, as shown in Table 2, indicate that about 75% of the 295 total participants have been teaching between zero and fifteen years.

Table 2: Participants' Years of Teaching

Years of Teaching	# of Participants	% of Total Participants
0 to 5	72	24.4
6 to 10	78	26.4
11 to 15	69	23.4
16-20	36	12.2
21-25	19	6.4
More than 25	21	7.1
Total	295	100.0%

A second question at the beginning of the survey asked participants to identify their school. The data indicates that participants in this study come from thirty-eight different schools, twenty-four elementary and 14 secondary schools. Each school had a range of between six and ten teachers participating in this professional development experience, as shown in Table 3, and who took the pre and post questionnaire.

Table 3: Participants by School

School by Level	# of Participants	% of Total Participants
Elementary		
1	7	2.4
2	10	3.4
3	8	2.7
4	9	3.1
5	6	2.0
6	7	2.4
7	7	2.4
8	8	2.7
9	9	3.1
10	8	2.7
11	9	3.1
12	7	2.4
13	7	2.4
14	8	2.7
15	10	3.4
16	10	3.4
17	9	3.1
18	10	3.4
19	8	2.7
20	6	2.0
21	9	3.1
22	9	3.1
23	6	2.0
24	6	2.0
Secondary		
1	8	2.7
2	7	2.4
3	6	2.0
4	7	2.4
5	8	2.7
6	7	2.4
7	7	2.4
8	9	3.1
9	7	2.4
10	7	2.4
11	7	2.4
12	7	2.4
13	7	2.4
14	8	2.7
Total	295	100.0%

Each participant was asked to complete a thirty-five question Stages of Concern questionnaire in February and then again in May. The thirty-five questions represent concerns across a continuum of seven phases. There are five questions relating to each phase of the concerns continuum. Participants were asked to rate their level of concern using a Likert scale from zero to seven, zero meaning “not relevant to me at this time” and seven meaning “very true of me at this time.” For each participant, an average total survey score was calculated in addition to the average score within each stage of concern for the pre and post survey data. In addition to calculating seven stages of concern averages and a total average for each participant’s pre and post questionnaire, the average scores of participants by school were calculated, and are displayed in two parts, one for the overall means and Stages 0 through Stage 2, and one for Stages 3 through 6 in the two tables below (shown in Table 5 and 6).

As seen in the summary table below, there are changes in the pre and post means across the different stages.

*Table 4: Summary of Pre and Post Survey Means, Overall and for Each Stage**

Stage	Mean	Std. Deviation	Minimum	Maximum
Stage 0 Pre-Test	2.18	1.10	0.00	5.80
Stage 0 Post-Test	1.82	1.01	0.00	4.60
Stage 1 Pre-Test	4.10	1.10	0.60	7.00
Stage 1 Post-Test	3.59	1.09	0.00	6.40
Stage 2 Pre-Test	3.76	1.34	0.00	7.00
Stage 2 Post-Test	3.28	1.45	0.00	6.80
Stage 3 Pre-Test	3.08	1.45	0.00	6.80
Stage 3 Post-Test	3.37	1.41	0.00	7.00
Stage 4 Pre-Test	3.50	1.27	0.80	7.00
Stage 4 Post-Test	3.79	1.25	0.00	6.80
Stage 5 Pre-Test	4.29	1.43	0.60	7.00
Stage 5 Post-Test	4.58	1.33	1.20	7.00
Stage 6 Pre-Test	3.27	1.17	0.40	6.60
Stage 6 Post-Test	3.26	1.12	0.00	6.20

* Total pre-test and post-test means were calculated (3.26 and 3.58) but were not fully analyzed based on the guidelines in the SoCQ guide.

However, as we look closely at the individual stage means, we see an interesting pattern. For Stage One and Stage Two, the mean decreases from pre-test to post-test. This indicates that overall, participants answered questions from these two stages with lower ratings on the Likert scale in May than they did in February. Where in February participants indicated that these statements reflected “very true of me now,” fewer participants self-identified their concerns as reflecting the concerns within these two lower-level stages.

In each Stage Three, Four, and Five, the post-test means are higher than the pre-test means. This indicates that on average, participants identified more with these higher stages of concern as being reflective of their concerns in May than they did in February.

Stage Six is interesting in that the average stayed close to the same from pre-test to post-test. Stage Six is the highest stage and reflects a participant’s interest in fully embracing the reform initiative to the point of suggesting alternatives or changes to the initiative to make it more effective or impactful. The means for this stage indicate that on average, there was the same amount of interest at this stage in February as in May.

The next step in the data analysis was to import this data into SPSS to conduct t-tests on the pre and post means to determine whether or not the difference between the means is statistically significant or just occurring by chance. The findings from these t-tests and the detailed analysis of the data are found in the next section under the first research question.

Table 5: Stages of Concern Questionnaire Means by School, Overall Means and Stages 0 through Stage 2

School by Level	Mean Pre-Test	Mean Post-Test	Stage 0 Pre-Test	Stage 0 Post-Test	Stage 1 Pre-Test	Stage 1 Post-Test	Stage 2 Pre-Test	Stage 2 Post Test
Elementary								
1	3.57	4.01	2.46	1.34	4.86	3.77	4.69	3.83
2	3.75	3.12	1.86	2.08	3.64	4.26	3.24	4.36
3	3.30	3.47	2.15	2.03	3.80	3.18	3.98	3.55
4	3.65	3.80	2.20	1.47	4.47	4.22	3.98	4.22
5	2.89	3.13	1.53	2.00	4.10	3.60	3.00	2.50
6	3.29	3.80	1.89	1.40	4.29	3.37	4.49	3.54
7	3.20	3.45	1.31	1.17	4.11	3.97	4.00	3.14
8	3.21	3.72	2.68	1.78	4.05	3.35	4.15	3.28
9	3.15	3.40	1.53	1.47	4.44	3.67	3.31	3.02
10	3.88	3.84	2.40	1.73	4.48	4.38	3.98	4.45
11	2.87	3.71	2.20	1.24	4.49	3.27	3.80	2.38
12	3.12	3.97	2.77	1.86	4.54	3.11	4.57	3.54
13	3.11	3.03	1.83	2.00	3.60	3.40	3.11	2.83
14	3.08	3.53	2.45	1.43	4.25	3.63	3.43	3.13
15	3.23	3.80	2.14	2.20	4.10	3.54	4.32	3.32
16	3.19	4.11	2.56	1.08	4.82	3.56	4.76	3.32
17	2.91	3.50	1.42	0.93	4.04	3.49	3.64	3.00
18	3.16	3.56	2.64	2.38	3.82	3.12	4.06	3.28
19	3.04	3.27	2.43	1.45	3.97	3.93	3.20	3.48
20	2.85	3.16	1.63	1.80	3.50	3.30	3.10	2.97
21	3.46	3.58	3.09	2.58	4.33	3.73	4.09	3.64
22	3.13	3.48	2.27	2.07	4.13	3.13	3.71	2.71
23	3.48	3.94	2.47	1.93	4.83	3.93	4.53	4.00
24	2.50	2.97	1.53	1.53	3.63	3.13	2.60	2.20

