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I am submitting herewith a dissertation written by Geri Armagost Landry entitled “Creating and Validating an Instrument to Measure Middle School Mathematics’ Teachers’ Technological Pedagogical Content Knowledge (TPACK).” I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

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**Creating and Validating an Instrument to Measure Middle School Mathematics
Teachers' Technological Pedagogical Content Knowledge (TPACK)**

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Geri Armagost Landry
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DEDICATION

This dissertation is dedicated to my husband, Chris, who has supported, pushed, pulled, and nudged me as I have pursued a Ph.D. I cannot fathom the magnitude of his uninterrupted love, loyalty, faith, friendship, and selfless efforts on behalf of my success. He is a wonderful husband and an outstanding father. He deserves magnanimous respect, love, and gratitude for hanging in there while I took for four long years to pursue my dream.

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ABSTRACT

Due to the pervasiveness of technology, the role and preparation of teachers as they strategically use technology for teaching mathematics needs to be examined. Technological pedagogical content knowledge (TPACK) is a framework for knowledge as teachers develop meaningful learning experiences for their students while integrating strategic use of technology (Mishra & Koehler, 2006). The purpose of this study was to develop a survey for measuring mathematics teachers' Mathematical Technological Pedagogical Content Knowledge (M-TPACK). The survey measures the domains of mathematics content, pedagogy and technology. This mixed methods study first examined middle school mathematics teachers' TPACK through the use of an existing survey (Schmidt et al., 2009). Interviews were conducted to determine the availability and use of technology in middle school mathematics classrooms, and teachers' strategic use of available technology for mathematics instruction. Finally, a survey measuring M-TPACK was developed to specifically measure teachers' mathematical TPACK.

Grandegenett (2008) asks for more concentration on helping teachers to imagine "possibilities" for using various approaches and strategies for integrating technology in mathematics instruction. This study presents important findings and supports the need for mathematics teachers' professional development to reconceptualize the role of technology in mathematics instruction. By using the developed M-TPACK Survey, teacher educators and administrators can use information about teachers' knowledge and beliefs concerning technology to enhance teacher education programs and plan professional development. The survey developed from this study can be used for stakeholders as they determine the needs of mathematics teachers, move the concept of

TPACK beyond theory and toward practice, and move toward offering appropriate technology experiences to enhance strategic mathematics instruction.

Keywords: Middle School, Mathematics, Technology, TPACK,

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CHAPTER I

Introduction

“Major limitations of computer use in the coming decades are likely to be less a result of technological limitations than a result of limited human imagination and the constraints of old habits and social structures.” (Kaput, 1992, p. 515)

This quote from a chapter in the *Handbook of Research on Mathematics Teaching and Learning* (Kaput, 1992) sums up the concern that old habits and social structures may be keeping teachers from optimizing the value of using technology in instruction. Our society continues to be highly impacted by the availability and use of technology. As knowledge about technology advances rapidly, responsibilities and opportunities are great for educators to incorporate technology in the learning environment.

In the sixth annual report of the *Speak Up National Research Project* (Manzo, 2009), students expressed that they would like to use more technology such as mobile devices, Smartphones, Web 2.0 tools, and social networking sites to assist learning in school. Manzo stated that students’ use of personal technologies outside of school is on the increase, yet they are asked to “power down” while attending school. They would also like to use the technology to think critically, problem-solve, collaborate, and communicate while at school. Students think teachers are not taking advantage of the technology tools that many of them use at home. Taking advantage of students’ interests in learning with new technologies can be an opportunity for mathematics teachers. Yet, changing the way one teaches is a challenge. Students learn more deeply and retain information longer when they have a say in what and how they will learn (Kohn, 1998; Vokoun & Bigelow, 2008). Therefore, when technology is used strategically as a

teaching tool, the impact on student learning of mathematics can be great (Sefton-Green, 2006). Teachers and students need 21st century skills to be successful in the 21st century.

As students progress through the upper elementary grades, mathematical ideas move from an emphasis on the additive structure of numbers to the multiplicative structure of numbers and relationships (Van de Walle, 2007). This means students are faced with new kinds of numbers, fractions, and decimals that rely on multiplication for their underlying structure.

Lappan's (2000) research indicates that during the middle grades, students develop a solid foundation for understanding mathematics where they need to have time and opportunities to explore, experiment, and play with mathematical ideas and concepts. At this age, middle school students' intellectual capacity to reason expands rapidly and they develop their ability to think abstractly. This signals a need for providing instruction that gives students the opportunity to extend their experiences "doing" mathematics. Technology is engaging for middle school students. At this level, technology can allow access and freedom to mathematical ideas that students could not explore in the past. Technology helps to create environments in which students can engage in problems with messy data and connect mathematics to real world ideas. Technology can also give students control over different forms of representations of mathematical relationships, and allow for engagement in dynamic ways with mathematical conjecturing.

As more opportunities become available for teachers to embrace and exploit the power of the latest technological tools for mathematics instruction, there is evidence that they are not taking advantage of these opportunities in the state of Tennessee. In the 2009 Technology Reports, the state of Tennessee ranks 36, receiving a grade of C for

“Capacity to Use Technology” and a D+ for the “Use of Technology.” This is a drop from the overall score of C in 2008 and indicates a need for improvement in educating teachers as they implement technology in their instruction.

As part of the economic-stimulus plan, President Barack Obama has pledged to launch “the most sweeping effort this country has ever seen” to modernize school buildings and equip all classrooms with computers (Ash, 2008). His plan includes improving school structures in order to optimize the potential for implementing new technologies. This administration also asks that Americans come together to deal with the current issues of job losses in order to be globally competitive with other markets. When teachers are well prepared and technology is available to all students, then the U.S. may be able to reclaim its position as a premier educational system. For this reason, it has become increasingly important that U.S. students are well trained in the use of technologies in order to possess skills necessary to become the innovators, remain on the leading edge of economic development, and produce the needed advances to create and sustain jobs. While the current administration addresses this need for schools to have technology, the Association of Mathematics Teacher Educators’ (AMTE) Technology Committee is developing strategies for helping teachers optimize their technology resources by identifying mathematics technology standards for students and teachers (Niess et al., 2009).

Many opponents of the use of technologies, particularly calculators, argue that calculators “dumb down” the curriculum or are used as a “crutch” (Van de Wall, 2007). Some of those opponents believe that students are prevented from discovering and understanding mathematical concepts because of technology. They also argue that

technology provides a false sense of confidence for students as they learn to problem solve.

Technology enables us to rethink and refresh our pedagogy by providing opportunities rather than solutions for issues in mathematics instruction. Merely using technology to replicate traditional lessons is not enough. Students should be empowered to take more responsibility for their own learning and develop meaningful mathematical skills using technologies. Mathematics teaching should maximize the potential of technologies to enrich and transform instruction. In order to take advantage of these opportunities, educators will be required to think, work, and often experiment with technology (Bressoud, 2009). Teachers have to move away from trying to use technology to replicate what was once done with chalk, paper, and multiple-choice tests, and move toward an understanding of how to create and support a mathematical environment where students develop their mathematical skills to meet standards.

As the cost of technology has decreased and the power and accessibility has increased, access to technology has moved from stationary desktop computer labs to mobile devices that provide overwhelming amounts of information. Mathematics teachers must utilize technological resources by taking advantage of the access of technologies to improve mathematics instruction rather than using these devices to merely modify the method of delivery. As many teachers were not taught this way, adopting such practices may be difficult. For teaching practices to remain state-of-the-art in this information-driven age, we must consider more closely how the power of technologies necessitates change in a way to help students learn mathematics.

Kennedy (1995) described a “Tree of Mathematics” using the trunk, branches, and leaf as an analogy for learning mathematics. The trunk of the tree represents the general mathematical knowledge including skills, rules, facts, and ideas. From the trunk protrudes different branches of mathematics concentration and from the branches are twigs representing deep mathematical concepts. The only access to the branches and twigs is by way of the trunk because the trunk is the foundation of the tree. Many people tried to climb the tree but could not get their hands around the enormous and intimidating trunk; therefore, they had no ability and no use for mathematics. He goes on to say:

Look around you in the tree of mathematics today, and you will see some new youngsters playing around in the branches. They are exploring parts of the tree that have not seen this kind of action in centuries, and they did not even climb the trunk to get there. Do you know how they did it? They cheated: they used a ladder. They climbed directly into the branches using a prosthetic extension of their brains known in the education business as technology. ... You can argue all you want about whether they deserve to be up so high, and about whether they might fall, but that argument will not change the fact that they are there, straddled alongside the best trunk-climbers in the tree. (p. 84)

Technology allows students to discover the beauty and power of mathematics while they build their mathematical skills. Mathematics teachers must be prepared to make productive use of technology to help students learn more effectively. When planning instruction, mathematics teacher educators should view the issue of preparing teachers to use technology strategically as an important component of a teacher

preparation program (Wise, 2009). Students should feel comfortable in a technological world; therefore, teacher preparation programs should support pre-service teachers as they learn to provide technology-enhanced learning opportunities for students. There is much to be learned about how to accomplish this goal and this research aims to advance the knowledge of how to prepare mathematics teachers for the strategic use of technology.

Background

Literature from the past century has articulated thoughtful attention concerning the advances and use of technology for mathematics classroom instruction. As early as the nineteenth century, when calculating machines were developed, the inclusion of this technology for classroom use was addressed. In *Elementary Mathematics from an Advanced Standpoint* (Klein as translated by Hedrick & Noble, 1932), Felix Klein, in the early 1900s, described in detail the mechanics of the Brunsviga calculating machine. His description concluded with, “every teacher of mathematics should become familiar with it, and it ought to be possible to have it demonstrated in secondary instruction” (p. 22). This provides some evidence that even a century ago, scholars considered the need for technology to be included in classroom instruction.

For more than 30 years, modern calculators have been accessible for teachers and students to use in the classroom. Researchers began studying the effect of calculators on mathematics instruction in the 1970s. Research has indicated that the availability of calculators has no negative effect on traditional skills (NRC, 2001). One consistent finding was that children who used calculators on tests have a higher degree of skills in both basic computation and problem solving. Further, Hembree and Dessart (1986)

reported that , students who used calculators had more positive attitudes toward mathematics than children who were not given access. These findings helped educators begin to embrace the use of calculators for mathematics problem-solving.

The *National Council of Teachers of Mathematics* (NCTM) “Agenda for Action” from the 1980s called for mathematics programs to take full advantage of the power of calculators and computers at all grade levels. The “Agenda for Action” recommended that schools be active in preparing students to live in a world in which “more and more functions are being performed by computers” (NCTM, 1980). While integrating the use of electronic tools in the mathematics curriculum, the technology should be used in “imaginative ways for exploring, discovering, and developing mathematical concepts and not merely for checking computational values or for drill and practice” (p. 3).

Kaput (1992) synthesized research in the use of technology for teaching. By comparing computer technology in mathematics education to that of a newly active volcano, he described technology as an explosion rapidly evolving before our eyes with forces coming from all different directions. He accurately said we can only guess what the future holds with new technologies and added that because of this rapid change, we should not wait for the latest word before becoming involved in implementing technology in instruction.

By the new millennium, NCTM’s *Principles and Standards for School Mathematics* (2000) stated that technology is “essential in teaching and learning mathematics; it influences what is taught and enhances students’ learning” (p. 24). In October of 2003, NCTM’s position paper on technology made five recommendations for technology-supported mathematics learning environments. Those recommendations include:

- Every school mathematics program should provide students and teachers with access to tools of instructional technology, including appropriate calculators, computers with mathematical software, Internet connectivity, handheld data-collection devices, and sensing probes.
- Pre-service and in-service teachers of mathematics at all levels should be provided with appropriate professional development in the use of instructional technology, the development of mathematics lessons that take advantage of technology-rich environments, and the integration of technology into day-to-day instruction.
- Curricula and courses of study at all levels should incorporate appropriate instructional technology in objectives, lessons, and assessment of learning outcomes.
- Programs of pre-service teacher preparation and in-service professional development should strive to instill dispositions of openness to experimentation with ever-evolving technological tools and their pervasive impact on mathematics education.
- Teachers should make informed decisions about the appropriate implementation of technologies in a coherent instructional program (p. 2).

The above recommendations give significant insight into how technology should be used in the mathematics classroom. By making clear that technology is an essential part of the mathematics curriculum, the position paper affirms that “using the tools of technology to work within interesting problem contexts can facilitate a student’s achievement of a variety of higher-order learning outcomes, such as reflection, reasoning,

problem posing, problem solving and decision making” (p. 1). In *Technology-Supported Mathematics Learning Environments* (NCTM, 2005), technology is described as “an essential tool for teaching and learning mathematics effectively; it extends the mathematics that can be taught and enhances students’ learning” (p. 1).

