MIXING THE EMIC AND ETIC PERSPECTIVES: A STUDY EXPLORING DEVELOPMENT OF FIXED-ANSWER QUESTIONS TO MEASURE IN-SERVICE TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

by

M. Brooke Robertshaw

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Approved:

Mimi Recker Major Professor	Steven Camicia Committee Member
Anne Diekema Committee Member	Ronald B. Gillam Committee Member
Andrew Walker Committee Member	Mark R. McLellan Vice President for Research and Dean of the School of Graduate Studies

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Logan, Utah

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DEDICATION

This document represents six years of work.
These years and this document are dedicated to:

My parents Harry Hull Robertshaw (1943-2010) & Dianne Robertshaw Yardley

My friend Mary Melissa Edwards (1959-2012)

ABSTRACT

Mixing the emic and etic perspectives: A study exploring development of fixed-answer questions to measure in-service teachers' technological pedagogical content knowledge

by

M. Brooke Robertshaw, Doctor of Philosophy

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Major Professor: Mimi Recker
Department: Instructional Technology & Learning Sciences

Using a sequential mixed-method methodology, this dissertation study set out to understand the emic and etic perspectives of the knowledge encompassed in the technological pedagogical content knowledge (TPACK) framework and to develop fixed-answer questions based on that knowledge. While there have been many studies examining ways to measure TPACK in in-service and pre-service teachers, very few have addressed measuring TPACK using fixed-answer questions. Through the use of the mixed-methods, a snapshot of the emic (inside) and etic (outside) perspectives on the TPACK framework was obtained. This study used a focus group with in-service teachers (emic perspective) and interviews with teacher educators (etic perspective) to understand the kind of knowledge attributed to the TPACK framework. Six themes were derived from the focus group and interviews, from which 11 fixed-answer questions were developed. Those six themes included such issues as access to technology, the use of technology for solid teaching and learning purposes, and passive versus active learning when using technology. Following best practices, the eleven questions included a scenario that gave context to the questions asked and the answers provided. In-service teachers reviewed the items to assure that the language and context were appropriate to classroom practice. Four experts on the TPACK framework reviewed the items for face validity. Across the experts six of the eleven items were rated as valid. Although only the experts saw a small number of items as valid, this study indicates that this kind of measurement for the TPACK framework may be possible.

(190 pages)

PUBLIC ABSTRACT

Mixing the emic and etic perspectives: A study exploring development of fixed-answer questions to measure in-service teachers' technological pedagogical content knowledge

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M. Brooke Robertshaw
2013

The purpose of this dissertation study was to develop fixed-answer questions to measure teachers' technological pedagogical content knowledge when teaching with online learning resources. Technological pedagogical content knowledge (TPACK) is a framework to describe the kind of knowledge that teachers use when they are teaching with technology. Online learning resources include text, video, images, and interactive websites that teachers can use to help teach subject matter to their students. Fixed-answer questions are the kinds of questions found on standardized tests like the SAT, and tests that K-12 students take as a part of state and national testing. Many measures have been developed to measure TPACK in in-service and pre-service teachers, but only a few researchers have used multiple choice and ranking type questions.

To develop the questions, this dissertation study used a mixed methods approach. Mixed methods allow a researcher to use different kinds of ways to investigate knowledge. This dissertation had two phases, each completed as a stand-alone study. The first phase of this dissertation used a qualitative methodology and the second phase used a mixed methods approach, with quantitative being the primary investigative method,

whereas qualitative was used to reinforce and give further information about the quantitative findings.

This dissertation study used two sequential research phases. The first phase included a focus group with in-service teachers and interviews with three teacher educators. The data were then analyzed, using the lens of the TPACK framework, and six themes were found. These themes included such things as access to technology, using active and passive forms of teaching when teaching with technology, and using online learning resources for purposeful teaching and learning.

Based on the themes derived in phase one, eleven items were written during phase two of this study. Those eleven items were sent to teachers to make sure the language was written in a way that they could understand. The items were then sent to experts in the TPACK framework to evaluate how much they measure TPACK in teachers. Out of the eleven items, six were deemed valid by all of the raters.

Although this study did not show validity for all eleven items, it does indicate promise in this kind of measurement for TPACK. It is standard practice for more than one round of examination by experts to take place, giving the measurement developer a chance to rewrite items. Given more rounds of updates and reviews by experts, it is likely that these eleven items could eventually be pilot tested with teachers.

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The original draft of this section of my dissertation was over five pages long. I have decided to shorten this section considerably. Instead of naming each one of you individually, and for fear of missing someone, I simply want to thank all of you who contributed to my life in any part before, during, and as this process has reached its final end. Some of you know who you are, others of you will never know who I am. To all of you, I will forever indebted to your presence in my life.

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M. Brooke Robertshaw

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CHAPTER I

INTRODUCTION

The life of the 21st Century student in the United States is becoming more centered on the digital world for social interactions and information retrieval (Greenhow, Robelia, & Hughes, 2009). The same digital, online, world that is transforming their social lives has the potential to also transform their education, giving them access to other learners beyond their community along with real-time data to solve problems (CRA, 2005; Dede, 2007; Greenhow, et al., 2009; Hansen & Carlson, 2006). These same digital resources can bring students to the center of instruction, since they are adaptable to the needs of each individual classroom and individual students (Dede, 2001; Hansen & Carlson, 2006).

While 21st century students are adapting to a digital world, studies show their abilities lacking in use of online technology for information retrieval and learning compared to their abilities to use the same technology for social purposes (Druin, 2009). In order for students to learn how to use online digital technologies for learning, their teachers must first know how to use these technologies (Druin, 2009). Though teachers view digital resources as being important, they infrequently use them as instructional tools (Netday, 2001; Bebell, Russell, & O'Dwyer, 2004), mostly due to lack of ability to do so (Hansen & Carlson, 2006).

The process of learning how to use technology in teaching and learning contexts calls for teachers to learn how to *incorporate the technology into their teaching practices, not just how to learn the technology* (Harris & Hofer, 2009; Mishra & Koehler, 2006;

Niess, 2012). Pedagogical content knowledge (PCK) is the kind of knowledge that teachers use when they are teaching a particular content (Shulman, 1986). When teachers do not integrate technology into their PCK, they miss out on the innovative ways digital resources could enrich student learning, since they revert to their conventional teaching practices (Cuban, 2001; Hansen & Carlson, 2006; Niess et al., 2009).

The challenge before researchers and teacher educators is to develop new ways to help teachers to become more comfortable with the use of technology in their classrooms (Pea et al., 2008). Shulman's (1986) initial description of PCK included media, but it was unlikely that he could imagine the impact of digital technologies in the classroom. In order to overcome this potential oversight in PCK, researchers began investigating technology use in teaching and learning through the lens of PCK (Margerum-Leys & Marx, 2002; Pierson, 2001). The new description of PCK included terms such as pedagogical content knowledge of technology (Margerum-Leys & Marx, 2002). This body of research resulted a new framework for describing the kind of knowledge that researchers should aim to develop in teachers, technological pedagogical content knowledge (TPACK) (Keating & Evans, 2001; Mishra & Koehler, 2006; Pierson, 2001).