<u>Secondary</u>								
1	3.64	3.71	1.48	1.50	3.95	3.80	3.35	3.75
2	3.22	2.77	1.89	2.17	3.43	3.37	2.26	2.34
3	3.34	3.38	3.10	2.53	3.50	3.50	4.07	3.67
4	3.33	3.27	2.31	1.57	3.31	3.57	2.94	3.20
5	3.99	3.98	2.18	2.50	4.30	4.18	4.15	3.93
6	3.37	4.35	2.00	2.71	5.03	3.60	5.20	3.43
7	3.16	3.78	2.66	1.43	4.00	3.80	3.69	3.17
8	2.76	3.41	2.51	2.24	3.49	2.80	3.29	2.47
9	4.10	4.22	2.54	2.51	4.60	4.26	4.29	3.97
10	2.99	2.96	1.71	2.03	3.26	3.11	2.66	2.23
11	3.31	3.65	2.46	1.89	4.06	3.40	3.74	3.77
12	3.32	3.31	1.71	2.34	3.77	3.60	3.31	2.74
13	3.27	3.42	1.71	2.14	3.60	3.57	3.74	3.03
14	2.90	4.00	2.65	1.03	4.70	3.60	3.85	2.68
Total	3.26	3.57	2.17	1.83	4.10	3.59	3.76	3.28

Table 6: Stages of Concern Questionnaire Means by School, Stage 3 through Stage 6

School by Level	Stage 3 Pre-Test	Stage 3 Post-Test	Stage 4 Pre-Test	Stage 4 Post-Test	Stage 5 Pre-Test	Stage 5 Post-Test	Stage 6 Pre-Test	Stage 6 Post Test
Elementary								
1	3.17	3.34	3.91	4.14	5.20	5.29	3.74	3.31
2	3.62	2.98	4.04	2.88	4.34	4.38	3.52	2.86
3	2.60	2.80	4.05	4.15	4.10	4.15	3.63	3.25
4	3.62	3.44	3.40	3.89	4.82	5.02	3.78	3.56
5	3.00	2.43	2.73	3.73	3.60	4.03	2.80	3.07
6	3.26	3.89	3.66	3.94	4.51	5.06	3.29	3.09
7	1.74	1.97	3.54	3.86	5.60	5.26	3.23	3.66
8	3.53	4.08	3.35	3.55	3.38	4.13	3.83	3.40
9	2.87	2.80	3.24	3.67	4.62	5.20	3.13	2.84
10	2.88	3.30	4.43	4.45	5.35	4.90	3.93	3.35
11	1.84	3.13	3.24	3.84	4.60	5.00	3.51	3.49
12	3.00	4.63	3.46	3.77	3.77	4.14	3.09	3.34
13	4.34	3.66	2.66	2.77	3.57	3.46	3.00	2.80
14	2.38	3.30	3.53	3.90	4.53	4.43	2.95	2.93
15	3.56	3.96	3.04	4.32	3.92	4.38	3.00	3.32
16	1.68	3.40	3.68	4.18	5.54	5.50	3.44	3.54
17	2.20	3.51	3.29	3.87	4.44	4.82	3.04	3.16
18	3.56	3.78	3.30	3.92	3.52	3.74	2.96	2.94
19	2.33	3.03	2.63	3.18	4.68	4.50	2.83	2.58
20	2.70	3.53	3.20	3.00	3.63	4.63	2.37	2.73
21	3.07	3.69	3.49	3.11	4.29	3.82	3.42	2.93
22	3.27	3.44	3.98	3.64	3.53	4.07	3.20	3.07
23	3.90	3.87	3.17	3.73	4.13	5.13	3.27	3.00
24	2.83	3.50	2.43	2.93	2.87	3.70	2.53	2.90

Secondary								
1	3.80	3.50	4.65	4.53	4.75	5.48	3.20	3.68
2	3.37	2.00	4.03	3.29	4.37	4.37	2.86	2.14
3	3.70	3.30	3.17	3.63	3.53	3.17	3.30	2.90
4	2.91	3.20	3.91	3.54	4.51	3.86	3.60	3.71
5	4.20	3.93	4.10	4.20	4.68	5.10	4.33	3.98
6	2.91	3.37	3.40	4.89	4.20	6.06	3.31	3.89
7	3.09	3.40	3.14	4.09	4.20	4.80	3.31	3.83
8	2.69	3.53	3.27	3.71	3.24	3.71	2.62	3.62
9	4.40	3.40	4.17	5.09	4.91	5.57	4.46	4.09
10	2.26	2.17	3.51	3.29	4.11	4.20	3.69	3.40
11	3.03	3.26	3.94	3.89	3.66	4.63	3.46	3.54
12	3.94	3.63	3.23	3.26	3.94	4.17	3.43	3.31
13	3.26	2.97	3.66	3.80	4.66	5.06	2.54	3.09
14	3.05	4.33	2.73	4.03	4.90	5.03	2.35	3.40
Total	3.08	3.37	3.50	3.79	4.29	4.58	3.27	3.26

Findings for Research Question One

Research Question One: Is there a statistically significant difference between how teachers think about integrating technology, content, and pedagogy in their classrooms as reflected by changes in their concerns about the initiative at the beginning and after several months of participation in targeted professional development?

In order to answer this question, the total survey mean score for the aggregated group was calculated for the pre and post questionnaire. In addition, the aggregated mean scores associated with each of the seven stages of concern were calculated for the pre and post questionnaire (shown in Table 6).

Table 7: Means and Standard Deviations for Each Stages of Concern

Stage	Mean	Std. Deviation	Minimum	Maximum
Stage 0 Pre-Test	2.18	1.10	0.00	5.80
Stage 0 Post-Test	1.82	1.01	0.00	4.60
Stage 1 Pre-Test	4.10	1.10	0.60	7.00
Stage 1 Post-Test	3.59	1.09	0.00	6.40
Stage 2 Pre-Test	3.76	1.34	0.00	7.00
Stage 2 Post-Test	3.28	1.45	0.00	6.80
Stage 3 Pre-Test	3.08	1.45	0.00	6.80
Stage 3 Post-Test	3.37	1.41	0.00	7.00
Stage 4 Pre-Test	3.50	1.27	0.80	7.00
Stage 4 Post-Test	3.79	1.25	0.00	6.80
Stage 5 Pre-Test	4.29	1.43	0.60	7.00
Stage 5 Post-Test	4.58	1.33	1.20	7.00
Stage 6 Pre-Test	3.27	1.17	0.40	6.60
Stage 6 Post-Test	3.26	1.12	0.00	6.20

* Total pre-test and post-test means were calculated (3.26 and 3.58) but were not fully analyzed based on the guidelines in the SoCQ guide.