Statement of the Problem

Researchers in mathematics teacher education have long been interested in the issue of educating teachers to use technology in their teaching (Kaput, 1992; NCTM, 1980). Advances in technology are developing at an exponential rate and it is necessary for teachers and students to be prepared to utilize and take advantage of these advances. As technology is pervasive and changes quickly requires that teachers work consistently to keep up with the opportunities afforded by the new technologies. Thus, learning to use and integrate technology into the mathematics curriculum requires continuous investment of time and energy from teachers. Teachers must understand the critical need for continual learning; must be willing to contend with ambiguity and change as they strategically use technology to enhance mathematics instruction and improve mathematics learning. Technology is “essential in teaching and learning mathematics” and “influences what is taught and enhances students’ learning” (NCTM, 2000, p. 24). Rather than just allowing students to use technology in the mathematics classroom, teachers should learn how to use technology to transform teaching and create opportunities for student learning. The strategic use of technology in mathematics instruction is critical and teacher educators and professional developers should know how to support teachers as they learn ways to use technology to enhance instruction. Teachers ultimately determine the time, place, and manner in which technology is used in the

classroom – the “if, when, and how” of technology use (NCTM, 2000, p. 26). As mathematics teachers face the challenge of changing learning and instructional environments, mathematics teacher education is also challenged to meet these demands.

This knowledge needed for teachers to use technology strategically in mathematics instruction is a topic that has recently gained much attention (Neiss et al., 2009; Mishra & Koehler, 2006). Technological Pedagogical Content Knowledge (TPACK), as described by Mishra and Koehler, “represents a thoughtful interweaving of all three key sources of knowledge – technology, pedagogy, and content” (2006, p. 14). The TPACK framework describes good teaching with technology by including the components of content, pedagogy, and technology. Shulman’s (1986, 1987) idea of pedagogical content knowledge (PCK) is the basis for this framework with the inclusion of the domain of educational technology. Technological pedagogical content knowledge describes how teachers’ knowledge of technology, content, and pedagogy interact to use technology strategically for instruction. Grandgenett (2008) describes six characteristics of teachers with strong TPACK:

1. Teachers are open to experimentation with technological tools and “trying” new lessons using technology.
2. Teachers stay on task when teaching mathematics topics.
3. Teachers have clear pedagogical strategies, knowing where students are academically, what students need to know, and how it should be taught.
4. Teachers help students understand why technology is important.
5. Teachers use technology for classroom management, for assessment, etc.
6. Teachers are comfortable and optimistic about changes in technology.

The TPACK framework for using technology in classroom instruction does not encourage technology as being a “stand alone” support to mathematics teacher education but as a tool specifically and uniquely applied to mathematics instruction. Teachers using various levels of calculators, Smartboards®, and data collecting devices, to support instruction may be missing the point if the technology is not used appropriately, pedagogically (Sefton-Green, 2006). Not only should teachers integrate technology in their instruction, they should learn to use technology to transform teaching and create new opportunities for students to problem solve, program, analyze, strategize, and design specific higher level skills (Harris, 2008). The TPACK framework offers teachers and researchers a way to evaluate and present research-based suggestions for developing the knowledge and skills needed to integrate technologies into teaching and learning.

Technology is becoming more advanced, less expensive, and readily available. Research should focus on how teachers can use technology as an advantage to teaching. Mathematics teacher educators must provide pre-service teachers with the TPACK experiences necessary to use technology strategically in their mathematics instruction. A tool for determining the knowledge teachers have about technology, pedagogy, and content may provide support for mathematics teacher educators and professional developers as they plan effective learning opportunities for the strategic use of technology for teaching mathematics.

Purpose of the Study

This study considers the overwhelming presence of various technologies in today’s society and seeks to capture the factors that foster the implementation of technology-rich mathematics instruction. Teacher educators and administrators can use

more information about teachers' knowledge and beliefs concerning technology to enhance teacher education programs and to plan professional development. Therefore, the purpose of this study is to develop a survey to measure middle school mathematics teachers' technological pedagogical content knowledge (M-TPACK). Schmidt, Baran, Thompson, Koehler, Shin, and Mishra (2009) created an instrument for measuring teachers' TPACK using the domains of content, pedagogy, and technology; and the overlapping areas of technology content, technological pedagogy, content pedagogy, and technological pedagogical content knowledge. The survey titled *Survey of Teachers' Knowledge of Teaching and Technology* was developed to measure preservice teachers' understanding about the relationship between technology, content, and pedagogy. The survey created in this study will adapt Schmidt's survey to specifically examine middle school mathematics teachers' TPACK. Therefore, middle school mathematics teachers will be interviewed to determine the technology available for use in their classrooms, the technology they are currently using in their classroom, and how they use this technology for mathematics instruction. The information gathered from these interviews will guide the adaptation of Schmidt et al.'s survey for general TPACK making it specific to mathematics.

Recently, standards have been developed to offer guidelines for thinking about the knowledge mathematics teachers need in order to teach mathematics with technologies (Neiss et al. 2009). The Association of Mathematics Teacher Educators' (AMTE) Technology Committee is working on developing a set of standards for addressing the matter of mathematics teachers' TPACK. These standards promote implementation of technology in the context of teaching and learning specifically in mathematics. The

mathematics teacher technology standards provide a framework for supporting those who prepare mathematics teachers as they incorporate technology into their instruction. The survey designed from this study will be used to capture the progression of mathematics TPACK as teachers integrate technology into the teaching and learning of mathematics.

Research Questions

The following questions will be used to address the purpose of this study:

1. What technological pedagogical content knowledge is identified by middle school mathematics teachers as necessary for strategically teaching mathematics?
2. Will the survey developed in this study be reliable and valid for measuring middle school mathematics teachers M-TPACK?

Significance of the Study

Research suggests that teacher educators need to build upon teachers' prior knowledge and current beliefs when planning and implementing instruction in coursework or professional developments (Wilson & Cooney, 2002). Through this research, I will develop a survey to measure middle school teachers' knowledge of and beliefs about the use of technology in their mathematics instruction for use by teacher educators, researchers, practitioners, and those planning professional developments. The results from the survey can be used to help plan instruction and encourage an environment conducive to developing positive attitudes in teacher education programs. At the same time, the survey will address misconceptions and counterproductive beliefs about technology and mathematics.

The survey developed from this study will inform stakeholders about whether teachers view technology as valuable and relevant. It will also reveal teachers' beliefs

regarding (a) how students learn, (b) what environments foster learning, (c) what teaching methods enhance students' understanding of mathematics, and (d) the role of technology for instruction. The survey will also address what major factors affect teachers' pedagogical decisions concerning their use of technology.

The survey developed for this research can also be used to address pre-service teachers' pedagogical use of technology. New teachers may be more comfortable in their personal use of technology due to more exposure than teachers who were educated during a different era. However, when it comes to teaching, teaching as we have been taught is a commonly expressed adage and occurs frequently (Britzman, 1991). The learning experiences pre-service teachers have had with the mathematics content was likely to have been with limited or no access to pedagogical uses of technology; therefore, new teachers may need more experience using pedagogical practices that involve instructional technology (Neiss, 2008). Knowledge of these instructional strategies and representations rely largely on personal experiences and these new teachers may not have had experiences as students that were rich with technology; therefore pre-service teachers' conception of what it means to teach with technology may be naïve.

Limitations

The intent of this study is to design a survey to measure middle school mathematics teachers' TPACK. This study not only adds to the research literature in mathematics education, but also is valuable to teacher educators and stakeholders as they prepare learning opportunities for mathematics teachers to strategically use technology for mathematics instruction. Several potential limitations should be noted. First, my

sample consists of middle school mathematics teachers from a single county in east Tennessee. The middle school enrollment for this county as of May 2009 is 12,369 students; 79.2% of the students are White, 2% are Hispanic, 0.2% Asian/Pacific Island, and 15% African American. All of the 14 middle schools are accredited by the Southern Association of Colleges and Schools. Although the middle schools in this county are fairly representative of other middle schools in the region, the results of this study may not be generalizable to all other school districts or larger populations.

The data collected for this study was done at a single point in time, thus the findings would not be as strong as collecting over a longer period of time. It is impossible to consider or identify every influential factor due to the complexity of characterizing, documenting, and analyzing the views of teachers. There is also a possibility that participants may have responded to the interview and survey questions in a way that reflects what is perceived as being expected by the researcher.

Delimitations

In this mixed methods study, data was collected from middle school mathematics teachers who were willing to participate. The two surveys were administered and conducted an on-line interview with middle school mathematics teachers to collect evidence of their use and knowledge of available technology at their schools. Excluded from the study were perspectives of other stakeholders; for example, principals and other technology support personnel. Factors not control in this study included the position of the principals and their influence on the technology available at the schools.

Assumptions

Two basic assumptions underlie this study. The first assumes that the TPACK survey developed by Schmidt et al. (2009) is valid and reliable and appropriate for this use. Secondly, data from the interviews are self reported are assumed to be accurate.

Definition of terms

The following terms have been defined to ensure clarity for this study.

ActivInspire is specialized teaching software allowing for support for handheld responder systems.

ActivSlate is a slate that allows teachers to use a pen to write or display information on the board from anywhere in the classroom.

ActiVote is a response device that interacts with a whiteboard by allowing learners to send text and numeric responses for assessment purposes.

Clickers are classroom response systems allowing teachers to ask questions and gather students' responses. Answers are displayed on an electronic whiteboard and can be shown in real time.

Educational technology is technology that impacts upon the learning process, such as delivering learning materials, facilitating communication, and providing assessment and feedback.

Excel is a spreadsheet application written and distributed by Microsoft. It features calculation, graphing tools, pivot tables, and macro programming language.

Individual whiteboards are whiteboards that allow the learner to interact between the whiteboard and content projected onto an Interactive Whiteboard.

Information technology (IT), as defined by the Information Technology Association of America (ITAA), is "the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." It deals with the use of electronic computers and computer software to convert, store, protect, process, transmit, and securely retrieve information.

Interactive whiteboards are large interactive displays that connect to a computer or projector. This includes Smartboard® and Activboard®. *Mobile devices* are pocket-sized computing devices with a touch screen or miniature keyboard.

Smart Boards are interactive whiteboards that use touch technology to detect user input in the same way a normal PC would do.

Study Island is educational software providing standards-based instruction, practice, testing and other tools for K-12 students.

Technology refers to all forms of electronic devices; including computers, calculators, and other handheld devices, telecommunications equipment, and multimedia hardware.

Technology integration involves the infusion of technology as a tool to enhance the learning in a content area or multidisciplinary setting. The technology should become an integral part of how the classroom functions — as accessible as all other classroom tools. The focus in each lesson or unit is the curriculum outcome, not the technology.

Technology literacy is defined as computer skills and the ability to use computers and other technology to improve learning, productivity, and performance.

TPACK is Technological Pedagogical Content Knowledge and refers to the knowledge teachers need to strategically use technology for teaching.

CHAPTER II

Literature Review

Due to the pervasiveness of technology, there is a need for examining the role and preparation of teachers as they strategically use technology for teaching mathematics.

Technological Pedagogical Content Knowledge (TPACK) provides a theoretical framework for successful technology integration in the mathematics classroom. Chapter II begins with a description of the theoretical framework for TPACK. The chapter continues by describing the standards that have been developed using the TPACK framework for use in mathematics teacher education programs and the Mathematics Teacher Development Model describing the development of TPACK for meeting those standards. Mathematics teacher educators should also consider that teachers' beliefs and knowledge of technology, pedagogy, and content are intertwined; therefore, chapter II describes the relationship between mathematics teachers' beliefs about how students learn, and how these beliefs influence the instructional decisions teachers make when using technology for teaching mathematics. Finally, this chapter summarizes the specific uses of the TPACK survey developed for middle school mathematics teachers.

TPACK Framework

Teacher education has primarily focused on technology as a stand alone subject, as teachers tend to learn about various technological tools and resources. Researchers have suggested that knowledge of technology alone is not sufficient for meaningful integration when teaching mathematics. The TPACK framework provides an approach to examine the technological, pedagogical, content knowledge needed to understand and develop practices that address the learning of mathematics using technology. This

TPACK framework builds on Shulman's (1986, 1987) idea of pedagogical content knowledge (PCK) and includes teacher knowledge for integrating technology in instruction (Koehler & Mishra, 2008). The idea of PCK is extended purposefully for this research to mathematics teachers strategically using technology in their instruction. This knowledge is what mathematics teachers develop and use as they plan to integrate technology in learning opportunities for their students.

Pedagogical content knowledge describes knowledge necessary for teachers to make it easier for students to better understand content by helping them construct understanding. This knowledge is the understanding of representations and examples used to illustrate a given idea, as well as an understanding of what ideas may be more difficult for students, why those ideas are difficult, and how to best clarify these ideas for students. Shulman (1986) proposed that content knowledge of a subject alone is not sufficient for effective instruction. Teacher knowledge must include disciplinary, general pedagogical, and pedagogical content knowledge. Shulman described PCK as "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented and adapted to the diverse interests and abilities of learners, and presented for instruction" (1987, p. 8). Pedagogical content knowledge consists of the essence of teacher expertise while including knowledge of stumbling blocks and misconceptions student may have learning mathematics.