TPACK is an extension of PCK in that it incorporates technology into pedagogical content practices beyond merely knowing how to use the technology, but how to use it for teaching, for representing content, and for teaching content with digital technologies (Graham, 2011; Koehler, Shin & Mishra, 2012; Mishra & Koehler, 2006; Niess, 2005; Niess 2012). It is complex in both structure and in definition. In structure, TPACK extends PCK from three different kinds of knowledge to seven. Although many scholars outside the TPACK community rely on the Mishra and Koehler (2006) definition of the framework (Manfra & Hammond, 2006; Tee & Lee, 2011; Ward & Benson, 2010), those directly investigating the framework differ in their definitions (Cox, 2008; Graham; Guzey & Roehrig, 2009) and even across their own work (Cox, 2008; Koehler & Mishra, 2005a; Mishra & Koehler, 2006).

As work is ongoing to define what TPACK *is*, work towards understanding how teachers and educators are developing this knowledge is proceeding. This work is needed because as Ball, Thames, and Phelps (2008) stated, without work to empirically test for PCK, it remains simply a hypothesis. Understanding how TPACK develops has proven to be difficult (Cox, 2008; Graham et al., 2009; Mishra & Koehler, 2006; Mishra & Koehler, 2012) and this difficulty has not been limited to TPACK. Researchers who have been investigating PCK describe problems in identifying what PCK is (Graham, 2011; Hill, Ball, & Schilling, 2008), and how to develop test items to measure it (Carlson, 1990; Graham; Rowan et al., 2001). In measuring TPACK this work is confounded by the added complexity of the framework (Graham, 2009) and the lack of agreement in how to define the framework (Cox, 2008; Graham, 2009).

While measuring TPACK is proving to be difficult, many different ways have been used to measure it. Researchers have heavily relied on self-report measures, open-ended questionnaires, performance assessments, interviews and observations to try to describe teachers' TPACK over time or at a snapshot in time (Koehler et al., 2012). Some research has begun to explore the use of fixed-answer questions in order to measure TPACK (Barrett, 2010; Koehler et al., 2012), but continued work is needed in this area.

The goal of the study presented in this dissertation was to further research of development of fixed-answer questions to measure TPACK in the technological context of online learning resources. This dissertation begins the process of developing these fixed-answer questions through work to understand both the emic and etic perspectives of TPACK. The emic perspective comes from within a culture or context and the etic perspective looks at a culture or a context from the outside (Onwuegbuzie, Bustamante, & Nelson, 2010). In the case of this dissertation work, the emic perspective seeks to understand the in-service teacher, whereas the etic perspective seeks to understand the teacher educator and researcher. In the context of TPACK and developing items to measure it, both perspectives are vital because they interweave as the teacher is building her knowledge, one source being the teacher educator. Throughout this dissertation the two positions stay the same; the difference is with whom this researcher sides when considering a particular issue within TPACK.

The dissertation study to be presented followed a sequential mixed method designed to get a snapshot of the emic and etic perspectives on knowledge, behaviors, and attitudes about teaching with technology attributed to the TPACK framework.

The second chapter of this study is the literature review. The main purpose is to examine how scholars conceptualize the TPACK framework, and its constituent parts. This includes high level descriptions as well as discussion of specific knowledge, behaviors, and attitudes attributed to TPACK, PCK (since it is a part of TPACK) and the constitutive parts that make up the entire framework. The literature review also addresses previous measures created to measure TPACK and describes a developmental framework for TPACK development in mathematics. Finally, it addresses issues with self-report surveys and a review of relevant mixed methods literature.

Phase one of the study (chapter three) is a qualitative investigation which aimed to understand the emic and etic perspectives of the knowledge used, behavior exhibited, and attitudes about teaching with technology as mapped to the TPACK. In order to understand these different perspectives, a focus group was held with three in-service teachers and interviews were held with three teacher educators, specifically teacher educators who had previously taught in a K-12 classroom. This phase aimed to answer the following questions using the TPACK framework as the analytic lens:

1. How do teachers and teacher educators describe technology knowledge when applied to a teaching and learning context?
2. How do teachers describe their current technology use behaviors in a teaching and learning context?
3. What do teacher educators convey about technology use in a teaching and learning context to pre-service teachers?
4. What attitudes to teacher educators hold about the use of technology in a teaching and learning context?

Phase two of this study (chapter four) was based on the findings from phase one, as well as information gathered in the literature review. Fixed-answer questions were developed around the themes derived from phase one and included behaviors, attitudes, and knowledge derived from the literature. After the items were developed, they were first sent to expert teachers to check that the items developed were aligned to practice and written in a language that made sense to teachers. They were then sent to experts in TPACK for a face validity examination. Based on the feedback given by the reviewers, the items were revised. This phase aimed to answer the following question:

1. What is the face validity of the items developed?

This question was answered through a sequential mixed method investigation, focusing mainly on the quantitative findings, and using a more informal qualitative investigation than found in phase one.

The conclusion of this dissertation (chapter five) summarizes the findings from phase one and phase two. It also addresses study limitations which include in phase one of this dissertation study not having reached data collection saturation; not having a more diverse sample of participants, and not having another researcher examine samples of the data to see if s/he would come up with similar themes as the researcher did. In phase two limitations include not providing face validity raters with rating of the answers to choose from or rank the items developed; having face validity raters with very different levels of experience with the TPACK framework; and not revising items and doing at least one additional round of face validity ratings. This last limitation leads directly into a recommendation for future research -- that the items should be revised and re-reviewed and eventually piloted. Finally, although this study did not finish with a set of valid items to be tested, the feedback that was provided shows that, with more work, there is promise with this kind of measurement of TPACK.

CHAPTER II

LITERATURE REVIEW

This primary purpose of this literature review is to describe how scholars define technological pedagogical content knowledge. This includes an understanding of how its predecessor, pedagogical content knowledge, is described. It also includes a description of specific behaviors and knowledge ascribed to TPACK and its constituent parts. Other objectives in this literature review are to address the issue of TPACK being a transformative or integrative form of knowledge; describe criticisms of TPACK; and discuss ways that the framework has been measured. Finally, to give light to the methodology of this study the following are addressed: issues with self-report measures, and the use of mixed methods in instrument development.

Eighty-five primary source articles written between 1977 and 2011 were found to be useful for the purposes of this study, using the following descriptors: pedagogical content knowledge, technological pedagogical content knowledge, measuring technological pedagogical content knowledge, measuring pedagogical content knowledge, technological pedagogical content knowledge measurements, pedagogical content knowledge measurements, self-report in education, mixed methodology, and mixed-methods for instrument development. The articles were located through different databases and search engines including Google, Google Scholar, Digital Dissertations, and Education Full Text.

Articles included in this review include those that:

- describe the characteristics of technological pedagogical content knowledge and its constituent constructs – pedagogical content knowledge, technological knowledge, pedagogical knowledge, content knowledge, technological content knowledge, and technological pedagogical knowledge;

- describe in-service and pre-service teachers' development of PCK and TPACK and how that development is measured;
- describe different measures of PCK, TPACK and their constituent constructs;
- use the mathematics developmental framework created by Niess et al. (2009).
- address issues with self-report instruments;
- describe how a mixed-method paradigm is different from qualitative or quantitative research paradigms; and
- describe the use of mixed-methodologies for instrument development.