In order to determine whether or not there was a statistically significant difference between teachers' concerns in February and their concerns in May for the entire group as an aggregate on the integration of technology with mathematics content and instruction, eight different t-tests were conducted: Overall pre and post survey; Stage One pre and post; Stage Two pre and post; Stage Three pre and post; Stage Four pre and post; Stage Five pre and post; and Stage Six pre and post. The results of the t-tests are presented in Table 8.

Table 8: t-Test for Pre-Post Stages of Concern Questionnaire

	Repeated Measure			
	Pre-Test	Post-Test	t	df
Stage 0	2.18 (1.10)	1.82 (1.01)	4.18*	294
Stage 1	4.10 (1.10)	3.59 (1.09)	5.91*	294
Stage 2	3.76 (1.34)	3.28 (1.45)	4.47*	294
Stage 3	3.08 (1.45)	3.37 (1.41)	2.66*	294
Stage 4	3.50 (1.27)	3.79 (1.25)	2.97*	294
Stage 5	4.29 (1.43)	4.58 (1.33)	2.80*	294
Stage 6	3.27 (1.17)	3.26 (1.12)	-.128	294
Total	3.26 (0.85)	3.58 (0.81)	4.81*	294

Note. * = $p < .05$. Standard Deviations appear in parentheses below means.

The t-test between the overall survey results in February and the overall survey results in May indicates that there are statistically significant differences between the teachers' pre and post-test concerns. The gain in the overall average score of the survey indicates that teachers' responses tended to reflect that items on the survey were truer of them in May than in February. Potentially, this could indicate that there was a growing awareness of the initiative and professional development effort over the three month period that could have attributed to this gain.

The t-test results between the pre and post survey at Stage Zero, Stage One, and Stage Two indicate that there is a statistically significant decrease in the average scores for these concern categories. Stage Zero reflects the level of unconcern or lack of interest about the initiative, and so the results seem to indicate that over time, teachers moved from unconcerned to some other level of concern. Questions from the survey associated with this "unconcern" at Stage 0 are shown in the following table.

Table 9: Stage 0 Questions from SoCQ

Question
I am more concerned about another innovation
I am not concerned about the innovation at this time
I am preoccupied with things other than the innovation
I spend little time thinking about the innovation
Currently, other priorities prevent me from focusing my attention on the innovation

Usually a high level of unconcern is related to a low level of implementation. We could potentially infer that over time, as teachers began participating in this project, their concerns shifted from unconcerned to a level of concern associated with implementing technology in their mathematics classrooms.

Stage One is a measure of awareness of the initiative. Questions associated with Stage One are shown in the table below.

Table 10: Stage 1 Questions from SoCQ

Question
I have a very limited knowledge of the innovation
I would like to discuss the possibility of using the innovation
I would like to know what resources are available if we decide to adopt the innovation
I would like to know what the use of the innovation will require in the immediate future
I would like to know how the innovation is better than what we have now

Not unlike Stage Zero, we can infer from the statistically significant decrease in the means at Stage One that as teachers became more engaged in the project, their concerns became less about what the initiative is about and more about some other aspect of implementing technology in their programs. From what we know about the decrease at Stage O over time, we can infer that teachers' concerns moved higher up the continuum and not back to an unconcerned state.

The level of personal impact is what Stage Two measures. Stage Two questions can be seen in the following table.

Table 11: Stage 2 Questions from SoCQ

Question
I would like to know the effect of reorganization on my professional status
I would like to know who will make the decisions in the new system
I would like to know how my teaching or administration is supposed to change
I would like to have more information on time and energy commitments required by the innovation
I would like to know how my role will change when I am using the innovation

The statistically significant drop in concerns at this level seem to indicate that while teachers had some concern about what this initiative meant for them at the beginning of the project, over time these concerns decreased. Again, because of the decreases in Stage Zero and One, we can infer that teachers' concerns shifted to a concern stage higher up the continuum. These shifts in concern up the continuum indicate positive changes in the levels of engagement in and implementation of the initiative, according to the CBAM program and scoring guide.

The t-test results between the pre and post surveys at Stage Three, Four, and Five also indicate statistically significant differences. However, unlike Stage Zero, One, and Two, these three stages of concern show significant increases from the pre-test to the post-test. Stage Three is focused on management of the initiative and the concerns that participants have about logistical aspects of implementing the new project. These management concerns include balancing demands of time, impact to classroom routines, and organizing resources to support this new expectation (see related questions in the table below). It is not unexpected that in this study, as participants learned more about the initiative, they became more concerned with the logistical management aspects of what was required of them.

Table 12: Stage 3 Questions from SoCQ

Question
I am concerned about not having enough time to organize myself each day I would like to know who will make the decisions in the new system
I am concerned about conflict between my interests and my responsibilities.
I am concerned about my inability to manage all that the innovation requires
I am concerned about time spent working with nonacademic problems related to the innovation
Coordination of tasks and people is taking too much of my time

Stage Four, also showing a statistically significant increase from the t-test comparing pre and post-test means, reflects concerns teachers have about the impact of the new initiative on students. As teachers work through the concerns progression, they move from concerns about themselves and the logistical aspects to concerns about their students, what this means for student learning, and the impact to student achievement (see associated questions in the table below).

Table 13: Stage 4 Questions from SoCQ

Question
I am concerned about students’ attitudes toward the innovation
I am concerned about how the innovation affects students
I am concerned about evaluating my impact on students
I would like to excite my students about their part in this approach
I would like to use feedback from students to change the program

As teachers continued to learn about and engage in this project, it would be anticipated that concerns about the impact to student learning would increase. In this way, it is important to note that the use of the word concerns does not necessarily imply negative worries. Instead, concerns is a word that is used to describe dominant thoughts, considerations, and factors that are most pressing in teachers' minds at a given time. Learning how to create learning experiences that integrate mathematics content and technology so that student learning is enhanced was a hoped outcome for this project.

Increased thought about collaboration with others was also a hope for this project, and the results of the t-test for Stage Five indicate that this occurred. The table below shows the questions associated with this stage of concern.

Table 14: Stage 5 Questions for SoCQ

Question
I would like to help other faculty in their use of the innovation
I would like to develop working relationships with both our faculty and outside faculty using this innovation.
I would like to familiarize other departments or persons with the progress of this new approach
I would like to coordinate my efforts with others to maximize the innovation's effects
I would like to know what other faculty are doing in this area

In fact, the average concerns for this stage were the highest across all stages. While these concerns could reflect worry about support during the implementation of this new initiative, they could also reflect satisfaction and excitement about new collaborative experiences presented through professional development activities. This stage of concern is a higher level area of concern and is one that is seen as favorable when an increase occurs over time. This indicates a positive shift in the concerns trajectory for teachers over time.

Stage Six, the highest stage, was the only stage that saw no significant difference between the pre and post-tests. Stage Six centers on refocusing the initiative to make it more effective and impactful (see questions below). This could include making significant changes or replacing it altogether with what participants see as something better.