The TPACK framework for teacher knowledge includes an interaction among content, pedagogy, and technology. Figure one illustrates Koehler and Mishra's (2008) model of TPACK. The main components of content, pedagogy, and technology knowledge intersect at the center to display TPACK.

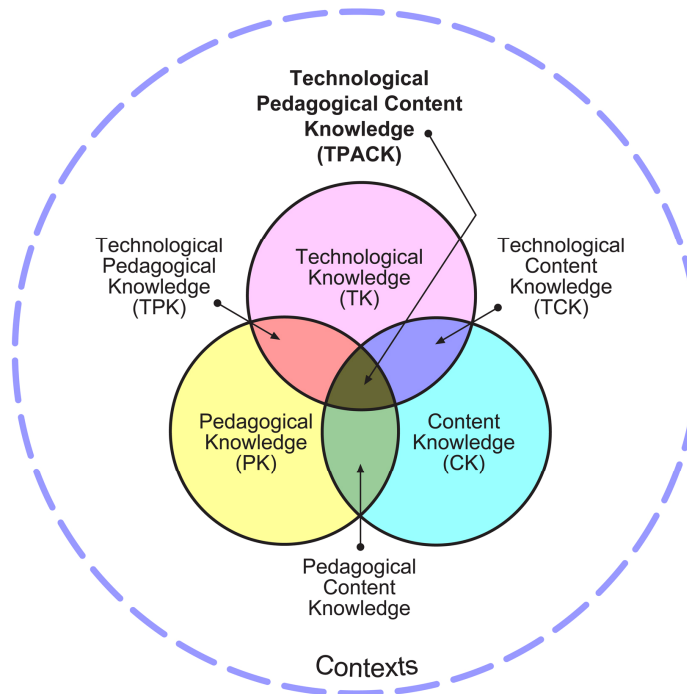


Figure 1. Technological Pedagogical Content Knowledge.

Taken from the TPACK Website: <http://tpack.org>

TPACK Domains

Awareness of the intersections of the elements of the TPACK construct – pedagogical knowledge (PK), content knowledge (CK), technology knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). - allows teachers and teacher educators to focus explicitly on the

meaning of the overlaps when they might not otherwise do so. Each domain is defined by Koehler and Mishra (2008):

- Content knowledge (CK) is knowledge about the actual subject matter that is to be learned or taught. It is knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches towards developing such knowledge.
- Pedagogical knowledge (PK) is an understanding of cognitive, social, and developmental theories of learning and how they apply to students in the classroom (p. 14).
- Pedagogical content knowledge (PCK) is knowledge of pedagogy specific to teaching content.
- Technology knowledge (TK) is a deep understanding of technology to achieve different tasks.
- Technological content knowledge (TCK) is an understanding of the manner in which technology and content influence and constrains one another (p. 16).
- Technological pedagogical knowledge (TPK) is an understanding of how teaching and learning changes when particular technologies are used (p. 16).
- Technological pedagogical content knowledge (TPACK) is the basis of effective teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and

theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones (pp. 17-18).

TPACK Standards

Recently, standards have been developed to offer guidelines for thinking about the knowledge mathematics teachers need in order to teach mathematics with technologies (Neiss et al. 2009). The Association of Mathematics Teacher Educators' (AMTE) Technology Committee developed these standards to address the matter of mathematics teachers' TPACK. The standards promote implementation of technology in the context of teaching and learning specifically in mathematics and provide a framework for supporting teacher educators as they prepare mathematics teachers to incorporate technology into their instruction.

The Association for Mathematics Teacher Educators Technology Position Statement states, "Mathematics teacher preparation programs must ensure that all mathematics teachers and teacher candidates have opportunities to acquire the knowledge and experiences needed to incorporate technology in the context of teaching and learning mathematics" (AMTE, 2006). The standards being developed by AMTE's Technology Committee are for use in teacher education programs and offers guidelines for thinking about the TPACK construct. The Mathematics Teacher TPACK standards is a work in progress that changes as new technologies are introduced into mathematics classrooms and as more research examines and describes the use of technology in the teaching and learning of mathematics.

The Mathematics Teacher TPACK Standards set goals for the use of technology for mathematics instruction. The standards do not provide information on how teachers progress through the knowledge needed for using technology strategically when teaching mathematics. Therefore, the survey developed for this research identifies the knowledge of technology displayed by teachers for teaching mathematics.

Addressing Teachers' Beliefs

Research indicates that what a teacher believes affects how they teach and teachers tend to teach the way they were taught (Britzman, 1991; Lortie, 1975; Pajeres, 1992; Grossman, 1990). Teachers tend to draw on their prior knowledge, beliefs, and experiences to interpret and enact reforms; they are likely to “gravitate” toward approaches similar to prior practices (Coburn, 2003, p. 4.). When considering the obstacles teachers have for using technology for mathematics instruction, teacher educators should also consider teachers’ beliefs. Teachers’ beliefs tend to be traditional (Carpenter, Fennema, Franke, & Levi, 2001) and tasks that teachers choose for their students are influenced by their beliefs (Lappan, 2000). Teachers’ attitudes and beliefs toward technology can affect their decision to use technology in the classroom (Spector et al., 2008). Because of the importance of beliefs, mathematics teacher educators need to consider ways to assess beliefs and how to influence positive change in those beliefs. Addressing these beliefs about technology can be done through the use of the survey developed in this research study. When teacher educators are aware of teachers’ beliefs about mathematics and their approach to learning, they can be mindful of these issues when planning for instruction for methods courses or professional development activities. A study by Gado, Ferguson, and van’t Hooft (2006), identified that teachers’ sense of

efficacy or confidence in their abilities were critical in their decision to use technology. The behaviors regarding teachers' incorporating innovative technologies are based in their beliefs and knowledge of mathematics (Brown & Borko, 1992).

Teachers' lack of comfort and lack of knowledge for using technology may lead to reluctance to use technology in their instruction. One concern could be teachers feel their students' knowledge of technology is greater than their own, stifling their confidence and willingness to use technology for instruction. They may also lack knowledge of what technology is available for enhancing mathematics instruction. Perhaps teachers believe they need knowledge of state-of-the art technologies to use them effectively in their instruction. Or they might not be accustomed to learning and teaching in a technology-rich learning environment. Finally, teachers might not feel confident in the skills they hold in order to strategically use technology. Some of these obstacles concern teachers' attitudes and beliefs about learning and teaching, which impact their use of technology. Changing teachers comfort level by addressing their beliefs and attitudes about technology can help strengthen teachers' willingness to adopt more technologies for instruction.

Teachers tend to be "goal-oriented, purposeful organisms" (Zhao & Cziko, 2001, p. 6); meaning they will choose whether to integrate technology in their instructional practices if they recognize the need to do so. In a study by Brown et al. (2007), mathematics teachers should be provided technical support, with the focus on influencing teachers' beliefs, mathematical knowledge, and pedagogical skills (Thompson, 1992). Mathematics teacher educators should encourage teachers to think about what technology and pedagogy might enable a mathematics teacher to better teach a concept to students.

Teachers should consider who their students are, while considering what concept is being taught and connecting technology tools with teaching. Figuring out the parameters in which technologies and tools can be used is what we need to pay more attention to.

The beliefs about mathematics learning have been engrained in teachers during their years of mathematics learning. Mathematics teacher educators must challenge prospective teachers' beliefs about teaching mathematics so that they can let go of teaching the way they were taught.

Teacher Education Programs

Teacher education programs tend to emphasize what traditional teachers do on a daily basis, such as planning lessons, using strategies to convey content, aligning content to standards, and assessing student understanding (Archambault & Crippen, 2009). A study by Archambault and Crippen (2009) found that teachers had knowledge of pedagogy, content, and technology; however, teachers dealt with issues related to pedagogy and content more strongly than dealing with issues of technology. When planning for instruction, teacher educators can consider TPACK and teachers' beliefs to develop courses and professional development opportunities. Technology can interact powerfully with mathematics content and mathematics teacher education programs should prepare teachers to establish pedagogical connections between those affordances of technology and the teaching of mathematics. Rather than helping teachers integrate technology in instruction, teachers should learn how to use technology to transform teaching and create opportunities for student learning. Support should be provided for teachers as they decide why, when, and how to implement technologies into their mathematics classroom instruction.

Belfort and Guimaraes (2004) identified issues where teachers may mistake correct instructional use of technology. Those issues are:

- Emphasis on technology mastery where the mathematics is of secondary importance
- Demonstration of an idea where students are treated as spectators
- Revisiting a mathematical topic to show how it can be done in a simple way where students' role is verification
- Replicating activities from the point of view of current instructional materials, underutilizing the technology's potential
- Fragmented ideas: obtaining a formula as an objective.

Knowledge about technology becomes quickly outdated and becomes obsolete; therefore, teacher education should focus on a way to create an awareness of the range of possible learning activities and know how to choose appropriately among, and effectively implement technology into learning situations (Grandegenett, 2008). The NCTM position paper on technology recognizes that mathematics teachers should “imagine” how new technologies can be used for classroom instruction and involve students in experimentations using the technology tools for learning.

Middle School Mathematics Teachers

The presence of technology in students' lives, in schools and society as a whole, dictates the necessity to accommodate the influence technologies have had on mathematics instruction. As students progress through middle school they are faced with new kinds of numbers, fractions, and decimals that rely on multiplication for their underlying structure. Students need to have opportunities to explore, experiment, and

play with mathematical ideas and concepts (Lappan, 2000). This indicates a need for providing instruction that allows students an opportunity to extend their experiences in mathematics. Technology can provide experiences that influence middle school students' intellectual needs by allowing for new types of classroom interaction and creating an environment where students solve problems with complex data while connecting real world ideas. Technology can also allow students to manage different forms of representations of mathematical relationships, and allow for engagement in dynamic mathematical conjecturing.

Assessment of Mathematics TPACK

Neiss et al. (2009) described a five-stage developmental cycle based on Everett Rogers's (1995) model of innovation-decision process (see Figure 2). This developmental process applies to teachers integrating technologies in teaching and learning mathematics.

1. *Recognizing* (knowledge), where teachers are able to use the technology and recognize the alignment of the technology with mathematics content, yet do not integrate the technology in the teaching and learning of mathematics.
2. *Accepting* (persuasion), where teachers form a favorable or unfavorable attitude toward teaching and learning mathematics with an appropriate technology.
3. *Adapting* (decision), where teachers engage in activities that lead to a choice to adopt or reject teaching and learning mathematics with an appropriate technology.
4. *Exploring* (implementation), where teachers actively integrate teaching and learning of mathematics with an appropriate technology.

5. *Advancing* (confirmation), where teachers evaluate the results of the decision to integrate teaching and learning mathematics with an appropriate technology. (p. 5)

Figure two is a visual provided by AMTE's Technology Committee for considering the levels in which teachers' progress as they develop their knowledge of TPACK. This figure depicts on the left where teachers begin to consider technology in their knowledge of pedagogy and mathematics content.

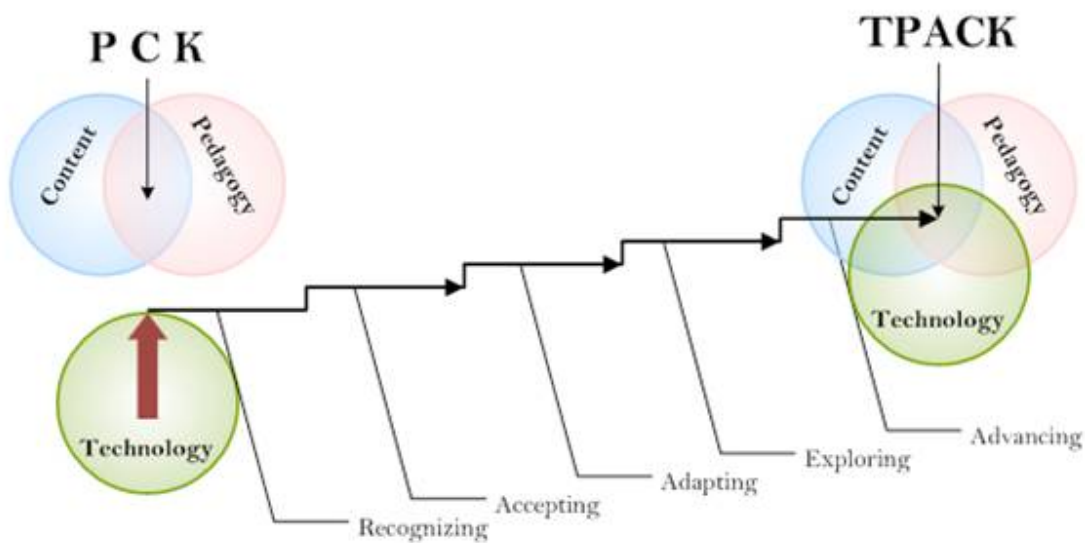


Figure 2 . Teacher levels of thinking and understanding identified by TPACK.