Pedagogical Content Knowledge

Pedagogical content knowledge (PCK), the construct that TPACK is built upon, was initially described as knowledge that goes beyond a particular subject knowledge and extends into a particular form of knowledge that is most germane to teaching content (Shulman, 1986). It is made up of content knowledge and pedagogical knowledge. When these are combined they transform into pedagogical content knowledge (Shulman).

Content knowledge (CK) is expert knowledge of a subject area (Forbes, 2007), or the kind of knowledge held by a research scientist or subject matter expert in the field (Baxter & Lederman, 1999; Shulman, 1986). It is knowledge of facts, concepts and procedures of subject matter along with how they are organized and connected (Harris, Mishra & Koehler, 2007; Koehler & Mishra, 2005a; Lee & Tsai, 2008; Mishra &

Koehler, 2006; Shin et al., 2009; Shulman; Valtonen, Wuff, & Kukkonen, 2006). CK is knowledge of the kind of inquiry that takes place *within a particular field of study* (Harris et al., 2007, Mishra & Koehler 2006; Valtonen et al., 2006).

Pedagogical knowledge (PK) is the knowledge, beliefs and practices held by educators about teaching and learning (Forbes & Davis, 2007; Mishra & Koehler, 2006). PK encompasses knowledge of students and how they construct knowledge, classroom management techniques, creating and implementing lesson plans, organizing a classroom during instruction, and evaluating student learning (Baxter & Lederman, 1999; Harris et al., 2008; Koehler & Mishra, 2005a; Mishra & Koehler, 2006; Shin, et al., 2009; Shulman, 1986; Valtonen et al., 2006).

Pedagogical content knowledge is a kind of knowledge in teaching (Carlson, 1990; Lee & Tsai, 2008; Rowan et al., 2001; Shulman, 1986; Valtonen et al., 2006). It is a highly contextualized form of knowledge (Lougrahn, Mulhall & Berry, 2004; Mishra & Koehler, 2006; Rowan et al.; Shulman, 1986) that includes knowledge of students and the school environment (Komfrey & Renfrow, 1991; Niess et al., 2009; Shin et al., 2009; van Driel, de Jong, & Verloop, 2002).

PCK is an understanding of how content and pedagogy are linked together, and what makes learning different subject areas easy or difficult (Harris, Mishra & Koehler, 2008; Hill et al., 2008; Shulman, 1986; Valtonen et al., 2006; van Driel et al., 2002). It includes understanding of the kinds of content-specific examples used to represent specific topics (Baxter & Lederman, 1999; Shulman, 1986). A teacher with PCK knows what teaching methodologies are best to teach different subject matter, how subject matter can be rearranged for different teaching methods (Graham et al., 2009; Lee & Tsai, 2008; Mishra & Koehler, 2006; Shin et al., 2009; van Driel et al., 2002) and the preconceptions, misconceptions and knowledge students have about a particular content area (Graham et al.; Hill et al., 2006; Niess et al., 2009; Rowan et al., 2009; van Driel et al., 2002).

Pedagogical content knowledge extends beyond basic teaching methods and subject matter, including knowledge of behavior management techniques (van Driel et al., 2002); knowledge of schools (Niess et al., 2009; van Driel et al., 2002); assessment techniques (Harris et al., 2007; Komfrey & Renfrow, 1991); knowing how to communicate with learners (Komfrey & Renfrow, 1991); and conditions that promote learning (Harris et al., 2007). Lastly, in order to have PCK a teacher must have a “deeply principled conceptual knowledge of the content” (van Driel et al., 2002, p. 680).

Finally, PCK is embedded in context. Scholars have defined context as being the environment within which teaching occurs (Komfrey & Renfrow, 1991); the community environment in which the school lies, and the environment of the particular school district in which the teacher is situated (Ball et al., 2008; Shulman, 1986; Veal & MaKinster, 1999).

Constituent Parts of PCK and TPACK

The TPACK *framework*, which could be a considered a 21st century extension of PCK, constitutes four constructs beyond PK, CK and PCK: technology knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK).

Technology knowledge (TK) is knowledge of technology access and operation

(Forbes & Davis, 2007). It encompasses knowledge of both computer and internet technologies, what it takes to operate a particular technology, and knowledge of standard technologies such as chalkboards and books (Koehler & Mishra, 2005a; Lee & Tsai, 2008; Mishra & Koehler, 2006). TK is constantly changing, and extends beyond the fundamentals of using technology. TK also includes how technology can work in our daily lives (Harris et al., 2008). Having TK enables teachers to use, apply, and adapt to changing technologies (Shin et al., 2009). Lastly, TK represents the kind of knowledge that was the early focus of using technology in the classroom (Graham, et al., 2009).

Currently debate prevails about how to define technology as encompassed in the TPACK framework. In their seminal work, Mishra and Koehler (2006) defined technology as being any media in the classroom. Shulman (1986) considers the use of media, such as visual materials, software and other classroom tools included in the arena of "curricular knowledge." Graham (2011) made the crucial point that TPACK scholars need to define technology as something beyond Shulman's definition, otherwise there is no need to extend the PCK framework. This dissertation aligns with Graham (2011) and Cox's (2008) definitions of technology, in that it is emerging technology that has not become "invisible" (e.g. whiteboards & chalkboards) to the classroom teacher.

Technological pedagogical knowledge (TPK) is an extension of PK and TK. Teachers with TPK understand how technology impacts teaching in ways that are non-content specific (Graham et al., 2009). TPK is knowledge of how different technologies can be used in teaching, how teaching may change as a result of using technology, and how technological strategies can impact meeting a pedagogical goal (Harris et al., 2008; Koehler & Mishra, 2005a; Mishra & Koehler, 2006; Shin et al., 2009). It is also knowing the pedagogical constraints of different technologies and how different technologies can be repurposed for teaching and learning (Harris et al., 2008).

Technological content knowledge (TCK) is an extension of CK & TK. TCK is knowing how technology can transform and create new understandings of a specific content area (Graham, et al. 2009; Harris et al., 2008; Koehler & Mishra, 2005a; Mishra & Koehler, 2006), and how knowledge in a content areas can be extended through the use of technology (e.g. the development and use of increasingly sensitive equipment to detect movement in the earth's crust) (Leatham, 2008). It is an understanding of how TK & CK constrain each other, as well as how technology can offer new metaphors for thinking about cognition in a specific content area (Harris et al., 2008; Mishra & Koehler, 2006; Shin et al., 2009). Lastly, TCK is the kind of technological knowledge held by scientists and subject matter experts in a particular field (Graham et al., 2009).

Technological Pedagogical Content Knowledge

Technological pedagogical content knowledge (TPACK) is one of the seven kinds of *knowledge* that constitute the *TPACK framework*. The TPACK framework is an extension of Shulman’s (1986, 1987) PCK (Koehler & Mishra, 2005a, 2005b). See Figure 2-1 for a visual representation of the TPACK framework. The rest of this section will focus on the knowledge TPACK, not the framework.