Table 15: Stage 6 Questions for SoCQ

Question
I now know of some other approaches that might work better
I am concerned about revising my use of the innovation
I would like to revise the innovation's approach
I would like to modify our use of the innovation based on the experiences of our students
I would like to determine how to supplement, enhance, or replace the innovation

This could be seen as positive in that participants at this stage assume complete ownership of the initiative. However, often it can be perceived as a negative result when Stage Six sees significant increases without substantial gains in the preceding stages. When this happens, often it means that participants have stopped engaging in the implementation of the project and have moved on to replacing it (Hall and Hord, 1987). In the case of this study, no significant differences were found between the pre and post-tests. Therefore, we can infer that teachers' concerns about replacing the initiative are not growing at this time.

Findings for Research Question Two

Research Question Two: How do the concern profiles of teachers change after several months of participating in targeted professional development on the integration of technology?

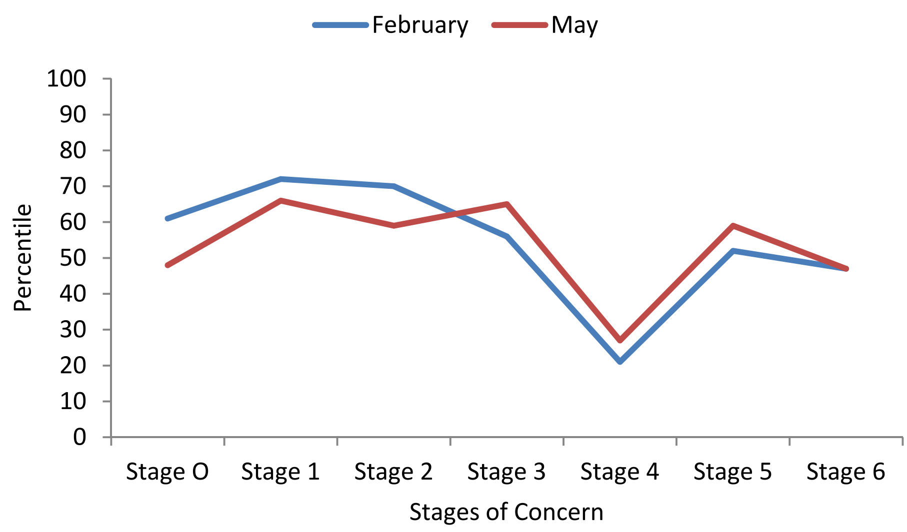
The first step in answering this question was to calculate the raw score for each stage for each participant for February and for May. Then, I calculated the average raw score for each stage for February and May for three groups: all participants, whole-school implementation participants, and participants who teach at partial-implementation schools. Following the directions in the scoring guide, I then matched each average raw scale score to the corresponding percentile score for each stage for February and May. Table 16 shows the scale score and corresponding percentile score for each stage of concern for all participants. With these percentile scores, I created profiles by graphing the percentile scores for each stage for February and May, according to the directions in the Stages of Concern Questionnaire handbook.

Table 16: Scale and Percentile Scores for All Participants

Stage	February		May	
	Raw Scale Score	Percentile Score	Raw Scale Score	Percentile Score
0	11	61	9	48
1	20	72	18	66
2	19	70	16	59
3	15	56	17	65
4	17	21	19	27
5	21	52	23	59
6	16	47	16	47

The first part of this question focuses on concerns of the entire participant group. In Figure 4, the concerns profile for the entire participant group for February and May is charted. In general, the higher the percentile scores, the higher the level of concerns for that particular stage. However, it is the relationship of relative high and low scores across the stages that is of primary importance within the CBAM survey. Further, changes in this pattern over time can suggest how an initiative is taking hold with respect to participant concerns.

Figure 4: February vs. May SoCQ Profile for All Participants



In Figure 4, we can see that there is a change in the relative intensity at Stage 0 for all participants from February to May. According to the scoring guide for this survey, this decrease in concern indicates that participants view this initiative as an important part of their work. The greater the score for Stage 0, the greater intensity of concerns are represented, which means the more likely it is that other things besides this initiative are of concern for participants.

As we look at the overall pattern of the profile, we can see that the overall profiles for February and May look similar. Both profiles have similar points of intensity, particularly at Stages 4, 5, and 6. However, there is an interesting change that occurs with participants' concerns over time. From February to May, participants' concerns decrease in Stages 0, 1, and 2. However, during this same time, participants' concerns increased in Stages 3, 4, and 5. The charted profile showing the shift, or wave, of change in concerns indicates that over time, participants are engaging in the initiative, and therefore moving through the change progression. We can clearly see that as anticipated, participants' relative levels of concerns change in intensity over time as they make positive progress in implementing a new initiative. This profile clearly illustrates this evolution along the continuum of concerns over time. Not only, then, are there differences in means, but the actual pattern of fluctuation and change helps us better understand how participants might be responding to their experiences.

By May, the profile indicates that participants' highest or most intense level of concern is about the management of the initiative. This is markedly different from the February profile where the highest concern was focused on awareness and personal use of the technology in the initiative. However, because the Stage 2 scores are still relatively high within both profiles, we can conclude that participants are not completely comfortable with this initiative at this time.

The lack of change at Stage 6 is interesting in that it indicates that participants on the whole have not been overly concerned with how to change things related to this initiative, and this concern has not changed over time. We could suspect, however, that if this survey were given again, we might see the wave of change continue and Stage 6 would show changes. This could happen for one of two reasons. First, the wave of change in concerns would indicate that potentially, participants will evolve to having increasing concerns with revamping the initiative based on their experiences and what they believe could be more effective. In addition, as teachers continue to engage in the professional development, their communities of practice will continue to evolve, assuming more ownership of the initiative over time. In this way, teachers could potentially begin to develop strong notions as to what could potentially work better than what has been presented thus far.

What is probably most interesting, for me, with this profile is the relative lack of concern for the impact of this initiative on students (Stage 4). It appears as though at no time, in February or May, were participants overly worried about how the integration of technology would impact their learning. Further, the two highest points of concern immediately surround this student interest. Stage 3, management of the initiative, and Stage 5, collaboration with others, seem to preoccupy the concerns of participants both in February and May. This is interesting because overall the profiles seem to indicate that as participants move through the initiative over time, they question and worry about several aspects of the initiative including how they are going to manage things, the logistics of implementing, the collaboration with others that may or may not be available, but they do not question or spend time with concerns about the impact to students and their learning. This could possibly indicate that teachers believe students will respond in a desirable fashion if they could get the logistics and the collaboration more in order. It could also potentially signal a red flag in the focus of the professional development. Because the professional development is primarily centered on teacher learning, teacher behavior, and teacher planning, it is possible that the student element of the process has not been of primary concern, as reflected in this charted profile.

Sub-question A: How do the concern profiles of teachers who teach in a whole-school technology integration model change after several months of participating in targeted professional development on the integration of technology?