<http://www.citejournal.org/vol9/iss1/mathematics/article1.cfm>

The survey designed for this research study will categorize what level middle school mathematics teachers are at as they adopt the use of technology for mathematics classroom instruction. The survey can be used for teacher educators to capture the progression of mathematics TPACK as teachers integrate technology in instruction.

Chapter Summary

This chapter presents the theoretical framework for TPACK and specific areas for consideration when developing mathematics teachers' TPACK. Using TPACK can shift the emphasis away from focusing on technology itself and toward appropriate application of technologies for mathematics instruction. Although the TPACK framework helps practitioners and researchers understand the relationships between knowledge of content, pedagogy, and technology; there is a need to develop reliable measures for TPACK so that approaches can be developed to improve teachers understanding of the technology needed to teach mathematics (Shin et al., 2009). The M-TPACK survey developed for this research serves as a tool to assess components of the TPACK framework. The development of the Mathematics TPACK survey and the five levels for integrating technology, pedagogy, and content are useful for teacher educators as they prepare mathematics teachers to develop TPACK. The five-stage developmental model is used to categorize the levels as teachers progress in their use of technology for mathematics instruction. Teacher educators should aim to have teachers progress through the levels while they also aim to develop teachers' dispositions, beliefs, and attitudes toward accepting technologies for mathematics instruction. Teachers often challenge integration that is different from the way they learned mathematics; therefore this survey is useful for mathematics teacher educators as they identify the level mathematics teachers are at on

the five-stage developmental model and as they support the use of technology for mathematics classroom instruction.

CHAPTER III

Methodology

The purpose of this study was to develop a survey to measure middle school mathematics teachers' mathematical technological pedagogical content knowledge (M-TPACK). The instrument was created by means of identifying factors that influenced the extent to which middle school mathematics teachers integrate technology in their classroom instruction. The sequential mixed-methods exploratory design was conducted in three phases. In the first phase, quantitative data was collected from the TPACK survey developed by Schmidt et al. (2009). During the second phase, qualitative data was analyzed to identify issues surrounding mathematics TPACK. The pertinent issues were used to adapt questions from Schmidt's et al. (2009) survey to create a new survey to identify teachers' mathematical TPACK. Finally, in phase III, the mathematical TPACK survey was tested for validity and reliability using quantitative methods. In this chapter, I identify the study research questions, participants, instrumentation, data collection, and data analysis procedure.

Research Questions

The questions addressed in this study are:

1. What technological pedagogical content knowledge is identified by middle school mathematics teachers as necessary for strategically teaching mathematics?
2. Will the new survey be reliable and valid for measuring middle school mathematics teachers' MTPACK?

Participants

For all phases of the research, one hundred twenty-nine mathematics teachers from 14 public middle schools located in a single county in Tennessee were invited to participate. In phase I they were asked to complete the existing TPACK survey by Schmidt et al. (2009). In phase II, the teachers were invited to participate in an online interview. Finally, during phase III, the same teachers were asked to complete the newly developed Mathematics TPACK (M-TPACK) survey.

Permission to conduct research was first granted through the Office of Research Compliance Service at the University of Tennessee. Then, the district office was asked for permission to contact the middle school principals (see Appendix D). Once permission was obtained, principals from each middle school were asked to allow survey and interview invitations to be sent via email to all mathematics teachers (see Appendix F). Finally, for all three phases, one hundred twenty-nine teachers from the fourteen middle schools were sent email invitations to participate in the study. The consent forms were included in the TPACK survey, the TPACK interview questions, and the M-TPACK survey.

Instruments

The original TPACK survey used for collecting the first phase of data in this study was titled *Survey of Teachers' Knowledge of Teaching and Technology* (Schmidt et al., 2009). The survey was developed to measure pre-service teachers' understanding about the relationships between technology, content, and pedagogy. This survey was used during phase I of the study to measure middle school mathematics teachers' TPACK.

During phase 2 of the study, nine semi-structured interview questions were developed using information from the existing TPACK (see Appendix B).

The *Survey of Teachers' Knowledge of Teaching and Technology* (Schmidt et al., 2009) initially contained 5 demographic questions and 54 self-report items measuring pre-service teachers' beliefs about teaching and technology. The items used a five point Likert scale to rate the extent to which participants agreed or disagreed with statements about their beliefs on the relationships between technology and teaching. Some items were revised and rewritten because the original survey was specifically developed to measure pre-service teachers TPACK. The survey contained twelve sub-scales because the CK, PK, and TPK scaled consisted of multiple factors. In the original survey, each sub-scale included a minimal number of questions that were content specific, therefore the items including science, social studies, and language were eliminated.

The interview questions were developed to glean information specific to mathematics TPACK. The questions also inquired what technology was available at the participants' schools, what technology was being used, and how the technology was used.

The final M-TPACK survey was developed using items from the original TPACK survey (Schmidt et al., 2009), as well as information gleaned from the interviews and supported by information gathered from the literature study.

Procedures: Data Collection

The research was conducted in three phases. This sequence for data collection first involved collecting quantitative data, then qualitative data, and finally followed by quantitative data. In phase one, the quantitative data was gathered using the existing TPACK survey (Schmidt et al., 2009). Qualitative data was gathered in phase II from

online interviews to explore middle school teachers' mathematics TPACK. This data was gathered from a group of eight middle school mathematics teachers. The results of the online interviews were used to design a closed-ended instrument used for the quantitative phase of the study. The advantage of this approach allowed for identifying measures actually grounded in the data obtained from the online interviews. The goal was to investigate TPACK items specifically related to middle school mathematics instruction and to further develop the existing survey to exclusively measure the TPACK of middle school mathematics teachers. The online interview qualitatively explored mathematics teachers' TPACK while the quantitative survey was used to assess middle school mathematics teachers TPACK. The survey will provide useful information to evaluate what middle school mathematics teachers know about technology for instruction. Cross-sectional survey design will be used to collect data at one point in time about current attitudes, opinions, beliefs, and practices. The research will also assess demographic information such as gender, age, and years of teaching experience.

Online Interview

The online interview was used to capture mathematics TPACK that was either new or replicated from the existing TPACK scale. This information was included in the final survey developed for this research. The interviews were administered to eight middle school mathematics teachers in the participating school district who volunteered to answer open-ended questions. Interviews were administered online using the *SPSS mrInterview* program. An invitation was emailed to participants where they could click on a link to access the interview. The link allowed for an anonymous response.

TPACK Survey

The survey used for this research is adapted from the *Survey of Pre-service Teachers Knowledge of Teaching and Technology* (Schmidt et al., 2009). Schmidt et al. developed the survey to measure preservice teachers' beliefs on the relationships between technology and teaching. Eliminated from the original survey are the content areas of science, social studies, and literature. In the final survey developed for this study, the mathematics content area will be expanded so that the survey may exclusively be used to measure middle school mathematics teachers' TPACK. The adapted survey will include seven content areas including: pedagogical knowledge (PK), content knowledge (CK), technology knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK).

Data Analysis Procedures

Data analysis was conducted in three phases. In phase 1, participants' responses to the existing TPACK survey were analyzed quantitatively to gain an understanding of the general knowledge. In phase 2, eight participants were interviewed. Their responses to the semi-structured interview on use of technology that influences classroom mathematics instruction was examined qualitatively. The information obtained from the interviews was used to modify the existing TPACK survey. The modified mathematics TPACK survey contains seven areas [pedagogical knowledge (PK), content knowledge (CK), technology knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and

technological pedagogical content knowledge (TPACK)] which were analyzed quantitatively in phase 3.

Descriptive statistics was used to describe the sample demographics and to answer the research questions. This is an appropriate method of analysis when used for an initial investigation into a research problem. Descriptive statistics include the frequencies and percentages, as well as the means and standard deviations. For categorical or nominal data, frequencies and percentages were conducted. Means and standard deviations were carried out on interval/ratio data (Howell, 2010). Frequency refers to the number of participants that fit into a certain category. Percentage refers to the percent of the sample that coincides with that category. Means and standard deviations were carried out on interval/ratio data. The arithmetic mean of the variables is defined as the sum of the scores divided by the number of scores. Standard deviation measures the spread of values in a set of data, otherwise known as the statistical dispersion. If the data points are valued close to the mean value, then the standard deviation is close to zero, and does not deviate much from the norm (Howell, 1992).

Exploratory Factor Analysis

An exploratory factor analysis (EFA) was planned on the TPACK mathematics and technology survey items to produce a seven factor solution that closely matches the variables that were to be considered in the research problems to follow. EFA provides analysis of a large number of variables to show which hang together as a group, or which are answered most similarly by participants (Leech, Barrett & Morgan, 2005). This type of analysis is appropriate when underlying constructs are suspected. In this analysis, seven constructs were suspected. To conduct this analysis, all items from the mathematics

TPACK survey were to be entered as factors into the factor analysis and high loadings of clustered items defined the seven separate constructs.

After the factors were confirmed, Cronbach's alpha was to be calculated to assess the reliability and internal consistency of the TPACK survey subscales. Also known as the coefficient alpha, the Cronbach's alpha provides the mean correlation between each pair of items and the number of items in a scale (Brace, Kemp & Snelgar, 2006). George and Mallery (2003) suggest the following rules of thumb for evaluating alpha coefficients, > .9 Excellent, > .8 Good, > .7 Acceptable, > .6 Questionable, > .5 Poor, < .5 Unacceptable.

Research Question 1

RQ1: For the interviewed middle school mathematics teachers, what themes are found regarding the use of technology that influences classroom mathematics instruction?

To examine research question 1, the interview responses were examined. Information obtained from a qualitative review of the interview responses were presented to two unique raters who endorsed whether or not each of the themes or items were present or absent in each of the excerpts.

Research Question 2

RQ2: To what extent are the mathematical TPACK knowledge subscales (pedagogical, content, technology, pedagogical content, technological content, technological pedagogical, and technological pedagogical content) present in the sample of middle school mathematics teachers?

H2_o: The mathematical TPACK knowledge subscales (pedagogical, content, technology, pedagogical content, technological content, technological pedagogical, and technological pedagogical content) present in the sample of middle school mathematics teachers do not differ significantly from the hypothesized population mean.

H2_a: The mathematical TPACK knowledge subscales (pedagogical, content, technology, pedagogical content, technological content, technological pedagogical, and technological pedagogical content) present in the sample of middle school mathematics teachers differ significantly from the hypothesized population mean.

To examine research question 2, seven one-sample t-tests were used to compare the seven knowledge subscales to a hypothesized population mean of 3.0 (neutral response). Participants rated their level of agreement to the knowledge specific questions on a 5-point Likert-type scale: 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). The one sample t-test is an appropriate statistical analysis when the extent of a research question is to assess if differences exist on a sample mean score as compared to population mean or known value (Morgan et al., 2007). The t-test was two tailed, with alpha levels, or the probability of rejecting the null hypothesis when it is true, set at $p < 0.05$ and will ensure a 95% confidence that differences did not occur by chance. Given an alpha set at 0.05, significant findings are revealed when a calculated t-value is larger than the critical t-value after taking into account degrees of freedom (df) for one sample ($N - 1$). When significance is revealed the null (H_o) is rejected and the alternative hypothesis (H_a) is accepted.

Sample Size, Power and Significance

In research, it is important to establish a priori the sample size necessary for the statistical analysis with considerations of power, population effect size, and level of significance (Cohen, 1992b). Cohen (1992b) wrote:

Statistical power analysis exploits the relationships among the four variables involved in statistical inference: sample size (N), significance criterion (α), population effect size (ES), and statistical power. For any statistical model, these relationships are such that each is a function of the other three. For example, in power reviews, for any given statistical test, we can determine power for given α , N , and ES . For research planning, however, it is most useful to determine the N necessary to have a specified power for given α and ES (p. 99).

Determination of an acceptable significance level for deciding when to reject the null hypothesis (i.e., the probability of committing a Type I error) is important. The standard values for significance level represented by α are set at 10%, 5%, and 1% (Aczel & Sounderpandian, 2006). An $\alpha = .05$ corresponds to $(1 - \alpha) = 0.95$ probability of a correct statistical conclusion when the null hypothesis is true (Lipsey, 1990). A .95 probability is equivalent to a 95 % confidence level to reject H_0 (Aczel & Sounderpandian, 2006). For the purpose of the proposed research, the level $\alpha = .05$, the most commonly designated value in social science research for this parameter, is used for the analysis (Lipsey, 1990).

The power of significance test is the probability of rejecting the null hypothesis when the null hypothesis is false. An acceptable level of power for the proposed study is .80, making the Type II error four times as likely as the Type I error. Since it is typically

more serious to make a false positive claim than it is to make a false negative claim, .80 is an acceptable level and will be considered in determining the sample size a priori (Cohen, 1992a).