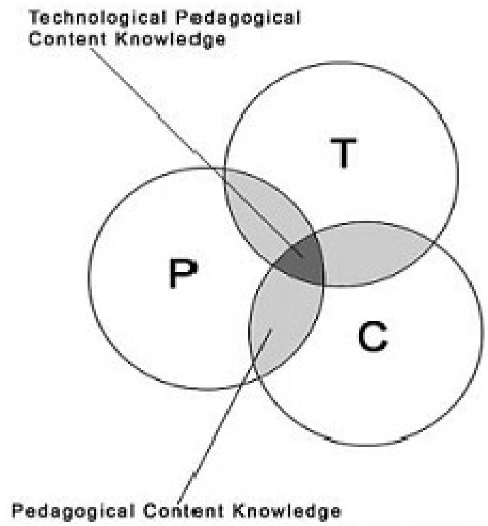

Figure 2-1. The TPACK framework, with TPACK knowledge denoted in the center of the diagram. Adapted from Mishra & Koehler, 2006.

In one of the first descriptions of TPACK (knowledge), Pierson (2001) includes understanding technologies that lend themselves to the teaching and learning process. Keating and Latham (2001) describe TPACK as the kind of knowledge that teachers have when they use their technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) together in a teaching and learning environment. These descriptions were expanded upon as exploration of TPACK continued. TPACK requires an understanding of how teaching and technology intersect (Mishra & Koehler, 2006); how knowledge of subject matter interacts with technology, teaching and learning; and how technology can help students to build on existing knowledge and to develop new epistemologies or strengthen old ones (Mishra & Koehler, 2006; Niess, 2005). It is how teachers think about pedagogical tasks such as planning and organizing for specific content while considering computer technologies (Graham, Borup & Smith, 2012; Graham et al., 2009) and an intuitive understanding of how to teach a subject matter with appropriate teaching methods and appropriate technologies (Schmidt, Sahin, Thompson, & Seymour, 2008). It arises from multiple interactions among CK, PK and TK (Harris et al., 2008).

TPACK is dynamic and transactional (Koehler & Mishra, 2005b; Slough & Connell, 2006), an integrated whole (Schmidt et al., 2008) and a way for teachers to use technology that has the potential to change education (Koehler & Mishra, 2005a).

Teachers with TPACK should have an understanding of how to integrate technology, pedagogy and content to support constructivist learning (Niess et al., 2009; Valtonen et al., 2006) and should be able to view use of computers in terms of function within a teaching and learning situation rather than how to use technology on its own (Pierson, 2001). Full development of TPACK is achieved when a teacher knows how technology can transform pedagogy in order to teach a particular subject area and how technology can impact students' understanding of a particular content area (Graham et al., 2009; Niess et al.).

A teacher who has TPACK knows students' understanding, thinking and learning with technology (Leatham, 2008; Niess, 2005). They also understand the diversity of students' needs in a technology-mediated classroom (Niess, 2008) and can develop instructional strategies to adequately teach a wide range of students with technology (Niess, 2005; Niess et al., 2009). They should also be able to know when to use it and when not to use it (Leatham, 2008); be able to assess student learning of a subject area in a technology-rich environment (Leatham, 2008; Niess et al., 2008); and know what misconceptions and prior knowledge students bring to a technology-mediated classroom (Leatham, 2008).

Inclusion of context in the TPACK framework is controversial (Cox, 2008; Graham, 2011). Before the introduction of PCK, content knowledge was seen as the context within which teaching transpired (Ball et al., 2008). As described above PCK scholars have defined context, but the importance of context in the PCK model is unclear (Cox, 2008; Graham, 2011; Niess, 2012; Robertshaw, 2010).

In their seminal work Mishra and Koehler (2006) touch on context as a part of their discussion of teacher knowledge because learning is situated. Teaching and learning cannot be separated from the environmental impacts of subject, grade, kinds of technology at hand, student background, teacher philosophy and experience. In 2006 context was not directly included in the framework presented by Mishra and Koehler (2006). Two years later Koehler and Mishra (2008) expanded the TPACK framework to add context as a mitigating factor in teachers' TPACK. As Mishra and Koehler (2005) and Koehler and Mishra (2008) describe context, others have as well. Kelly's (2008) descriptions of context overlap with Mishra and Koehler's (2006). Kelly (2008) mentions student demographics, availability of technology, teacher pedagogical practices, and demographics of teachers. Valanides and Angeli (2009) discuss teachers' epistemic beliefs and values about teaching as being factors that can mitigate TPACK. Robertshaw (2010), in a study analyzing in-service teachers' answers about what they need in order to teach with technology, described access to technology as well as teacher time constraints as two parts of personal context that impact teachers' TPACK and their ability to develop TPACK. Landry (2010) and Brush and Saye (2009) also cited access to technology as impacting pre and in-service teachers' ability to use technology for teaching. Finally, Niess (2012), in her historical description of TPACK, includes context in her discussion saying that addressing it incorporates the purpose of education, school values, and educational purposes to other descriptions of context.

Two dissenting voices to note are Cox (2008) and Graham (2011). Cox analyzed the many different definitions of the TPACK framework in the literature, up until 2008, and interviewed experts on the framework. Although her initial findings include context as a *feature* of the TPACK framework, her final model of the TPACK framework, and her final set of definitions of the constituent parts of the framework do not include context. In his theoretical discussion of TPACK, Graham (2011) details areas of weakness in the TPACK framework. He briefly discusses context, but in his description of the framework, as well has his visual representation of it, does not include context.

For the purposes of this dissertation study, context will be included as a part of the TPACK framework. Cox's (2008) and Graham's (2011) reasoning for not including context as a part of the knowledge model is understood, as it is not knowledge but a crucial *mitigating* factor to development and use of knowledge. The belief held by this author is that context needs to be acknowledged so that teacher educators can adequately help teachers integrate digital technologies into their pedagogical content practices. This is based on previous research completed by the researcher (Robertshaw, 2010; M. Robertshaw & Gillam, 2010). This researcher holds firm that although context is not necessarily knowledge, it does impact how knowledge is enacted and thus it must be a part of the TPACK framework.

Subject Matter Specific TPACK

More is beginning to be written exploring specific content areas and teachers utilizing TPACK (Brush & Saye, 2009; Guzey & Roehrig, 2009; Hughes & Scharber, 2008; Lee, 2009; Lee, Hollebrands & Wilson, 2007; Niess, Lee, Sadri & Suharwoto, 2007; Richardson, 2006; Shoffner, 2009; Voogt, Tilya, & den Akker, 2009). Specifically researchers have begun to define different types of TPACK, based on the subject area being covered. This body of research explores not only how TPACK can be developed at a content area level, but also the kinds of activities that teachers do in their classroom when they are utilizing their TPACK knowledge.