Sub-question A of this research question required me to first divide the participants into two groups: those who came from whole-school implementation settings and those who came from partial-school implementation settings. Whole-school implementation is defined as having the majority of instructional spaces filled with interactive technologies. Partial-school implementation is where fewer than ten instructional spaces have these interactive technologies. The focus of this question centers on how teachers from different implementation configurations change over time with respect to their concerns with implementing this new initiative.

After participants were divided into two groups, I calculated the average scale score for each Stage of Concern for the whole-school implementation group. I then converted the average scale score to its corresponding percentile score, as shown in Table 17.

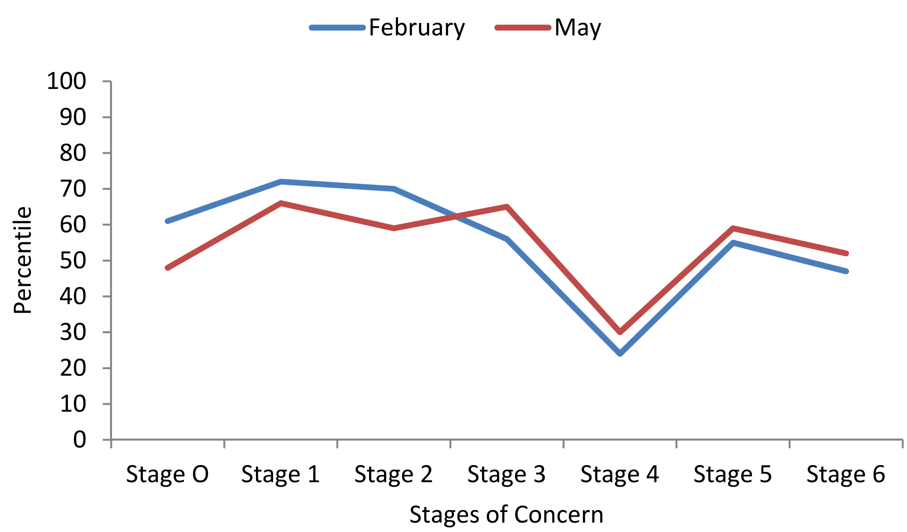
Table 17: Scale and Percentile Scores for Whole-School Implementation Participants

Stage	February		May	
	Raw Scale Score	Percentile Score	Raw Scale Score	Percentile Score
0	11	61	9	48
1	20	72	18	66
2	19	70	16	59
3	15	56	17	65
4	18	24	20	30
5	22	55	23	59
6	16	47	17	52

Percentile scores for February and May were used to generate the profiles for the participants teaching in a whole-school implementation school (Figure 5). These profiles closely mirror the profiles for all participants. While these two profiles look similar, it is interesting to observe the decrease in Stage 0, unconcerned, and Stage 2, personal concerns, over time. This seems to indicate that as participants engaged in this initiative over time, their concerns about the initiative in general, and their concerns about themselves and what it means for them, decreased and shifted to other areas of concern.

Specifically, over time, the teachers who belong to whole-school implementation schools shifted their highest concern of personal issues (Stage 2) in February to management issues (Stage 3) in May. This shift reflects the natural transition of teachers worrying about the personal impact of this initiative on them in terms of planning, time, learning, and knowing what to do to being more concerned with issues of implementation – classroom management, time management, and logistical planning and arrangements.

Figure 5: February vs. May SoCQ Profile for Participants from Whole School Implementation Participants



Other areas of shift can be seen in the profiles at Stages 4, 5, and 6. It seems that participants within whole-school implementation configurations mirror similar patterns of changes in concern during this initiative as all participants. However, one noticeable difference is at Stage 6. Stage 6 for this group shows an increase in concerns over time. This pattern is unique to this implementation configuration. In all other analyses included in this study, concerns at Stage 6 stayed the same. This unique finding could indicate that there is growing confidence for teachers within this whole-school implementation process in the enactment of the initiative. In this way, perhaps a whole-school implementation configuration allows for school ownership, customization, and empowerment to think about enhancements or changes to the initiative for which other implementation configurations do not allow. This will be discussed more fully in the next chapter.

Sub-question B: How do the concern profiles of teachers who teach in a partial-school technology integration model change after several months of participating in targeted professional development on the integration of technology?

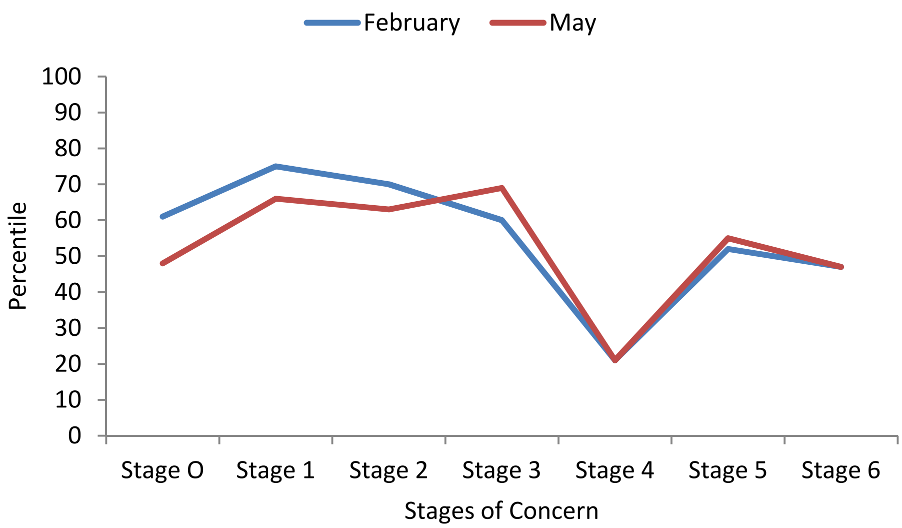
To answer this question, raw scale scores for participants teaching in partial-school implementation configuration models were calculated, and then average scale scores were calculated for each stage of concern. These average scale scores were matched with their corresponding percentile score for February and May (see Table 18).

Table 18: Scale and Percentile Scores for Partial-School Implementation Participants

Stage	February		May	
	Raw Scale Score	Percentile Score	Raw Scale Score	Percentile Score
0	11	61	9	48
1	21	75	18	66
2	19	70	17	63
3	16	60	18	69
4	17	21	17	21
5	21	52	22	55
6	16	47	16	47

Percentile scores for each stage for February and May were used to chart the profiles for the partial-school implementation participants (See Figure 6). While the profile is similar to the other profiles we have seen, particularly for all participants, one observation for this group is what is missing from the change in profiles from February to May. This group, unlike what is seen in the all participant profile and the whole-school implementation profile, showed no noticeable change in Stages 4, 5, or 6. In fact, the only noticeable shifts in this group from February to May occurred across Stages 0, 1, and 2. Participants showed a decrease in worries about what the initiative is, their awareness of it, and how their involvement in this project impacted and affected them. They showed an increase of management concerns over time, which is reflected across all other profiles in this study.