According to Cohen (1992a), effect sizes for a t-test are small if they are .20, medium if they are .50, and large if they are .80. In choosing an effect size, researchers decide how small a difference they are willing to accept and still find the results worthwhile. To allow a very small effect size, a large sample is required, and to allow a large effect size, a small sample is required. The power of a test is proportionate to the sample size with greater power from a larger effect size. A medium effect size is appropriate for the proposed study and will be used in the determination of the sample size. Considering the medium effect size of .50, a generally accepted power of .80, and a .05 level of significance, the necessary sample size to achieve empirical validity for the proposed study is a total of 64 participants (Cohen, 1992a).

Chapter IV

Introduction

The purpose of this study was to develop a survey to measure middle school mathematics teachers' mathematical technological pedagogical content knowledge (M-TPACK). The instrument was created by means of identifying factors that influenced the extent to which middle school mathematics teachers integrate technology in their classroom instruction. The sequential mixed-methods exploratory design was conducted in three phases. In the first phase, quantitative data was collected from the existing TPACK survey (Schmidt et al., 2009). During the second phase, semi-structured online interview data was analyzed quantitatively and qualitatively to identify issues surrounding mathematics TPACK. The pertinent issues were used to adapt questions from Schmidt's et al. (2009) survey to create new questions used for a survey identifying teachers' mathematical TPACK, or M-TPACK. Finally, in phase 3, the M-TPACK survey was tested for validity and reliability using quantitative methods.

The following questions were used to address the study:

1. What technological pedagogical content knowledge is identified by middle school mathematics teachers as necessary for strategically teaching mathematics?
2. Will the survey developed be a reliable and valid tool for measuring middle school mathematics teachers' technological pedagogical content knowledge (M-TPACK)?

The previous chapter described the research design and methodology applied to this study. Techniques for selecting the study sample and linking the methodology to the

research questions were also described. Chapter IV presents the results from this study. The results are organized in three sections. The first section contains results from the existing TPACK survey which measures teachers' technological pedagogical content knowledge. The second section describes findings from the semi-structured online interview which was taken from middle school mathematics teachers. Some examples of participants' statements are used to illustrate their perspectives. The final section describes the newly developed Mathematics TPACK (M-TPACK) survey used to measure middle school mathematics teachers' mathematical technological pedagogical content knowledge and the results for validity and reliability.

Methodology Summary

Quantitative data were obtained from two surveys and qualitative data obtained from semi-structured online interviews. All data were collected and analyzed through an online program using *SPSS mrInterview (Standard) version 4.0*.

Some questions in the *Survey of Teachers' Knowledge of Teaching and Technology* (Schmidt et al., 2009) were not appropriate for the sample of teachers used in this study. The survey was originally designed to measure preservice elementary teachers TPACK. Questions addressing other content areas such as science, social studies, and literature were eliminated from the survey in order to measure the middle school mathematics teachers' general TPACK. The purpose for using the existing TPACK survey during this study was to provide a gain in perspective of participants' TPACK. Using the information learned from the first TPACK survey, along with data gathered from semi-structured online interviews, some items were reworded to ask mathematics specific questions and new questions were added to the M-TPACK survey in order to

retain the seven subscales. More questions were developed using Grandgenett's (2009) description of mathematics teachers who demonstrate strong TPACK.

The following questions were included in the first TPACK survey, but were eliminated from the newly developed M-TPACK survey in order to create a more succinct survey: (labels indicate the subscale for each item)

- I frequently play around with new technology (TK)
- I can adapt my teaching based-upon what students currently understand or do not understand (PK).
- I am familiar with common student understandings and misconceptions (PK).
- I know how to organize and maintain classroom management (PK).
- I can choose technologies that enhance the content for a lesson (TPACK).

The following questions were adjusted from the existing TPACK survey to be mathematics specific in the newly developed M-TPACK survey.

- I can choose technologies that enhance the teaching approaches for a mathematics lesson (TCK).
- I am thinking critically about how to use technology in my mathematics classroom (TCK).

The following questions were newly added to the M-TPACK survey to address characteristics Grandgenett describes of teachers with strong backgrounds in TPACK (2009).

- I am comfortable and optimistic about changes in advances with technology (TPACK).

- I am open to experimentation with new technologies for mathematics teaching and learning (TPK).
- I make connections with students as to why technology is useful for certain mathematics problems (TCK).
- I am able to focus on the mathematics while taking advantage of instructional opportunities offered by technology (PK).
- I allow students to use technology for assessment as it parallels instruction (TPK).
- When I approach mathematics instruction with technology, I know where students are conceptually, what they need to achieve, and how to proceed (PK).

The following question was added to the M-TPACK survey address teachers' beliefs about student learning and instruction in mathematics:

- Teachers should teach exact procedures for students as they use calculators (PCK).

Information gleaned from the semi-structured online interviews was considered when developing new survey items.

Participants

This study began in February 2010, with an invitation emailed to a total of 129 middle school mathematics teachers. The middle school mathematics teachers teach in a single county in East Tennessee. Permission to conduct research was first granted through the Office of Research Compliance Service at the University of Tennessee. Next, the district office was asked for permission to contact the participating middle school principals (see Appendix D). Once permission was obtained, principals from each middle school were asked to allow survey and interview invitations to be sent via email to all

mathematics teachers (see Appendix E). Finally, for all three phases of the research, one hundred twenty-nine teachers from the fourteen middle schools were sent email invitations to participate in the study (see Appendix F). During phase 1, twenty-one participants agreed to complete the existing TPACK survey. For phase 2, eight participants completed the semi-structured online interviews. Finally in phase 3, twenty-eight participants completed the newly developed M-TPACK survey.

When the email invitation was sent during phase 1, there was an invitation included to participate in a personal semi-structured interview. Only one willing participant responded to the invitation asking for a face-to-face interview; therefore, a decision was made to send the semi-structured interview questions using the *mrInterview* SPSS online service. Permission was granted from the Office of Research Compliance Service at the University of Tennessee to adjust the procedure for collecting qualitative data from personal interviews to online interviews. This allowed for more willing participants to complete the interview during their own time and at any location where access to the internet was available.

Results

Research was conducted in three phases. In phase 1, participants' responses to the existing TPACK survey were analyzed quantitatively to gain an understanding of the general knowledge. In phase 2, eight participants were interviewed through a semi-structured questionnaire that was administered online. The interview results on use of technology that influences classroom mathematics instruction were examined quantitatively and qualitatively. The information obtained from the interviews was used to modify the existing TPACK survey. The modified TPACK mathematics and

technology survey containing seven content areas [pedagogical knowledge (PK), content knowledge (CK), technology knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK] was analyzed quantitatively in phase 3.

Phase 1

Twenty-one participants completed the existing TPACK survey for the first phase of this project, of these, 19 (90.5%) participants were female and 2 (8.0%) were male. The majority of participants (8, 38.1%) had taught for more than 20 years. Frequency and percentages for gender and years of teaching experience are presented in Table 1. For age, the minimum age was 23 and the maximum age was 64 ($M = 42.70$, $SD = 12.24$). Means and standard deviations for age are presented in Table 2.

Table 1

Characteristics of Participants TPACK Survey

Characteristic	<i>n</i>	%
Gender		
Male	2	9.5
Female	19	90.5
Years of teaching experience		
0 to 2 years	3	14.3
3 to 5 years	3	14.3
6 to 10 years	4	19.0
11 to 20 years	3	14.3
20 or more years	8	38.1

Table 2

Means and Standard Deviations for Participants Age TPACK

Variable	<i>n</i>	<i>M</i>	<i>SD</i>
Participant age	20	42.70	12.24

Reliability

Cronbach's alphas for the research variables are presented in Table 3. The alpha coefficients include: Technology Knowledge ($\alpha = .921$); Content Knowledge ($\alpha = .612$); Pedagogical Knowledge ($\alpha = .908$); Pedagogical Content Knowledge ($\alpha = .825$); and TPACK ($\alpha = .782$). George and Mallery (2003) suggest the following rules of thumb for evaluating alpha coefficients, $> .9$ Excellent, $> .8$ Good, $> .7$ Acceptable, $> .6$ Questionable, $> .5$ Poor, $< .5$ Unacceptable. The alpha results indicate the internal consistency of the scales were generally excellent to good. The exception was in Content Knowledge which was questionable with $\alpha = .612$. Alpha coefficients are not provided for two subscales (Pedagogical Content Knowledge and Technological Content Knowledge) because the scales were comprised of fewer than two items.

Participants' responses to the existing TPACK survey were analyzed quantitatively to gain an understanding of the general knowledge. Seven one-sample *t*-tests were conducted to compare the seven knowledge subscales to a hypothesized population mean of 3.0 (neutral response). Participants rated their level of agreement to the knowledge specific questions on a 5-point Likert-type scale: 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree) and 5 (strongly agree). All *t*-test analyses

Table 3

Cronbach's Alpha for TPACK Research Variables

TPACK Research Variables	α	Items
Technology Knowledge	.921	7
Content Knowledge	.612	3
Pedagogical Knowledge	.908	7
Pedagogical Content Knowledge	--	1
Technological Content Knowledge	--	1
Technological Pedagogical Knowledge	.825	4
TPACK	.782	4

revealed significant differences, suggesting that participant's responses were different from the hypothesized mean of 3.0. Investigation of those individual means show participants tended to agree or strongly agree with the knowledge items. Results for the seven one sample *t*-tests are presented in Table 4.

A one sample *t*-test was conducted to assess if participant's scores on Technology Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(20) = 3.13, p = .005$, suggesting that participants who took the TPACK scored higher than the median value on Technology Knowledge ($M = 3.54, SD = 0.79$).

A one sample *t*-test was conducted to assess if participant's scores on Content Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(20) = 13.152, p < .001$, suggesting that participants who took the TPACK scored higher than the median value on Content Knowledge ($M = 4.27, SD = 0.10$).

A one sample *t*-test was conducted to assess if participant's scores on Pedagogical Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(20) = 12.48, p < .001$, suggesting that participants who took the TPACK scored higher than the median value on Pedagogical Knowledge ($M = 4.27, SD = 0.47$).

A one sample *t*-test was conducted to assess if participant's scores on Pedagogical Content Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(20) = 10.66, p < .001$, suggesting that participants who took the TPACK scored higher than the median value on Pedagogical Content Knowledge ($M = 4.20, SD = 0.52$).

A one sample *t*-test was conducted to assess if participant's scores on Technological Content Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(20) = 3.57, p = .002$, suggesting that participants who took the TPACK scored higher than the median value on Technological Content Knowledge ($M = 3.67, SD = 0.86$).

A one sample *t*-test was conducted to assess if participant's scores on Technological Pedagogical Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(20) = 6.30, p < .001$, suggesting that participants who took the TPACK scored higher than the median value on Technological Pedagogical Knowledge ($M = 3.79, SD = 0.57$).

A one sample *t*-test was conducted to assess if participant's scores on TPACK differed significantly from the median value of 3.0. The results were statistically

significant, $t(20) = 5.84, p < .001$, suggesting that participants who took the TPACK scored higher than the median value on TPACK ($M = 3.70, SD = 0.55$).

Phase 2

To investigate research question 1, the semi-structured interview responses were examined to understand how middle school mathematics teachers used technology in classroom mathematics instruction. Eight participants were interviewed through an online semi-structured questionnaire (see Appendix B). The interview results on use of technology that influence classroom mathematics instruction were examined qualitatively and quantitatively. Information obtained from a qualitative review of the interview responses was presented to two unique raters who endorsed whether or not each of the

Table 4

One Sample t-Test on TPACK Subscales

TPACK Subscale	Participants				
	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i>
Technology Knowledge	3.54	0.79	20	3.13	.005
Content Knowledge	4.27	0.44	20	13.15	.000
Pedagogical Knowledge	4.27	0.47	20	12.48	.000
Pedagogical Content Knowledge	4.19	0.51	20	10.66	.000
Technological Content Knowledge	3.67	0.86	20	3.57	.002
Technological Pedagogical Knowledge	3.79	0.57	20	6.30	.000
TPACK	3.70	0.55	20	5.84	.000

themes or items was present or absent in each of the excerpts. A quantitative analysis was conducted to determine the frequency of the items reported. A summary of the qualitative findings is presented by interview question type.

Table 5 presents the technology items teachers identified for each interview question by each rater. For the currently available technologies offered by the school, mathematics teachers reported the computer lab and calculators (62.5%) and SmartBoards (50%) predominantly. Classroom internet access, cameras, ActiveInspire and Individual White Boards were less common (12.5%). For mathematics instruction, teachers reported the use of calculators (62.5%) as the predominant technology, followed by SmartBoards to present lessons (50%). TV, ActiveInspire, cameras and Study Island were less common (12.5%). For assessment, teachers reported fewer uses of technology. Few (12.5%) used spreadsheets and an electronic gradebook for recording student scores. Some permitted students to use technology on tests, including calculators and graphing calculators (25%). Technology was used for communication purposes among all respondents. The majority (62.5%) used email to communicate with parents, students, and colleagues, while half (50%) used their classroom website to communicate with students, parents and others. Some used technology for other purposes, including sending homework to absent students, record student behavior online for staff and faculty to view, and posting student grades (12.5%).