There is consensus that, in order to have a particular subject matter TPACK, pre- and in-service teachers should have knowledge of the content area and how it intersects with technology; knowledge of how particular instructional strategies intersect with technology; knowledge of curriculum and how it intersects with technology; and knowledge of how students understand, think and learn with technology (Lee et al., 2007; Niess, 2005; Niess et al., 2007; Voogt et al., 2009).

This researcher believes that the discussion of subject-matter specific TPACK is vital, as it is the subject matter that gives reason for teaching and learning. Discussions of TPACK, and specifically measuring TPACK, cannot occur without some mention of a specific subject matter. To that end this dissertation aligns with those scholars who believe that TPACK cannot be measured independent of a particular content area. This belief is illustrated in the items developed in phase three of this dissertation.

Integrative versus transformative view of the TPACK framework

One of the issues facing the community of researchers investigating the TPACK framework is whether the knowledge encompassed in the more complex parts of it – PCK, TPK, TCK, and particularly TPACK itself – is integrative or transformative. The question is whether these kinds of knowledge are simply additive in nature, e.g. TK + PK + CK = TPACK, or transformative, meaning that TPACK is a completely different kind of knowledge from TK, CK, and PK (Graham, 2011).

Since TPACK is an extension of the PCK framework (Mishra & Koehler, 2006) the discussion will begin there. Shulman (1986) clearly viewed PCK as a *synthesis* of pedagogical and content knowledge. He states, "A second kind of content knowledge is pedagogical knowledge, which goes *beyond* knowledge of subject matter per se to the dimension of subject matter knowledge *for teaching*" (p. 9). This is the view that is echoed by later researchers of PCK (Carlson, 1990; Hill et al., 2008; Rowan, et al., 2001; van Driel et al., 1998).

This view of interconnectedness and interrelation between the constituent parts extends into TPACK. Niess (2005) described the construct as wholly separate from TK, PK, & CK. Although a teacher must have those kinds of knowledge, TPACK is an entity all to itself. She strengthens this point by discussing how pre-service teachers in a teacher education program develop TPACK. The courses geared towards TPACK development do not teach PK, CK, and TK separately; they bring the three together within one course. Material is separated based on content, but within the different content areas instruction of TK, CK, and PK is integrated. Mishra and Koehler (2005a) echo this perspective by saying, “True technology integration, we argue, is understanding and negotiating the relationships between these three components of knowledge” (p. 134). Later works continue to echo this interconnected and interrelated view of TK, CK, and PK (Archambault & Crippen, 2009; Graham et al., 2009; Harris et al., 2008; Leatham, 2008; Mishra & Koehler, 2006; Niess, 2008; Niess, et al., 2009; Slough & Connell, 2006; Valtonen et al., 2006). Schmidt et al. (2008) comment that TPACK is larger than the sum of its parts, meaning that a teacher must have more than simply CK, PK, and TK in order to have TPACK.

Whereas some hold the view that TPACK is a transformative kind of knowledge, there are those who say that TPACK is simpler, that it is a sum of CK, PK, and TK. McCrory (2008) investigated science teachers' TPACK. McCrory’s view is that TPACK is knowing what content to use technology with, how to use it with the intended pedagogy, and how to use the technology itself. McCrory gives no discussion of TPACK being a kind of knowledge separate from its parts.

Guzey and Roehrig (2009) did a summer workshop for science teachers specifically for developing their TPACK. They conceptualize TPACK using McCrory's (2008) model. They describe participants' TPACK by describing participants' knowledge of science, pedagogy and technology separately.

Koehler, Mishra and Yahya (2007) describe a study investigating faculty members' development of TPACK in a workshop. In the beginning of their paper they describe the framework as dynamic and transactional, indicating that they see TPACK as a transformative kind of knowledge. In the results of the study, however, they discuss hearing content and pedagogy being *added* to discussions with technology as the workshop moved into later stages. They indicate that seeing the addition of technology to discussions of content and pedagogy is discussion of TPACK. The problem in this study seems to be that although they view TPACK through a transformative lens (this is apparent in all of Koehler & Mishra's work), it is in detecting and describing it in participants that appears to lead them to an integrative view. See Table 2-1 for mathematical expressions to illustrate the differences between the two views better.

Table 2-1
Integrative vs. Transformative States of TPACK in Described in a Mathematical Expression

Integrative state of TPACK	Transformative state of TPACK
CK + PK + TK = TPACK	∫[TK, CK, PK]=TPACK

The view held by this researcher is that TPACK is a transformative kind of knowledge. The problem this researcher faced in the past, however, is in detecting TPACK in this transformative state. A study (Robertshaw, 2010) was conducted to detect change in participants' TPACK during a workshop. This was accomplished through the use of a rubric to evaluate participants' answer to an open-ended question asking what they needed to know in order to teach with technology. Although the study (Robertshaw, 2010) sought to evaluate expression of TPACK in its transformative state, this proved to be difficult and the integrative state was used to code for indications of TPACK, TCK, TPK, and PCK. This means that indications of PK, CK, and TK were simply added together to reach TPACK, TCK, PCK and TPK (see table 2-1 for this expressed in a mathematical expression).

As Angeli and Valanides (2009) described, TPACK knowledge is tacit, meaning that teachers use it without necessarily knowing they are doing so. Detecting and investigating this kind of knowledge is difficult at best. This problem was also faced in this dissertation study.

The reason for addressing the issue of how TPACK is described, and examined, is that for the purposes of this study, it was a goal to develop questions and answers that represent TPACK in its transformative state, rather than its integrative state. This proved difficult and whereas some of the questions and answers represent TPACK in the transformative state, but most do not.

Criticisms of TPACK

TPACK is a framework that builds on an earlier framework (PCK) that was introduced to the scholarly community as a way to conceptualize what teachers know when teaching with technology. When technology was added to the pedagogical content knowledge model the complexity of the model more than doubled (from three to seven kinds of knowledge) (Graham, 2011). In the twenty-five years since PCK was first described (Shulman, 1986) scholars have been working to describe, detect, measure, develop, and test it (Baxter & Norman, 1999; Carlson, 1990; Graham, 2011; Hill, Ball & Shilling, 2008; Komfrey & Renfrow, 1991; Niess, 2005; van Driel et al., 2002). Graham called this “building on an unsure foundation” (p. 1955). Graham pointed out that as recently as 2007 researchers have discussed the difficulty in nailing down adequate descriptions of *PCK* theoretically.

Increasing the complexity of a framework already as complex as PCK leads to its usability being in question (Archambault & Barnett, 2010; Graham, 2011). Using it as a prescriptive model for practical work in professional development is difficult because the framework does not indicate how TPACK should be developed, e.g. whether to start with technology knowledge or pedagogical content knowledge (Archambault & Barnett, 2011; Graham, 2011).