Figure 6: February vs. May SoCQ Profile for Participants from Partial School Implementation Participants



Again, we see in this profile what has occurred in the other profiles at Stage 4. Concerns about the impact on students remain the lowest area of concern for this group of participants, and they do not seem to change over time as participants learn more about the project and shift concerns in other areas.

Summary of Results

This chapter presented the findings as related to each of the research questions. The first section of this chapter outlined the descriptive data of the participants and the variables. Next, the results for each research question were presented under each of the questions. Significant differences were found between February and May for Stages 0, 1, 2, 3, 4, and 5. No significant differences were found at Stage 6, the stage where participants have ideas about how to change or alter the reform initiative.

In addition, Stages of Concern profiles were generated for all participants, whole-school implementation participants, and partial-school implementation participants for February and May. These concern profiles were analyzed using the interpretive framework outlined in the CBAM scoring guide. The profiles reflected shifts in concerns over time for all participants and the sub-groups that were analyzed. Across all groups, one of the major areas of concerns that evolved over time was an increase in management concerns. All profiles also reflected relatively low concerns about the impact to students. This low concern was surrounded by the highest concerns for all profiles – the concerns about management and the concerns about collaborating with others on the initiative.

The next chapter will discuss these findings in greater detail and will situate them within the research on teacher change, professional development, and whole-school reform initiatives. Implications for future professional development possibilities are discussed as well.

CHAPTER FIVE: DISCUSSION

The purpose of this research was to study teachers' changes in concerns as they work to integrate technology with their content and pedagogy. Through the analysis of the Stages of Concerns Questionnaire (SoCQ), as part of the Concerns-Based Adoption Model (CBAM) given at the beginning and end of this professional development cycle, this study sought to analyze the changes in teacher concerns about the integration of technology, pedagogy, and content in their mathematics teaching and learning program as a result of participating in a specific professional development initiative in order to better understand how this professional development initiative influenced, if at all, changes in teachers' implementation practices.

This chapter discusses the findings of this study and elaborates on the implications for professional development on the integration of technology in mathematics content. The first section of this chapter reviews the findings and implications related to these findings. The limitations of this study are discussed at the end of this chapter.

Findings and their Implications

When it comes to integrating technology into mathematics classrooms, "teachers are learners who move toward deeper understanding of what it means to use mathematics technology effectively with students" (Zbiek & Hollebrands, 2008, p.288). The focus on concerns in this study acknowledges prior research findings indicating that teachers move through various stages toward deeper understanding and application as they attempt to implement changes or new innovations in their practice. The ability to define where teachers are in the progression of change affords us a better opportunity to understand present concerns and design professional development practices from which teachers at any particular stage may benefit. Like other innovations, improving the teaching of mathematics through the effective integration of technology can be viewed as a developmental process through which mathematics teachers experience the affective dimensions of changing practice. The CBAM Stages of Concern Questionnaire attempts to measure these changes through the classification of teachers' concerns.

The seven stages of concern that are contained within this concerns scale can be clustered into three categories. The first three stages reflect concerns that are focused on self. The Awareness, Information, and Personal stages all reflect a participant's concern with understanding the reform effort, what is being required, and what the impact is to the individual in terms of work, thought, and change. The middle category, Management focuses on mastering the initiative. It is in this phase that participants set about implementing the initiative. The third category, which consists of the last three stages (Consequence, Collaboration, and Refocusing) all focus on how participants might evaluate the impact of the initiative being implemented. It is across these stages that value statements are made about whether or not this is good for student learning, how we might improve the initiative or the process, and how we might work together to make it better.

The results from question one of this study, that sought to determine whether or not there were significant differences between concerns in February and May, indicate that teachers' concerns were significantly different across Stages 0, 1, 2, 3, 4, and 5. For the first three stages, 0, 1, and 2, concerns decreased significantly over time. In this way, teachers became less concerned about issues dealing with themselves, what this project was about, and what was expected of them. For Stages 3, 4, and 5, participants' concerns significantly increased over time. Specifically, as participants engaged in this project, they became more concerned with issues related to management, implementing this project, and evaluating how the project is being implemented. This positive shift in concerns as teachers moved to higher levels of the concerns continuum is further explained in the results of question two where we are able to more clearly see the more intense areas of concern from February to May. What then, can we attribute to this shift in concerns for teachers, and what, if any, possible components of the professional development could have potentially contributed to this positive concerns growth over time?

While we cannot say what caused any change in concerns, as this study did not attempt to prove causation of any change, it might be interesting to focus on two areas of the concerns profile that surfaced surprising results. First, the concerns about the impact to students were among the lowest concerns of participants, both in February and in May. The profiles consistently indicate that teachers felt low levels of intensity when it related to students, this project, and the integration of technology in mathematics. A key driver for the purchase, installation of, and professional development for these interactive technologies is to help create student-centered learning environments where students can engage in learning inside of school in similar ways they engage in learning outside of school. To this end, teachers tend to recognize and be aware of the growing role of technology in students' lives, and their own lives, and often are receptive to the acquisition of technologies for student use. In this way, the benefit to students, viewed from this somewhat superficial way, could have been taken as given by the participants in this study. Perhaps they, at the same time, failed to make the connection that it is how these technologies are incorporated, planned for, and implemented by teachers that determine the quality of use by students in their classroom learning process.

Cuban (1986) reminds us that education and classroom instruction has been the “constancy amidst change” (p. 1) and explains that the integration of technology in classrooms epitomizes this “constancy and failure” (p. 2) of impactful reform. He states that, “nowhere is this paradox more apparent than in the interplay between the classroom teacher and technology” (p. 2). From Cuban’s perspective, over the decades of trying to implement reform, and specifically reform with technology, there has been little or no shift at all in teaching practice. Could it be this lack of real focus on student activity in the classroom that continues to stand in the way of meaningful and impactful change in teachers’ practice? The professional development focus for this project was on teachers, their planning, their knowledge, and the lessons they created. It was about their practice. This initiative, while claiming to be for the good of students, and potentially is for the good of students, did not explicitly focus on student activity, student thinking, student work, or student engagement. Perhaps a shift in the focus of the professional development could have yielded different results in the area of teacher concerns for student learning.

A second area of the concerns profile that stood out in the findings of this study is the lack of change in concern at Stage 6. Stage 6, the Refocusing Stage, showed no significant change over time, thereby illustrating that during the time of this study, participants, in the aggregate, had not intensified their concerns about altering the effort or making changes to this project as it was defined. However, when the survey responses were charted according to whole-school technology integration as opposed to partial-school technology integration, these results at Stage 6 differed. Teachers in schools that have been implementing technologies on a whole-school level showed an increase in intensity of concerns at this refocusing stage as compared to teachers working in partial-implementation schools who showed no change in concerns at this level. What might have contributed to this difference? Is it even a desirable result to see an increase in Stage 6 concerns given that it centers on refocusing or changing the initiative? These questions are important to consider as we think about the implications of the findings of this study.