The majority (50%) of teachers felt confident in their ability to use technology, while some wanted additional training (25%) and reported no time for additional training (25%). One participant reported being “not on top of things.” For supports, more training

was reported by most (62.5%), while time, equipment, and specific hands-on training was reported by 25%.

Teachers reported a number of technology item requests, including graphing calculators and classroom computers (25%), SmartBoards, Activotes/ActiveSlate, cameras, clickers, Study Island and Excel (12.5%). The technology resources they felt would meet their needs included classroom computers and graphing calculators (25%), laptop computer for the classroom, more time, access and strategies (12.5%). Regarding training, 37.5% reported they had no access to technology training, while (25%) reported access through county training sessions or occasional training sessions at their site. One participant noted training was available at their school whenever a need arose.

Based on the online interview responses, information was gained in several areas. This included the types of technology available to middle school mathematics teachers; how the teachers use the technology for mathematics instruction, assessment, and communication; their level of confidence in using the technology, the level of support provided for training and desire for more training; and additional technology needed.

Table 5

Frequency and percentages of Interview Items by Rater (1 vs. 2)

Interview Item	Items Identified	Rater 1		Rater 2	
		N	%	N	%
1. What technology is available at your school for you to use for mathematics instruction?	Smart Boards	4	50.0	4	50.0
	Clickers	2	25.0	2	25.0
	Computers	2	25.0	2	25.0
	Computer Lab	5	62.5	4	50.0
	Internet access	1	12.5	1	12.5
	Cameras	1	12.5	1	12.5
	Calculators	5	62.5	5	62.5
	Overhead Projector	1	12.5	1	12.5
	Active Inspire	1	12.5	1	12.5
	Individual White Boards for students	1	12.5	1	12.5
2. How do you use technology for the purpose of effective mathematics instruction?	Smart Boards to present lessons	4	50.0	4	50.0
	TV to show textbook CDs	1	12.5	1	12.5
	Computer Lab	2	25.0	2	25.0
	Cameras	1	12.5	1	12.5
	Calculators	5	62.5	5	62.5
	Active Inspire flipcharts	1	12.5	1	12.5
	Study Island	1	12.5	1	12.5
3. How do you use technology for the purpose of assessment?	Use spreadsheet program for scores	1	12.5	1	12.5
	Gradebook	1	12.5	1	12.5
	Allow use of calculator	2	25.0	2	25.0
	Allow use of graphing calculator	2	25.0	2	25.0
	On-line assessments of students	1	12.5	1	12.5
	Website for quizzes	1	12.5	1	12.5
	Study Island	1	12.5	1	12.5
	Do not use	2	25.0	2	25.0

Table 5 Continued

Interview Item	Items Identified	N	%	N	%
4. How do you use technology for the purpose of communication? Please provide examples (colleagues, parents, etc)	Email to communicate with parents, students, team members, staff, administrators & colleagues	5	62.5	5	62.5
	Email to send assignment to absent students	1	12.5	1	12.5
	School fusion allows students access at home to complete assignments/homework	1	12.5	1	12.5
	Classroom website to post announcements, assignments, upcoming tests/quizzes, objectives, web links, and showcase work and information.	4	50.0	4	50.0
	Online record of student behavior for teachers and administrators to view/edit	1	12.5	1	12.5
	Post grades on computer and print out for parents/students.	1	12.5	1	12.5
5. Describe your confidence in your ability to use technologies for mathematics instruction.	Confident	4	50.0	4	50.0
	Comfortable	1	12.5	1	12.5
	Not on top of things, but know how to use what I have	1	12.5	1	12.5
	Want additional training	2	25.0	2	25.0
	No time for additional training	2	25.0	2	25.0
6. What support do you need to use technology more often for mathematics instruction?	Time	2	25.0	2	25.0
	Technology/more equipment	2	25.0	2	25.0
	More training	5	62.5	5	62.5
	Hands-on-training	2	25.0	2	25.0
7. What additional technology resources are needed to meet the needs of students?	Activotes/ActiveSlate	1	12.5	1	12.5
	Graphing calculators	2	25.0	2	25.0
	Smart Boards	1	12.5	1	12.5
	Computers in classroom	2	25.0	2	25.0
	Cameras (digital, video and document)	1	12.5	1	12.5
	Clickers	1	12.5	1	12.5
	Study Island	1	12.5	1	12.5
	Excel	1	12.5	1	12.5
	Don't know	1	12.5	1	12.5

Table 5 Continued

Interview Item	Items Identified	N	%	N	%
8. How can technology resources be used to meet your needs as a teacher?	Laptop for classroom	1	12.5	1	12.5
	Computers in classroom	2	25.0	2	25.0
	Graphing calculators	2	25.0	2	25.0
	More resources/more training	1	12.5	1	12.5
	Time	1	12.5	1	12.5
	Access	1	12.5	1	12.5
	Use more strategies	1	12.5	1	12.5
9. What hands-on training in the use of technology is available at your school?	Whatever is needed, training in groups	1	12.5	1	12.5
	All through county training sessions	2	25.0	2	25.0
	Few/occasional	2	25.0	2	25.0
	None	3	37.5	3	37.5

Types of Technology Available

Participants provided a variety of responses, where the majority had access to SmartBoards, school computer labs and calculators. Clickers were mentioned by several participants, which one participant described as an “automatic recording device for students to answer and have data automatically recorded on screen (clickers).” One participant reported having access to a “flat screen TV with Active Inspire on computer.” Several teachers were specific in reporting types of calculators they used, including TI-73 calculators, TI-83 calculators, TI-130XS calculators, and graphing calculators. One participant mentioned the use of flip video cameras and digital cameras, while another referred to having a document camera.

Teacher’s Use of Technology for Mathematics Instruction

Again, SmartBoards and calculators were cited by several participants. One teacher described the use of technology for “demonstration purposes” while another

stated technology was use “to visually enhance lessons and encourage interactive participation.”

SmartBoards were used to present lessons and interact with students. One participant stated, “I create flipcharts with my Activeboard for instruction each day. This enables me to be prepared for class, allows students to come up to the board in an interactive capacity, and lets me design lessons that have interactive pieces to support my objectives.” Another stated, “(the) SmartBoard is used for PowerPoint presentation s, streaming videos, and hands on activities.”

Calculators were used by students for calculations. One participant stated, “(the) graphing calculator is used to enhance the skills that are being presented.” Another specified that the TI-83 was used “after written content mastery.”

Other technology use included online skill practice via the school’s computer lab or a classroom web demonstration presented via a television. One participant stated, “We have gone to the computer lab on several occasions to visit math websites and use Study Island as a review for TCAPS.”

Teacher’s Use of Technology for Assessment

Teacher responses on assessment varied depending upon the way in which the question was interpreted. Teachers who interpreted the question based on their assessment of student performance described the use of spreadsheet programs and online gradebooks for tracking student performance. Those that interpreted the item specific to student assessment reported the use of calculators, graphing calculators, and online assessments by students.

Teacher's Use of Technology for Communication

Email correspondence was mentioned by most participants who used the technology to communicate with parents, students, staff, colleagues and administrators. This tool was used for general communication, discussing student progress, and sending assignments to absent students.

Classroom websites were used by some who posted homework assignments, class objectives, and important information, including upcoming tests/quizzes. One participant describes the website as a “place to showcase current work and information for parents.” Another stated “I update my class page daily with assignments and have a variety of websites linked for students.”

Confidence in Ability to Use Technology for Mathematics Instruction

The majority of teachers expressed general confidence in their ability to use the technology available to them. Two participants identified a lack of time for gaining additional training to incorporate technology, and one stated, “...with the explosion of technology I can’t say I am on top of it all! I know how to use what I have, and am always trying to learn better and more effective uses of our resources.”

Type of Support Needed to Incorporate More Technology into Instruction

Time and additional training were the primary responses by participants. One participant stated, “I need to be able to have breaks from teaching and meetings so that I can take time to learn about technology.” Others noted the need for support gained from specific hands-on training, including “subject specific technology training.” One participant stated, “I am able to understand specific strategies in terms of technology, but it is often difficult to incorporate them into my classroom content.”

Additional Technology Resources to Meet the Needs of Students

Participants identified technology items when asked about additional resources. These items included in-classroom computers, and specific materials such as Activotes and ActiveSlate, SmartBoards, clickers, and graphing calculators. While some participant's schools had these materials available, their preference was for additional items, such as items for all students in their classroom. One participant stated, "We also have a new system with the individual "clickers" for students to record answers. How cool to have that for my classroom. Again, with two for the school, it is difficult to get on the list to check one out."

Technology Resources Used to Meet the Needs of the Teacher

Several participants identified more resources and training to assist them in being more effective at teaching mathematics using technology. Some participants reported specific needs, for example, "I would like to have a laptop in my classroom so that I can take attendance, check e-mail, and e-mail parents in a timely manner...Using the technology in my classroom also helps me to better communicate with parents, coworkers, and administrators." Two participants reported that individual student computers for the entire class would be helpful," and one further clarified "so students can explore more (such as virtual manipulatives) rather than watch me demonstrate topics."

Availability of Hands-on Training

Training availability varied among participants; some had limited access whereas others reported more opportunities. The opportunity to attend countywide training sessions and workshops was a common response. Most participants did not have personal

access to training at their particular school, but three reported their school provided after-school workshops. One participant identified the use of the “fusion” website for training purposes. Another participant identified a technology trainer at the school that “trains groups as technology becomes available.”

Phase 3

Phase 3 of the research study involve quantitative examination of the revised TPACK survey that included mathematics specific questions. Twenty-eight participants completed the Mathematics TPACK (M-TPACK) survey. Of these, 23 (82.1%) participants were female and 5 (17.9%) were male. The majority of participants (12, 42.9%) had taught for more than 20 years. Frequency and percentages for gender and years of teaching experience is presented in Table 6. For age, the minimum age was 27 and the maximum age was 64 ($M = 45.86$, $SD = 10.64$). Means and standard deviations for age are presented in Table 7.

Table 6

Characteristics of Participants

Characteristic	<i>n</i>	%
Gender		
Male	5	17.9
Female	23	82.1
Years of teaching experience		
3 to 5 years	3	10.7
6 to 10 years	7	25.0
11 to 20 years	6	21.4
20 or more years	12	42.9

Table 7

Means and Standard Deviations for Participant Age

Variable	<i>n</i>	<i>M</i>	<i>SD</i>
Participant age	28	45.86	10.64

Reliability

The a priori plan for the analysis included an exploratory factor analysis (EFA) of the data obtained from the Mathematics TPACK (M-TPACK) to produce a factor solution for the revised survey. However, in order to conduct an EFA, a sample of at least 200 participants is required. Given the final sample contained 28 participants, the EFA was not practical.

Cronbach's alpha was conducted to assess reliability and internal consistency of the M-TPACK subscales. The final version of the M-TPACK was comprised of seven subscales; seven Cronbach's alphas were conducted for the research variables and are presented in Table 3. The alpha coefficients include: Technology Knowledge ($\alpha = .877$); Content Knowledge ($\alpha = .847$); Pedagogical Knowledge ($\alpha = .713$); Pedagogical Content Knowledge ($\alpha = .628$); Technological Content Knowledge ($\alpha = .892$); Technological Pedagogical Knowledge ($\alpha = .347$); and TPACK ($\alpha = .819$). George and Mallery (2003) suggest the following rules of thumb for evaluating alpha coefficients, $> .9$ Excellent, $> .8$ Good, $> .7$ Acceptable, $> .6$ Questionable, $> .5$ Poor, $< .5$ Unacceptable. The alpha results indicate the internal consistency of the scales were generally good to acceptable. The exception was in Pedagogical Content Knowledge which was questionable with $\alpha = .628$ and Technological Pedagogical Knowledge which was poor at $\alpha = .348$. Table 8 presents the Cronbach's Alpha results.

Table 8

Cronbach's Alphas for Research Variables

Research Variables	α	Items
Technology Knowledge	.877	6
Content Knowledge	.847	3
Pedagogical Knowledge	.713	5
Pedagogical Content Knowledge	.628	4
Technological Content Knowledge	.892	5
Technological Pedagogical Knowledge	.347	3
TPACK	.819	5

Research Question 2

To examine research question 2, seven one-sample *t*-tests were conducted to compare the seven knowledge subscales to a hypothesized population mean of 3.0 (neutral response). Participants rated their level of agreement to the knowledge specific questions on a 5-point Likert-type scale: 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree); 5 (strongly agree). Results for the six one sample *t*-tests are presented in Table 9.