Another issue with the framework is the fuzzy boundaries between its constituent parts (Archambault & Barnett, 2010; Angeli & Valanides, 2009; Graham, 2011). Statistically, only one factor analysis (Lux, 2010) has been able to distinguish between TPK, TCK and TPACK (a more detailed description of this study is provided in the measurement section, below). Use of open-ended measures has seen more ability to distinguish between TPK, TCK, and TPACK (Hughes & Wen, 2010; Robertshaw, 2010; Robertshaw & Gillam, 2010). Even Cox (2008), in her work to distill definitions of the framework from existing definitions in the literature, as well as through conversations with experts, found the boundary issue to be mitigating in her work. The importance of the scholarly community coming to consensus on definitions is a key recommendation by Graham (2011) in his analysis of the framework from a theory development point of view. Finally, Graham (2011) states that in order for the framework to be stronger, the scholarly community also needs to address the integrative versus transformative issue.

Developing and Measuring PCK and TPACK

The following section will address prescriptions for developing TPACK, a developmental framework created to address development of TPACK in Mathematics teachers, and measuring PCK & TPACK.

Developmental Framework

The Niess et al. (2009) TPACK development model was created in response to the changing technological pedagogical world that teachers of Mathematics find themselves in (Niess et al., 2009). In 2000 the National Council of Teachers of Mathematics (NCTM) released a statement stating that technology is essential in teaching and learning processes. In 2007 the International Society for Technology in Education (ISTE) updated its National Educational Technology Standards for Teachers (NETS-T) to focus on technological pedagogical issues rather than the basic technological issues that were the focus of the standards release in 2002. Finally, in 2006 the Association for Mathematics Teacher Education (AMTE) stated that teacher education programs needed to equip future teachers to be able to teach with technology.

In 2007 the AMTE convened a technology committee, of which one task was to develop a set of mathematics standards for TPACK. The AMTE committee adopted the five developmental levels observed by and discussed in Niess, Sadri and Lee's (2007) four year long study of teachers as they learned how to integrate spreadsheets into their pedagogical practices. The five developmental stages of the model are recognizing, accepting, adapting, exploring and advancing. These five developmental levels are traced across four themes, which were influenced by literature on pedagogical content knowledge. Those four themes are: curriculum and assessment, learning, teaching, and access. Each theme and developmental phase includes descriptors that are different for each theme; for example the curriculum and assessment theme includes a curriculum descriptor; the teaching theme includes a mathematics learning descriptor; and the access theme includes a usage barrier descriptor. See Figure 2-2 for the five different developmental levels.

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 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 (Niess et al., p. 9)."

Figure 2-2. Niess et al. (2009) mathematics TPACK developmental framework.

This developmental framework has been used in studies in mathematics education to show developmental levels of TPACK in pre and in-service teachers. Landry (2010) used the framework as the basis for assessing pre-service math teachers' TPACK development based on their responses to a self-report survey created to capture their TPACK. Chambers and Scaffidi (2010) used this developmental framework to guide value decisions about where participants in their study, on the use of spreadsheets, were in their TPACK development. Gillow-Wiles (2011) relied on the developmental framework in his case study of Masters' students in a Mathematics Education program. He used the framework in order to be able to make assessments of how the participants' TPACK expanded through participation in an online community of practice during their education. Ozgun-Koca, Meagher, and Edwards (2011) used the framework to describe not only a mathematics teacher's development of TPACK, but to elucidate on a non-linear development process for that development. The study in this dissertation generalizes the developmental framework beyond Mathematics to guide development of fixed- answer questions.

Prescriptions for TPACK development

As there is work towards measuring TPACK, there is also work towards specific prescriptions for developing TPACK. Niess (2005, 2008), at Oregon State University, has been on the forefront of the work to develop TPACK in mathematics teachers. Beginning in the early 2000's she began a concerted effort to develop TPACK through a two-year program wherein graduate level pre-service teachers took classes to develop not just pedagogical content knowledge, and technology knowledge, but also TPACK.

Similar programs to Niess's are being developed and enacted in teacher education programs throughout the US. At George Mason University pre-service undergraduate elementary school teachers take courses that are paired, wherein a course focused on PCK within a content area is paired with a course focused on the technology of that content area. The same instructor often teaches the two courses, but when they are not they instructors work together to assure that the students understand the intersection of the three different kinds of knowledge (C. Johnston, personal communication, May 12, 2010).

Many different professional development (PD) programs have been and are being developed for in-service teachers. These activities have spanned content areas and range from summer immersion programs to after school professional development activities (Brush & Saye, 2009; Guzey & Roehrig, 2009; Hughes & Scharber, 2008; Lee, 2009;

Lee et al., 2007; Niess et al., 2007; Richardson, 2008; Shoffner, 2009; Voogt et al., 2009).

Among the many PD programs to develop TPACK, there are a few to make specific note of. Koehler and Mishra (2005a) developed the Learning Technology By Design (LBD) program. LBD deviated from the typical PD programs of the early 2000-decade that had participants learning specific technologies to then use in the classroom. Instead it focused on authentic teaching design problems and had participants design solutions using technologies that would best fit their teaching needs as well as teaching environment.

For pre-service teachers, a corollary program to LBD is the Collaborative Lesson Design program (So & Kim, 2009). This program was formulated for pre-service elementary and secondary teachers to learn how to teach with technology using problem based learning (PBL). Within this program, participants integrated different kinds of information and communication tools (ICT) within the content areas of english, science and math to design ICT based PBL lessons.

Finally, Harris and Hofer (2009) have expanded on the notion of activity types to focus on different ways that in-service teachers can utilize technology into different content areas. Activity types, as used by Harris and Hofer (2009), are different pedagogical tools that can be planned into lesson plans. In the context of TPACK these activity types involve some sort of technology. As developed by Harris and Hofer (2009) they are specific to each content area, divided into knowledge building and knowledge expression activities, and can be easily planned into lessons by in-service teachers.

The programs mentioned above are not an exhaustive review of the TPACK professional development literature. It does show that researchers and teacher educators are taking note of the framework and attempting to work within it to help teachers become more adept at integrating technology into current pedagogical content practices.

Measuring pedagogical content knowledge

Measuring pedagogical content knowledge and technological pedagogical content knowledge has proven to be a challenge since Shulman first introduced the concept of PCK in 1986. In their review of studies that assessed pedagogical content knowledge, Baxter and Norman (1999) described three different ways of measuring PCK: convergent and inferential techniques, concept mapping, card sorts and pictorial representations, and multi-method ways of evaluating the knowledge. The convergent and inferential techniques include likert-type scales, self-report scales, multiple-choice, and short answer formats. The concept mapping techniques provide a way for teachers to visually represent their knowledge. Teachers describe their knowledge and how it links together, then the teacher or the researcher creates a map of the different kinds of knowledge expressed by the teacher and shows how those kinds of knowledge are linked together. If the researcher does this, the researcher then shows the teacher the map for any misinterpretations to be corrected. The multi-method techniques include data collection methods such as interviews, concept maps, and video-prompted recall.

Carlson (1990) described difficulties in trying to develop test items to measure PCK for the Connecticut Elementary Education Certification Examination. One of the problems faced in writing this exam was how to combine pedagogical and content knowledge in order to be able to assess pedagogical content knowledge. Further, because of the difficulty in defining PCK, the defensibility of the items being developed was made even more difficult. Rowan et al. (2001) worked on creating a similar type of measure of PCK. In their conclusion they remarked on the same difficulty that Carlson discussed – creating items that fully measured teachers' abilities and levels of PCK.