It is at this stage that participants assume ownership of the initiative and often express an eagerness to change, improve, or abandon the initiative. Because this study was limited to the survey data and did not include interviews of teachers, it is hard to say why teachers in whole-school implementation models expressed more intense concerns at Stage 6 than their colleagues in partial-school implementation schools. However, we are reminded of Usiskin's (1999) comments on his notion about the failure of teaching reform. In a speech on mathematics reform, he outlines an eleven-step process that leads to a failure of sustained reform initiatives. Step seven, the oversimplification of reform efforts, could shed light on the differences between whole-school and partial-school implementation.

Usiskin (1999) describes this step in the implementation process as the time when implementers, or even the trainers themselves, work to make the new approach simple, clean, packaged and easy to implement. In doing this, they fail to realize that most often these new approaches evolved into what they are because of someone's creativity, experiments, and openness to explore things differently (Usiskin, 1999). By removing the creative, innovative process that helped to form the new approach in the first place, we run the risk of stopping the change cycle and we work to have teachers implement what has been created already instead of fostering the culture of continuous change and improvement of initiatives such as the one in this study. In this light, the goal of this effort is not fidelity of implementation. Instead, the goal should be continuous inquiry and exploration of ways in which technology can improve, enhance, and transform mathematics teaching and learning. In this way, there is no such thing as fidelity of implementation because the implementation is always changing and evolving. This refocusing effort at Stage 6 then becomes an indication that teachers are fully embracing this project and their role in it to be thinking, contributing, full participants in this community of learners that we've been working to create.

In whole-school reform efforts, even though only some teachers may come to the face to face training, often these teachers are used as the vehicle for bringing these new ways of thinking back for the whole-school to implement. While no data was collected in this study to help us understand how the teachers from whole-school implementation schools were used, we could argue that as part of the whole-school focus on technology, the goals of implementation and use are often found in school improvement plans and serve as a focus for staff meetings, team meetings, and general conversation on the school's effort to meet this school-wide goal. It is very likely that this team of teachers was seen as scavengers, gathering materials and ideas and returning not as experts to teach others in the building, but co-members of the school community who can share resources and help the community grow together as they experiment with their whole-school effort.

Partial-school implementation, however, doesn't always subscribe to this same behavior. Teachers in partial-school implementation efforts are often the only ones who actually have access to the new technologies. In this way, they are isolated from the rest of the school. Their involvement with the project could be viewed as a pilot program, one that must first be explored before being applied to all. In these cases, the new initiative is not always seen as part of the whole-school improvement effort, but instead is viewed as a project by a select group that is unrelated to the other teachers in the building. Once the technologies are provisioned for the rest of the building, if they are, it is assumed that the problem-solving and struggle that the pilot teachers went through could be eliminated for other teachers. In this way, the oversimplification of the effort has removed the inquiry and exploration from the core of the effort.

To this end, a clearly articulated goal of teacher-shaping and ownership of this professional development effort and the ways in which the integration of technology come alive in mathematics classrooms should be a foundation for future efforts. Teachers should be encouraged and have the ability to approach their practice, and even new practices such as these being introduced at the district level, with inquiry and exploration in the same ways we expect them to allow children to approach their learning. Potentially, this is more readily approached through a whole-school effort where all teachers are exploring this new approach together at the same time. However, this is not always feasible due to budget constraints related to the provisioning of technology and the capacity to plan for and deliver professional development at such a large scale. In these cases, efforts should be made to keep the exploratory, inquiry-based perspective alive for all participants, no matter when they enter the initiative, so that they too have opportunities to create and shape the effort and participate fully in these communities of practice.

Limitations of this Study

While the results of this study provide insight into some aspects of teacher changes in concerns and professional development on integrating technology in mathematics classrooms, this study was limited in several ways. First, the professional development initiative spanned only one-half of the school year. Had there been more time allotted for this professional development initiative, it would have been possible to see more change in concerns or different patterns of changes in concerns. It would have also been possible to repeat the concerns survey more than once, thereby creating a repeated-measures situation that spanned a longer time frame and included additional data sets from the additional administration. Patterns of changes in concerns could fluctuate over a longer period of time and these changes potentially were not captured as the study did not span more than four months.

A second limitation of this study was the data source. By only focusing on the survey of concerns from the CBAM model, we were only able to gather self-reported teacher data as related to the Likert scale on the survey. This limited the ability to hear from teachers through interviews or observe teacher behavior through classroom observations. Had these data sources been included in the study, we might have better insight into why teacher concerns changed the way they did, how teachers describe the changes they are experiencing, and how teachers implement these reform initiatives in their classroom.

This study was limited to one professional development initiative within one school district with teachers that had been selected to participate due to their acquisition of interactive technologies. Had this study been extended to include multiple districts and a broader range of professional development opportunities, it might have been possible to examine changes across a more generalized audience and compare professional development approaches. This served as an additional limitation to this study.

Summary

The change in concerns showed positive attitudes toward the initiative, a willingness to learn and embrace the project, and positive shifts in concerns as teachers sought to understand and implement new technologies in their mathematics program. Findings from this study, given that the length of time of the project was just under five months, lead us to believe that continuing the project would lead to a continued wave of change in teachers' concerns. However, we now can better plan for teachers' needs as expressed by their profile. Instead of continuing with this professional development effort in somewhat of a generic way, we can now pinpoint a focus of student learning and student activity, along with ways in which teachers could refocus this effort by customizing, tailoring, and creating new approaches and techniques for integrating technology in their classroom.

Given the limitations of data collection of this study, it is difficult to identify what exactly influenced the change in teacher concerns over time. Heid and Blume (2008), in their compilation of the most current research on the integration of technology within mathematics teaching and learning environments, clearly articulate that "it is the confluence of technological environment, teachers, learners, curriculum, and mathematical activity that sets the stage for changes in teaching and learning mathematics in the context of technology" (p. 420). They further state that the "promise of technology is accompanied by a corresponding challenge of implementation" (p. 421). Zbiek and Hollebrands (2008) elaborate on this claim by stating that "how teachers believe learning occurs and how they envision teaching related to learning influence greatly their concerns and modes as they work to teach mathematics with technology" (p. 322). Specifically, they have found that "the ways in which technology is integrated into teachers' classrooms is influenced by their conceptions of technology, mathematics, learning, and teaching. And, teachers conceptions of technology, mathematics, and teaching influence the ways in which technology is integrated into their practices" (p. 309). It is this co-dependent relationship of knowledge and beliefs across these domains that create the complexity of changing teacher knowledge and practice. Heid and Blume (2008) echo this in their claim that "the ways in which technology is used in the mathematics classroom is determined by choices the teacher makes in engaging students in technology-supported mathematics. Choices teachers make include emphasizing procedures or concepts and electing to use one representation over another" (p. 420). Perhaps the professional development experiences included in this study that were modeled with these considerations helped to shift teachers' concerns as they worked to integrate technology into their practice. More in-depth studies could seek to explore this interest.