Table 9

One Sample t-Test on M-TPACK Subscales

Math TPACK Subscale	Participants				
	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i>
Technology Knowledge	3.54	0.73	27	3.92	.000
Content Knowledge	4.48	0.50	27	15.61	.000
Pedagogical Knowledge	3.99	0.48	27	10.93	.000
Pedagogical Content Knowledge	4.06	0.48	27	11.73	.000
Technological Content Knowledge	3.80	0.67	27	6.29	.000
Technological Pedagogical Knowledge	3.92	0.57	27	8.494	.000
TPACK	3.66	0.72	27	4.86	.000

A one sample *t*-test was conducted to assess if participant's scores on Technology Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 3.92, p < .001$, suggesting that participants who took the M-TPACK scored higher than the median value on Technology Knowledge ($M = 3.54, SD = 0.74$).

A one sample *t*-test was conducted to assess if participant's scores on Content Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 15.61, p < .001$, suggesting that participants who took the M-TPACK scored higher than the median value on Content Knowledge ($M = 4.48, SD = 0.50$).

A one sample *t*-test was conducted to assess if participant's scores on Pedagogical Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 10.93, p < .001$, suggesting that participants who took the M-TPACK scored higher than the median value on Pedagogical Knowledge ($M = 3.99, SD = 0.48$).

A one sample *t*-test was conducted to assess if participant's scores on Pedagogical Content Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 11.73, p < .001$, suggesting that participants who took the M-TPACK scored higher than the median value on Pedagogical Content Knowledge ($M = 4.06, SD = 0.48$).

A one sample *t*-test was conducted to assess if participant's scores on Technological Content Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 6.29, p < .001$, suggesting that

participants who took the M-TPACK scored higher than the median value on Technological Content Knowledge subscale ($M = 3.80$, $SD = 0.67$).

A one sample t -test was conducted to assess if participant's scores on Technological Pedagogical Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 8.50$, $p < .001$, suggesting that participants who took the M-TPACK scored higher than the median value on Technological Pedagogical Knowledge ($M = 3.92$, $SD = 0.57$).

A one sample t -test was conducted to assess if participant's scores on Technological Pedagogical Knowledge differed significantly from the median value of 3.0. The results were statistically significant, $t(27) = 4.86$, $p < .001$, suggesting that participants who took the M-TPACK scored higher than the median value on Technological Pedagogical Knowledge subscale ($M = 3.66$, $SD = 0.72$).

Summary

In summary, this chapter described development of the M-TPACK survey and the data analysis from the three phases of data collection. The data analysis provided detailed insight to the participants' interview responses regarding role of technology for mathematics instruction. Data analysis also included demographic information and reliability measures gathered from the TPACK and M-TPACK surveys.

The final chapter will address the data that assisted in exploring elements within the M-TPACK subscales and the participants' responses during the semi-structured online interview. The final chapter will also speak to insights constructed from the literature review, as well as contributions of the study and possible future research needs based on the findings of the study.

Chapter V

Introduction

Technology is a ubiquitous part of every modern child's life. As students express an interest in using more technology to assist learning in school, educators are scrambling to make innovative use of technological tools for learning. Teachers' understanding the lives of children with respect to technology is different in the ways they may have encountered technology. Experiences with, and attitudes toward, technology are not the same for teachers as they are for the students they are teaching; causing a divide between generations with respect to digital technologies (AACTE, 2008). As young people tend to be "natives" to the digital world, adults deal with digital technologies as "immigrants" (Prensky, 2001). Prensky suggests that "if Digital Immigrant educators really want to meet Digital Natives – i.e. all their students – they will have to change" (p.6).

The teachers in this study indicated having access to technologies such as interactive whiteboards, computer labs, and other high-quality, multi-media materials; yet they shared a concern that they lacked knowledge for strategically using the technology for mathematics instruction. Though the availability of technologies have changed the dynamics of the classroom, it is important to consider the potential for using technologies to make innovative gains in mathematics instruction. Responses to the interview questions indicated the teachers in this study tend to use technology for demonstrative purposes rather than purposes for mathematical instruction. Data from the M-TPACK interviews indicate some of the barriers or needs teachers have for using technology more strategically in their instruction.

Summary of Results

In the past, teacher education has consisted primarily of learning about various technology tools and resources. Teacher educators have focused on technology as a discrete object, rather than applying strategic use of technology for instruction. The TPACK framework provides mathematics teachers a venue for enhancing instruction using technology. The framework also helps researchers reason about the relationship among content, pedagogy, and technology. Considering the mathematics TPACK standards developed by Niess et al (2009), and the views of the participants' perspectives, theories are generated for technology instruction in mathematics instruction. The survey designed for this study was used to capture the mathematics TPACK of teachers.

During the first phase of the study, the existing TPACK survey measuring teachers' general knowledge was given to middle school mathematics teachers. The survey was divided into seven subscales: pedagogical knowledge (PK), content knowledge (CK), technology knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). Scores on the subscales indicate teachers' strengths were in knowledge of pedagogy and content (PK, CK), but weak in technology knowledge (TK). This weakness was also indicated across the subscales technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK. In phase 3 of the study, scores on the M-TPACK survey indicated a similar trend by teachers' showing strength in content and pedagogical knowledge, but not so much using technology for content and pedagogy.

During phase 2 of the study, teachers described how they used technology. One teacher indicated in the interview response that she had the ability to understand how to use technology, but found it difficult to incorporate the technologies into class content. Teachers have access to technologies but they claim to have had little training in how to use the technology for mathematics instruction. This indicates teachers have the confidence and willingness to use technology for mathematics instruction but lack the knowledge of how the technology could be used for instruction. Another teacher indicated she had access to clickers but there were so few at her school that she had difficulty “getting on the list to check one out”. When technology is available, but not easily accessible, this poses another problem. Interview results also indicated teachers often use technology for classroom management, correspondence with students and parents, and even allowing students to use graphing calculators “to enhance skills being presented” and “after written content mastery”. The findings from this research indicate teachers are in need of more time to work on technology. Also, for teachers who do not have a solid knowledge base, technology becomes an object rather than a part of instruction.

Relationship of Findings to Theory

New technologies are transforming education, but too often individual teachers have to figure out technologies for themselves. A successful program for helping teachers develop strong TPACK for strategically using technology for mathematics instruction may exhibit the following characteristics (Grandgenett, 2009):

1. Teachers have an opportunity to develop an “imaginative openness” and a disposition for experimenting with new technologies for mathematics instruction.

2. The program would combine instruction in technology, pedagogy, and mathematics content rather than separating topics across coursework.
3. The program would carefully select TPACK related examples to model strong TPACK instruction.
4. Allow opportunities for teachers to understand the cultural importance of selecting strategies while considering that all strategies do not work for all students.
5. Use the TPACK framework to support technology and mathematics together.
6. Provide support for teachers as they discover the broad spectrum of the use of technology (classroom management, parent communication, etc.).
7. Helps teachers to understand students should be given opportunities to take intellectual chances rather than using technology to overshadow students as the individual.

The recent standards developed by the AMTE Technology Committee addresses the implementation of technology for mathematics instruction by providing a framework for supporting those who prepare mathematics teachers. The TPACK framework helps practitioners and researchers understand the relationship between knowledge of content pedagogy, and technology; there is a need to develop reliable measures for TPACK so that approaches can be developed to improve teachers understanding of the technology needed for strategically teaching mathematics (Shin et al., 2009). Teacher educators can use the TPACK framework to shift the emphasis away from focusing on technology itself and toward strategic application for mathematics learning. The M-TPACK survey developed for this research serves as a tool to assess components of the TPACK

framework. The development of the M-TPACK survey along with the five levels for integrating technology, pedagogy, and content discussed in chapter 2 of this study, are useful for teacher educators as they prepare mathematics teachers to develop TPACK. As teacher educators aim to have teachers progress through these levels, they should aim to develop teachers' dispositions, beliefs, and attitudes toward accepting technologies for mathematics instruction. As teacher educators prepare mathematics teachers to strategically use technology for instruction, the TPACK framework offers an opportunity to be aware of the knowledge base including TK, TPK, TCK, and TPACK. To capture this awareness, teacher educators can use the M-TPACK survey to recognize areas of strength within teachers TPACK.

Implications for Further Research

While technology enables us to rethink and refresh our pedagogy, it provides opportunities rather than solutions for mathematics instruction. In order to take advantage of these opportunities, educators will be required to think, work, and often experiment with technology (Bressoud, 2009). Balancing pedagogy, mathematics content, and technology can aid teachers as they take opportunities to represent concepts, such as fractals, that are closely tied to computers. Although the findings from this research relied on data yielded from self-report surveys and an interview, several important implications for both research and practice were found.

Several qualitative studies have been conducted to explore teachers' understanding of the TPACK, few studies have used quantitative measures (Koehler & Mishra, 2005). Quantitative measures in this research examined teachers' mathematical understanding about teaching and technology. This study shows that questionnaires can

serve as an assessment tool to reliably assess components of the M-TPACK framework. Finally, the findings from this study provide valuable insight into the development of mathematics teachers M-TPACK.

Recommendations

Technology integration is defined not by the amount or type of technology used, but by how and why it is used. In a study by Brown et al. (2007), mathematics teachers should be provided technical support, with the focus on influencing teachers' beliefs, mathematical knowledge, and pedagogical skills. Teacher educators need to build upon teachers' prior knowledge and current beliefs when planning and implementing instruction in coursework or professional developments.

Through this study, a survey was developed for teacher educators to measure teachers' beliefs and use of technology for mathematics instruction. Along with teacher educators, policymakers, researchers, practitioners, and those planning professional developments can use this survey to plan instruction and encourage an environment conducive to developing positive attitudes while addressing misconceptions and counterproductive beliefs about technology and mathematics. Technology involves the tools with which we deliver content and implement practices in better ways. The focus must be on curriculum and learning.

The M-TPACK survey developed for this study could be used for pre- and post-test assessment in mathematics content classes. The survey can inform educators whether teachers' knowledge of TPACK changes over time as well as adding to the discussion of the importance of mathematics teacher education and preparation in the area of TPACK to improve learning and instructional environments using technology in the mathematics

classroom. Teachers' strategic use of technology for mathematics instruction to date is unsophisticated. It is limited in breadth, variety, and depth, and not well integrated into curriculum based teaching and learning. The M-TPACK survey developed in this study can be used to inform stakeholders about how teachers view technology. It also reveals how teachers believe students learn, whether teachers believe they give knowledge to students, and if students learn best by using technologies for problem-solving. The survey can also be used to address what major factors affect teachers' attitudes toward decision-making in their pedagogical practices using technology.

Summary and Conclusion

Technological Pedagogical Content Knowledge (TPACK), “represents a thoughtful interweaving of all three key sources of knowledge – technology, pedagogy, and content” (Mishra & Koehler, 2006, p. 14). The TPACK framework describes good teaching with technology by including the components of content, pedagogy, and technology. Shulman’s (1986, 1987) idea of pedagogical content knowledge (PCK) is the basis for the M-TPACK framework with the inclusion of the domain of educational technology. Technological pedagogical content knowledge describes how teachers’ knowledge of technology, content, and pedagogy interact to use technology strategically for instruction.

The TPACK framework for using technology in classroom instruction does not encourage technology as being a “stand alone” support to mathematics teacher education but as a tool specifically and uniquely applied to mathematics instruction. Teachers using various levels of calculators, Smartboards, and data collecting devices, to support instruction may be missing the point if the technology is not used appropriately,

pedagogically (Sefton-Green, 2006). Not only should teachers integrate technology in their instruction, they should learn to use technology to transform teaching and create new opportunities for students to problem solve, program, analyze, strategize, and design specific higher level skills (Harris, 2008). The TPACK framework offers teachers and researchers a way to evaluate and present research-based suggestions for developing the knowledge and skills needed to integrate technologies into teaching and learning.

Technology is becoming more advanced, less expensive, and readily available. Research should focus on how teachers can use technology as an advantage to teaching. Mathematics teacher educators must provide teachers the TPACK experiences necessary to use technology strategically in their mathematics instruction. A tool for determining the knowledge teachers have about technology, pedagogy, and content may provide support for mathematics teacher educators as they plan effective learning opportunities for the strategic use of technology for teaching mathematics, and for school personnel as they provide professional development opportunities for teachers; therefore, this research provides such a tool for measuring the knowledge middle school teachers have about technology, pedagogy, and mathematics content.

This study considered the overwhelming presence of various technologies in today's society while seeking to capture the factors that foster the implementation of technology-rich mathematics instruction. Teacher educators and administrators can use more information about teachers' knowledge and beliefs concerning technology to enhance teacher education programs and to plan professional development. Therefore, the purpose of this study is to develop a survey to measure middle school mathematics teachers' technological pedagogical content knowledge (M-TPACK). Schmidt et al.