Recently Hill et al., (2008) created a measure of teachers' knowledge of content and students (KCS) that they describe as one part of PCK. One of the limitations they discuss in their measurement description is the difficulty in measuring teacher knowledge because their knowledge is not always easy to identify. Teacher knowledge encompasses things like what students know, but they also 'reason' about teaching and learning as well (Hill et al., 2008) which can be incredibly difficult to quantify.

Measuring Technological Pedagogical Content Knowledge

The difficulty in measuring PCK extends to measuring TPACK. The measure of TPACK, however, becomes even more difficult than PCK because of how many different kinds of knowledge are found within the framework. As discussed throughout this literature review, there still is not agreement in the scholarly community about exactly what TPACK is (Graham, 2011), and where the distinctions lie between TPACK, technological pedagogical knowledge, and technological content knowledge (Archambault & Barnett, 2010; Cox, 2008; Graham).

Assessment of the development or differences of TPACK in in-service and pre-service teachers has been described since it appeared in the literature. Between 2006 and 2010, 141 measures had been created to assess TPACK in many different teaching populations (Koehler et al., 2012). Koehler and colleagues' (2012) review of instruments to measure TPACK is extensive, but not exhaustive; other measurements do exist. These include, but are not limited to, case studies, performance assessments, self-report, rubrics to assess open-ended questions, rubrics to assess artifacts created, and multiple-methods in one study (Barett, 2010; Koehler et al., 2012; Graham et al., 2009; Hughes & Wen, 2010; Lambert & Sanchez, 2007; Lux, 2010; Niess, 2005; Pierson, 2001; Robertshaw & Gillam, 2010).

The case study method has been used by a number of researchers. It has been used to investigate specific subject matter development of TPACK in English, Social Studies, Science and Math (Hofer & Swan, 2008; Hughes & Scharber, 2008; Manfred & Bolick, 2008; Manfred & Hammond, 2007; Yesildere & Akkoc, 2008). The case study method has also been employed outside the context of specific subject matter (Mishra & Koehler, 2006; Pierson, 2001). Pierson's (2001) study is one example of the case study method. She used it to describe different levels of TPACK in three different in-service teachers, and evaluated their PK, TK, CK, and how technology was used in their classrooms to make a judgment about their level of TPACK.

Others have used multiple methods combined together to assess participants' TPACK. These methods include combinations of discourse analysis, pre-post surveys and content analysis to discover how teachers develop TPACK in specific subject areas (Kersaint, 2007; Koehler & Mishra, 2005a; Lambert & Sanchez, 2007; Niess, 2005, 2008; Niess et al., 2007; Richardson, 2006). An example of the multiple method is Niess (2005, 2008) where she describes development of TPACK in a pre-service education program. The evaluation of the development of pre-service teachers' TPACK uses a variety of methods including observation of teaching, analysis of lessons created, and being able to follow students' progress as they move through the program. The case study and multiple method way of evaluating teachers TPACK, although valuable, can be difficult to replicate, time consuming, and may not always be possible to implement in a professional development setting. Thus having a less time consuming, easier to implement, method for evaluating teachers' TPACK is needed.

A study of note in *this genre* is Mouza and Wong (2009), who used the case development method to understand how teachers' developed TPACK. Case development is a process by which learners design, enact and reflect on the design and enactment process in order to improve both learning and practice. It is a method that has not been used much in TPACK development. In the context of a college course on cognition and teaching, five in-service teachers utilized the case development process to enact a technology-based lesson in their classroom. Mouza and Wong found through analyzing the written case studies, interviews, and online discussion entries that the case development process did improve in-service teachers' TPACK. The participants were able to use technology in a meaningful way for their context; identified technology that met their learning objectives, and altered their pedagogy in order to be able to teach with the technology used.

Another method that has been employed to investigate how much TPACK participants have is through the use of a rubric (Harris, Grandgenett & Hofer, 2010; Robertshaw & Gillam, 2010). The Harris et al. (2010) rubric assess the amount of TPACK that can be seen in the lesson plans of pre-service teachers. This rubric aims to remove judgment based on the kind of pedagogy used in the lesson plan, as well as the kind of technology used. The Robertshaw & Gillam (2010) rubric assesses in-service teachers' responses to an open-ended question about what they need to know in order to teach with technology. This rubric has a specific technology context, being online learning resources.

The most popular kind of TPACK assessment instrument, currently, is self-report. These instruments have been designed to assess such areas as faculty members TPACK who are learning how to create online courses (Koehler & Mishra, 2005a); pre-service science teachers' TPACK (Graham et al., 2009); and online teachers' TPACK (Archambault & Barnett, 2010; Archambault & Crippen, 2009). Along with these context specific instruments, there has also been development of self-report instruments to assess pre-service and in-service teachers' TPACK outside of a specific content area (Jamieson-Proctor, Watson, Finger, Grimbeek, & Burnett, 2007; Lux, 2010; Schmidt et al., 2008; Shin et al., 2009). The instrument developed by Lux (2010) is important to note. Many of the self-report instruments assessed validity through the use of factor analysis (Archambault & Barnett, 2010; Graham et al., 2009; Jamieson-Proctor et al., 2007). Statistically, the vast majority of factor analysis on the self-report measures validated the view of many scholars – that the boundaries between TPACK, TCK and TPK are fuzzy (Archambault & Barnett, 2010; Graham et al., 2009), except for Lux (2010). Lux (2010) delivered his pre-service TPACK measure to 120 participants, and in an exploratory factor analysis was able to statistically discern between TPACK, TCK, and TPK.

One last instrument is important to note. Barrett (2010) set out to move the assessment of TPACK beyond the methods described above. As he stated, this would allow for confirmation of self-report findings. For him, this first step was to create a multiple-choice test to measure teachers' *technological pedagogical knowledge (TPK),* not TPACK. His instrument was made up of items adapted from state praxis exams for educational technology certification. Each item was aligned to educational technology standards created by the International Society for Technology in Education, and were validated by a pool of experts. 178 pre-service and in-service teachers were given the instrument to pilot. Reliability testing from this pilot test showed an adequate reliability for his exploratory purposes. This measurement is a valuable one and shows that measurement of a part of the TPACK framework can be done using fixed-answer questions.

Issues in Use of Self-Report Measures

As described above, many of the measures currently used in assessing TPACK rely solely on self-report. Although self-report does have value, it has also shown to be fallible (Darling-Hammond, 2006; Kagan, 1990; Mabe & West, 1983; Darling-Hammond, Wise, & Pease, 1983). The extent to which self-report generates reliable information about teachers' beliefs is debated (Fang, 1996). Social pressures also may influence responses, as some items may be rated higher to be seen as 'correct' (Kagan). People may make guesses or estimates about their internal states, which can be biased based on influences such as social desirability, self-esteem, or even want to get into a particular treatment or other program (Hill & Betz, 2005; Nisbett & Wilson, 1977). Due to guessing or estimating, people cannot always be objective about their own abilities (Mabe & West), thus there are often discrepancies between self-reported abilities and actual abilities in practice (Darling-Hammond). Finally, when the standard pre-survey – post-survey design is used, a participant may be filling out the post-test using a different perception lens than they used when filling out the post-survey. This can be caused by the treatment given to the participant, thus comparisons between the pre-post surveys can be like comparing apples and oranges (Howard, 1982; Rohs, 1999).