While there is an emerging body of research on the integration of technology and what that means for teacher practice, teacher knowledge, and professional development, there is still much to learn and explore about how these new technologies can potentially change teaching and learning environments. One of the limitations of the existing research is related to the availability of studies representing a range of methodologies that analyze this integration. Most studies that have been conducted thus far have been case studies that serve to illustrate how teaching has or has not changed over time, but do not shed light on teacher concerns as they work on the integration of technology in their practice. This study explored the changes in teachers' thoughts and concerns as they participated in and experienced professional development that models and supports how to meaningfully select and integrate technology into their instructional design and practice.

CHAPTER SIX: CONCLUSION

The purpose of this study was to study teachers' changes in concerns as they work to integrate technology with their content and pedagogy. Through the analysis of the Stages of Concerns Questionnaire (SoCQ), as part of the Concerns-Based Adoption Model (CBAM) given at the beginning and end of this professional development cycle, this study sought to analyze the changes in teacher concerns about the integration of technology, pedagogy, and content in their mathematics teaching and learning program as a result of participating in a specific professional development initiative in order to better understand how this professional development initiative influenced, if at all, changes in teachers' implementation practices.

This chapter discusses the future directions for professional development for teachers related to the integration of technology with mathematics content. In addition, this chapter suggests future research efforts that could serve as areas of focus that would further extend and enrich the findings from this study. A summary conclusion is the last section of this chapter.

Future Directions

One of the findings of this study that is most interesting to me is the design of the professional development and how this may or may not impact teachers in different ways. When thinking about the work of integrating content, technology, and pedagogy, there is no clear model or design to adopt or implement. The work is new, authentic, and situated in the individual and unique contexts of teacher-student classroom communities. The model and design for teacher experiences must emerge and be created as teachers evolve and grow in their experiences. To this end, the design must be flexible, dynamic, authentic, and relevant to the different audiences of teachers. This could be quite challenging because often it appears more appealing or desirable to purchase or implement an already planned packaged program to implement instead of a more dynamic authentic approach that requires time, work, and some comfort with uncertainty. However, the results of this study and others suggest that this authentic teacher-centered professional development is the only format that works to promote teacher change in positive ways. It is because of this that these types of professional development experiences must continue, particularly as we continue to grow in our understanding of meaningful integration of technology.

A related hope for future professional development as a result of this study is that professional development experiences must be grounded in the work of teachers. This means there is an organic nature to the design and program that is constructed, co-developed, and modified. This also means that it takes time - more time than we often have in the fast-moving K-12 world of implementation. Teaching is a cultural activity. Because of this, it does not change or transform so quickly. It evolves over time, through experiences, conversations, and interactions with others. We often don't observe or appreciate the subtle shifts that occur as a result of different professional development efforts. Therefore, we must be more observant of the small but significant cultural shifts in the ways teachers talk about their practice, talk to each other about their content, and ask for different supports throughout the initiative. This way of thinking about the results of professional development is not natural to K-12 environments and is not valued as a sound measurement of “effective” results, and so that challenge remains. Even still, a challenge for future professional development is to work to provide experiences that are grounded in teacher practice and honor the time it takes to change the culture of teaching and learning.

While there is a large body of research on professional development for teachers, there are few studies that focus on the integration of technology with mathematics content and what this means for what teachers need to know and be able to do. Two prominent researchers leading this new and quickly developing field of research are Mishra and Koehler, two professors from Michigan State University. Mishra and Koehler (2006), after spending five years working on a design study that focused on teacher professional development on the integration of technology, developed a theoretical framework for the kinds of teacher knowledge that are necessary for transforming classroom practice through the integration of technology with content and pedagogy. With the introduction and growing integration of technology in classroom settings, implications for teacher knowledge and how that knowledge is cultivated with respect to what teachers know and believe about mathematics, learning, their own abilities, and technology are a critical area of focus that still has yet to be fully explored and understood.

Future research focusing on teachers' development of technological pedagogical content knowledge is needed in order for us to better understand what Heid and Blume (2008) describe as "the confluence of technological environment, teachers, learners, curriculum, and mathematical activity that sets the stage for changes in teaching and learning mathematics in the context of technology" (p. 420). Heid and Blume (2008) state that the "promise of technology is accompanied by a corresponding challenge of implementation" (p. 421). Studies that focus on the change continuum of teacher implementation so that we may better understand what kinds of professional development experiences help to foster the meaningful integration of technology and mathematics can shed insight on this important, and growing field.

Specifically, it would be interesting to study teachers more in-depth as they move through the change process of implementing new technologies within their mathematics classrooms. Bringing in the other components of CBAM, including the Levels of Use component would broaden our understanding of how teachers integrate technologies in meaningful ways to achieve interactive, engaging mathematics classrooms where students are engaged in constructing deep understandings. Strategically organized ethnographic case studies could serve an unfulfilled need for better understanding of how teachers implement technologies and how students then respond. How these rich, dynamic, 21st century classroom communities evolve as they incorporate interactive technologies is something we know little about, and it would be helpful for future studies to focus on how these communities evolve over time, and what the drivers and restrainers are in creating these communities.

Finally, if there were opportunities for partnerships with K-12 institutions and universities, it would be a worthwhile endeavor to create true professional development schools that focus on this integration of technology with mathematics content, and other content as well. There is a growing need to understand the impact of technologies on the content we are now able to teach, the ways in which we teach that content, the ways in which students access each other, when students learn, and who they learn from. There are endless questions to be answered in this fast-growing field, and partnerships that can bridge the link between practice and research would be incredibly beneficial to the field of education.

Conclusion

One key principle of the NCTM *Standards* envisions that "technology is essential in teaching and learning mathematics; [and] it influences the mathematics that is taught and enhances students' learning" (NCTM, 2010, p. 11). Over the past two decades, we have witnessed and participated in the rapid growth of new technologies. Kurzweil (2001) contextualizes this growth in his statement that over the next century, we will not experience 100 years of growth; instead, "it will feel like 20,000 years of progress," (p. 1). He further explains that the "overall technological progress of the 21st century is the equivalent of what would require the past 200 centuries to accomplish," (p.1) and this is about 1000 times greater than the progress we saw in the last century (Kurzweil, 2001).

Classroom teachers across the country have begun to integrate content, pedagogy, and information and communication technologies in their classroom learning communities. However, while there are many studies and anecdotal reports on the benefits of this integration, there is a need for studies that describe the changes in teacher concerns that support the growth in integration of technology, pedagogy, and content as they participate in professional development experiences. Researchers (Heid, 2008; Hollenbeck, Wray, & Fey, 2010) have begun to explore the possibilities and potential that the growth and progress in the various information and communication technologies that are "available for teaching and doing mathematics [hold for transforming the] ways that we can engage students in exploring mathematical ideas and solving mathematical problems" (Hollenbeck, Wray, & Fey, 2010, p. 265). It is through this continued exploration and study that we can better understand the transformations that can occur in mathematics teaching and learning with the meaningful integration of technology.

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