(2009) has created an instrument for measuring teachers' TPACK using the domains of content, pedagogy, and technology; and the overlapping areas of technology content, technological pedagogy, content pedagogy, and technological pedagogical content knowledge. The survey titled *Survey of Teachers' Knowledge of Teaching and Technology* was developed to measure preservice teachers' understanding about the relationship between technology, content, and pedagogy. The survey created in this study adapted the existing survey to specifically examine middle school mathematics teachers' TPACK.

The NCTM position paper on technology makes it clear that technology is an essential part of mathematics by stating, "using the tools of technology to work within interesting problem contexts can facilitate a student's achievement of a variety of higher-order learning outcomes, such as reflection, reasoning, problem posing, problem solving and decision making." (p.1). As technology becomes more pervasive in our schools, it is becoming a critical tool for facilitating mathematics instruction. The AMTE position paper endorses the idea that an effective teacher of mathematics in today's classroom must have "the knowledge and experiences needed to incorporate technology" (2006, p. 1).

The twenty-first century has been filled with rapid, continued innovation and advances in the domains of technology, information, and knowledge transfer. The sociopolitical and educational context of school-aged children is under a period of redefinition and redesign (Sefton-Green, 2006). There is a discrepancy between the visions of the leaders and practitioners actions. Professional development should be designed to incorporate integration. There is no single approach that applies for every

teacher, every course, teachers must develop an understanding of the complex relationships, among technology, content and pedagogy and use it to develop appropriate context-specific strategies and representations. As the president of Promethean, says, “If Rip Van Winkle had fallen asleep in the 1800s and woken up in a traditional classroom today, he’d find there wouldn’t be a lot of change. Classes may have computers, but teachers don’t always use them.” (Elliot, 2010).

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APPENDIXES

Appendix A

The items in this survey are measured on a 5-point Likert scale. Respondents specify level of agreement to each statement by indicating strongly disagree (1), disagree (2), neither agree or disagree (3), agree (4), or strongly agree (5).

Survey Items

Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Neither Agree or Disagree"

TK (Technology Knowledge)

- I know how to solve my own technical problems.
- I can learn technology easily.
- I keep up with important new technologies.
- I frequently play around the technology.
- I know about a lot of different technologies.
- I have the technical skills I need to use technology.
- I have had sufficient opportunities to work with different technologies.

CK (Content Knowledge) Mathematics

- I have sufficient knowledge about mathematics.
- I can use a mathematical way of thinking.
- I have various ways and strategies of developing my understanding of mathematics.

PK (Pedagogical Knowledge)

- I know how to assess student performance in a classroom.
- I can adapt my teaching based-upon what students currently understand or do not understand.
- I can adapt my teaching style to different learners.
- I can assess student learning in multiple ways.
- I can use a wide range of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.).
- I am familiar with common student understandings and misconceptions.
- I know how to organize and maintain classroom management.

PCK (Pedagogical Content Knowledge)

- I know how to select effective teaching approaches to guide student thinking and learning in mathematics.

TCK (Technological Content Knowledge)

- I know about technologies that I can use for understanding and doing mathematics.

TPK (Technological Pedagogical Knowledge)

- I can choose technologies that enhance the teaching approaches for a lesson.
- I can choose technologies that enhance students' learning for a lesson.
- I am thinking critically about how to use technology in my classroom.
- I can adapt the use of the technologies that I am learning about to different teaching activities.

TPACK (Technology Pedagogy and Content Knowledge)

- I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.
- I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.
- I can use strategies that combine content, technologies and teaching approaches that learned about in my coursework in my classroom.
- I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.
- I can choose technologies that enhance the content for a lesson.

Background info:

I have taught

0-2 years

3-5 years

6-10 years

11-20 years

20+ years

Gender

Male

Female

Age

(Survey adapted from: Schmidt, D., Baran, E., Thompson, A., Koehler, M.J., Shin, T., & Mishra, P. (2009). *Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for pre-service teachers*. Paper presented at the 2009 Annual Meeting of the American Educational Research Association. April 13-17, San Diego, California.)

APPENDIX B

Semi-structured Interview Questions

Thank you for agreeing to participate in this interview which is part of my work at the University of Tennessee. I will ask you questions about your use of technology for teaching. There is no right or wrong answer to the questions, so please answer them as honestly as possible. For each question, please provide me with as many examples as you can offer. Your name will not be associated with your answers so please feel free to answer honestly.

Semi-structured Interview questions:

1. What technology is available at your school for you to use for mathematics instruction?
2. How do you use technology for the purpose of effective mathematics instruction?
3. How do you use technology for the purpose of assessment?
4. How do you use technology for the purpose of communication? Please provide examples (colleagues, parents, etc)
5. Describe your confidence in your ability to use technologies for mathematics instruction.
6. What support do you need to use technology more often for mathematics instruction?
7. What additional technology resources are needed to meet the needs of students?
8. How can technology resources be used to meet your needs as a teacher?
9. What hands-on training in the use of technology is available at your school?

APPENDIX C

MTPACK Survey Items

TK 1 I know how to solve my own technical problems.

TK 2 I can learn technology easily.

TK 3 I keep up with important new technologies.

TK 4 I know about a lot of different technologies.

TK 5 I have the technical skills I need to use technology.

TK 6 I have had sufficient opportunities to work with different technologies.

CK 1 I have sufficient knowledge about mathematics.

CK 2 I can use a mathematical way of thinking.

CK 3 I have various ways and strategies of developing my understanding of mathematics.

PK 1 I am able to focus on the mathematics while taking advantage of instructional opportunities offered by technology.

PK 2 I know how to assess student performance in a classroom.

PK 3 I allow students to use technology for assessment as it parallels instruction.

PK 4 When I approach mathematics instruction with technology, I know where students are conceptually, what they need to achieve, and how to proceed.

PK 5 I can adapt my teaching style to different learners.

PCK 1 I can assess student learning in multiple ways.

PCK 3 I can use a wide range of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project based learning etc.).

PCK 4 Teachers should teach exact procedures for students as they use calculators.

PCK 5 I know how to select effective teaching approaches to guide student thinking and learning in mathematics.

TPK 1 It is appropriate for the students to show the teacher how to use new technology.

TPK 2 I am open to experimentation with new technologies for mathematics teaching and learning.

TPK 3 I use technology to manage student assessment information.

TCK 1 An effective teacher explicitly teaches the correct way to use a technology.

TCK 2 I know about technologies that I can use for understanding and doing mathematics.

TCK 3 I can choose technologies that enhance the teaching approaches for a lesson.

TCK 4 I make connections with students as to why technology is useful for certain mathematics problems.

TCK 5 I am thinking critically about how to use technology in my mathematics classroom.

TPCK 1 Children should master procedures for using technology before using the technology for mathematics problem solving.

TPCK 2 I can adapt the use of the technologies that I am learning about to different teaching activities.

TPCK 3 I am comfortable and optimistic about changes in advances with technology

TPCK 4 I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.

TPCK 5 I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.

APPENDIX D

John Beckett
Evaluation Specialist
Knox County Schools
Andrew Johnson Building
Phone: (865)594-1735
Fax: (865)594-1709

Dear Mr. Beckett,

As a doctoral candidate in the Teacher Education-Mathematics program at the University of Tennessee, I am conducting dissertation research entitled *Creating and Validating an Instrument to Measure Middle School Mathematics Teachers' Technological Pedagogical Content Knowledge (M-TPACK)*. I am supervised and supported by my major advisor, Dr. Vena Long. The purpose of this research is to examine the availability and use of technology for mathematics instruction in order to create and validate a survey to measure Mathematics Technological Pedagogical Content Knowledge (M-TPACK). I will use an existing survey measuring technological pedagogical content knowledge (TPACK), along with interviews, to develop and validate a survey to measure middle school mathematics teachers' M-TPACK. The instrument will be created by means of identifying factors that influence the extent to which middle school mathematics teachers integrate technology in their classroom instruction.

The research participants during phases one and three of the project will include all middle school mathematics teachers from the fourteen Knox County public middle schools. During phase two of the project, I will select one middle school mathematics teacher from each school randomly from those indicating in the survey response a willingness to be interviewed for gathering data during the semi-structured interview questions.

The data collection procedures will occur in three phases. In the first phase, quantitative data will be collected from an existing TPACK survey. Permission has been granted by the developer of the existing survey (please see attached email document). During the second phase, I will use qualitative data analysis to identify specific issues surrounding Mathematics TPACK gleaned from semi-structured interviews with 14 teachers. The pertinent issues will then be used to adapt questions from the existing survey and create new and/or adapted questions to be used for a survey that identifies teachers' M-TPACK. In phase three, the M-TPACK survey will be administered to the original population and subsequently be compared to the TPACK results for validity and reliability using quantitative methods.

Participation and subsequent identification is voluntary. Identifying information will only be solicited from those willing to be interviewed. Survey responses will be coded and identifying information kept in a separate and secure location available only to the researchers. Once those to be interviewed are identified, all other identification information will be destroyed. The subsequent administration of the modified survey will be conducted with no information solicited that would identify the participant or the school in which they teach.

All data collection will take approximately four weeks and will begin upon Knox County approval. All participants will be given information in writing about the study when they are asked to participate in the research (see attached letter). Subjects who agree to be interviewed will sign an Informed Consent form that includes how to contact Research Compliance Services at the University of Tennessee's Office of Research for more information about their rights as participants. Subjects may decline to answer a specific question and may withdraw from the research at any time.

All data will be kept confidential and all subjects and the system will be kept anonymous in any publication. The formal write up of the study will mask the district and schools participating.

Attached you will find a copy of the existing survey for measuring Teachers' Knowledge of Teaching and Technology and a semi-structured interview that will be further developed once data has been analyzed from the existing survey. The final survey will be developed after data has been coded and analyzed from the interviews.

A final copy of the dissertation will be submitted to Knox County Schools to be used as seen fit. Individual schools may receive a copy upon request.

Thank you,

Geri A. Landry
1131 Appaloosa Way
Knoxville, TN 37922
glandry@utk.edu
Home Phone: (865)769-9448
Mobile Phone: (865)307-4447

APPENDIX E

Dear Principal,

Your school is invited to participate in a dissertation research study which examines mathematics teachers' mathematical technological pedagogical content knowledge (M-TPACK). This study will take place in three parts. First, mathematics teachers will complete an online survey related to their use of technology for mathematics instruction. The survey should take no longer than twenty minutes to complete. Second, one mathematics teacher from your school will be asked to complete a semi-structured interview. The interview will last approximately thirty minutes. The researcher will use the information gleaned from the interview to develop questions to adapt the existing survey that identifies teachers' mathematics TPACK. The new M-TPACK survey will subsequently be administered to the original population and tested for validity and reliability.

The results of this survey may be helpful in the school improvement process for meeting technology for mathematics instruction goals.

Sincerely,

Geri A. Landry
1131 Appaloosa Way
Knoxville, TN 37922
glandry@utk.edu
Home Phone: (865)769-9448
Mobile Phone: (865)307-4447

Please sign and date verifying your approval

Name

Date

School

APPENDIX F

INFORMED CONSENT FORM Technological Pedagogical Content Knowledge Interview

Dear Mathematics Teacher,

Thank you for agreeing to participate in a study which examines the availability and use of technology for mathematics instruction. This study will be used to develop and validate a survey to measure middle school mathematics teachers' Mathematics Technological Pedagogical Content Knowledge (M-TPACK). The instrument will be used to assist the support of teachers as they strategically use technology in teaching mathematics.

I will ask interview questions that will help me to develop specific questions for a newly created Mathematics TPACK (M-TPACK) survey. Later you will be asked to complete a newly created M-TPACK survey which will measure TPACK specific to mathematics. Like the results of the survey, all results will be kept confidential.

Your information will be encoded to protect your identity. The benefit will be that a survey can be used to offer support for using technology strategically for mathematics instructional purposes.

The information in this study will be kept confidential. Data will be stored securely and will be made available only to persons conducting the study, unless participants specifically give permission in writing to do otherwise. No reference will be made in oral or written reports which could link the participants to the study.

If you have any questions at any time about the study or the procedures, or you experience any negative effects as a result of participating in this study, you may contact the researcher, Geri Landry, at A 507 Bailey Education Complex, Knoxville, TN 37996-3442, and (865) 974-5973. If you have questions regarding your rights as a participant, contact the Office of Research Compliance Officer at (865) 974-3466.

Your participation in this study is voluntary. You may decline to participate without penalty. If you decide to participate, you may withdraw from the study at anytime without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed, your data will be destroyed.

I have read the above information. By clicking on the next button, you agree to participate in this study.

Vita

Geri A. Landry was born May 23rd, 1972, in Panama City, Florida. She completed her undergraduate degree in Elementary Education and master's degree in mathematics education at Florida State University. After ten years of teaching in elementary and middle schools, she moved to Knoxville, Tennessee, to pursue a doctorate degree from the University of Tennessee in mathematics teacher education. She hopes to influence the field of teacher education by bridging the link between research and practice for mathematics instruction.