Mixed Methods in Instrument Development

This section will address mixed methodologies. The first section will include a general discussion of mixed methods as well as addressing epistemic beliefs in mixed-methods. A discussion of literature related to instrument development and mixed-methods will then ensue.

Defining mixed methods and epistemic issues in mixed methods

Mixed methods research is an emerging field that draws upon the strengths, and weaknesses, of both qualitative and quantitative paradigms (Teddlie & Tashakkori, 2003; Johnson & Onwuegbuzie, 2004). Whereas mixed methodologies draw from two other paradigms, it is not simply a mix of qualitative and quantitative epistemologies and methodologies, rather it is a third paradigm on its own (Johnson & Onwuegbuzie). It can be seen as a pragmatic approach to research (Johnson & Onwuegbuzie). Mixed-methods is difficult, because it forces researchers to be practiced in both qualitative and quantitative methodologies, as well as how to draw them together (Creswell & Plano Clark, 2007). It can be time-consuming as well. However, use of multiple methodologies can provide a better understanding of complex phenomena in ways that single methods cannot (Creswell & Plano Clark; Molina-Azorin, 2011). Finally, Collins, Onwuegbuzie & Sutton (2006) cite four areas where mixed methods are particularly useful: participant enrichment, instrument fidelity (both in creation and validation), treatment integrity, and significance enhancement.

One potential area of conflict between mixed methodologists and purists in qualitative and quantitative methods is in how epistemic lenses are used. Mixed methodologists posit that using methods from a particular paradigm does not limit the researcher to particular epistemic beliefs and the methodologies associated with that paradigm (Johnson & Onwuegbuzie, 2004; Long & Rodgers, 2010; Mertens, 2003). In a discussion on a transformative-emancipatory paradigm, Mertens points out that it has been standard to view post-positivist paradigms associated with quantitative methods and qualitative methods defined by more interpretive-constructivist paradigms. Mixed methods allow researchers to move beyond this dichotomy and view their research through an epistemic lens that is most appropriate to the researcher and purpose of the research (Johnson & Onwuegbuzie; Mertens). Thus, someone utilizing mixed methods can hold a critical epistemology if the purpose of their research is to examine power relations, or to promote change in communities to make them more equitable (Johnson & Onwuegbuzie; Koro-Ljungberg, Yendol-Hoppey, Smith & Hayes, 2009; Mertens).

Instrument development using mixed methods

The use of mixed methods for instrument development can be particularly advantageous. In a study investigating child youth resilience across cultures, researchers (Ungar & Liebenburg, 2011) used data from a qualitative study to create items for a fixed-answer measurement to measure youth resilience to adversity within their communities. Using a mixed method approach allowed them to ground their quantitative instrument in the experiences from the multiple cultures and contexts that their participants would come from.

Another study used the same process to develop an instrument for a multi-year project in Sri Lanka (Nastasi, Hitchcock, Sarkar, Burkholder et al., 2007). Utilizing a multi-phase sequential methodology to assess the mental health of Sri Lankan adolescents, researchers were able to create an instrument that used scenarios tied to questions that were culturally relevant. Qualitative methods were used in this study to inform the development of the instrument and then quantitative methods to validate it (Nastasi et al.).

A study investigating household perspectives on the removal of explosive instruments of war used in-depth and semi-structured interviews, as well as themes from a literature review, to create a multiple choice instrument (Durham, Tan, & White, 2011). The data from the focus groups and interviews were analyzed through the lens of the research questions as well as guidance from another questionnaire in the same field. The use of focus groups, interviews, and literature allowed for researchers to bring both etic (outside) and emic (inside) perspectives to the instrument. Quantitative methods were then used to assess for validity and reliability on the instrument (Durham, Tan & White).

Conclusion

The purpose of this literature review was to understand how scholars investigating the TPACK and PCK frameworks were conceptualizing technological pedagogical content knowledge, pedagogical content knowledge, and their constituent parts. Conceptualizing in this case means to understand which teacher behaviors and knowledge scholars were attributing to the frameworks, and their parts, in order to guide development of the interview and focus group protocols used in the next phase of this study. This information was also used in the following phase, the item development phase.

Another purpose of this literature review was to look at existing instruments for assessing and measuring TPACK and PCK. This literature review does not contain an exhaustive review of every instrument, but rather looks at types of instruments, and reviewed specific instruments within those categories. This literature review also discussed a developmental model (Niess et al., 2009) for mathematics that has been used in research with pre and in-service mathematics teachers. This model was reviewed, as well as some studies that used it as the basis for evaluating TPACK development in study participants. This dissertation study used this developmental model to evaluate statements about TPACK behaviors and knowledge in the qualitative analysis in phase one and as a guide for writing answers to questions during the item development phase (phase two). In reviewing this developmental model COMMA it also made sense to review work towards developing TPACK in in-service and pre-service teachers. The bulk of this section focused on work with in-service teachers as that is the population this dissertation study focuses on. This literature review also reviewed some literature pertaining to issues with self-report in assessing knowledge. Since the purpose of this study was to move beyond self-report on surveys assessing TPACK, identifying some of the limitations to self-report measures was important in making the case for moving in a different direction in measurement of TPACK.

Finally this review examined literature from the emerging field of mixed methods.

The purpose of this was to provide examples of existing measures that have used a similar methodology as the one used in this dissertation.

CHAPTER III

PHASE I STUDY

The purpose of this phase of this dissertation study is to gain a greater understanding of the emic and etic perspectives of TPACK, including the knowledge included it, behaviors expressed when someone has TPACK, and attitudes about TPACK. This phase of this dissertation study addressed the following research questions using TPACK as the analytic lens:

1. How do teachers and teacher educators describe technology knowledge when applied to a teaching and learning context?
2. How do teachers describe their current technology use behaviors in a teaching and learning context?
3. What do teacher educators convey about technology use in a teaching and learning context to pre-service teachers?
4. What attitudes do teacher educators hold about the use of technology in a teaching and learning context?

As stated in the introduction, the emic perspective is the view of a culture or context that comes from within; the etic perspective is the view of the culture or context from the outside. In this study the basic assumption is that the in-service teachers hold the emic perspective of teaching and learning in a K-12 classroom whereas the teacher educators hold the etic perspective (Onwuegbuzie, Bustamante & Nelson, 2010). This can be considered true for all the research questions except for number three, in which it is expected that the teacher educators draw upon their own experiences teaching in a K-

12 classroom when teaching their methods courses as well as from research (their own and others) about best practices. Thus in the case of research question three, the teacher educators hold both the emic and the etic perspective.

To answer these four questions, a qualitative methodology is employed, using a constructivist lens. It served to gather a snapshot of technology use knowledge by a small group of in-service teachers and teacher educators. Although the following findings cannot be generalized as a stand-alone study (Gall, Gall & Borg, 2006; Miles & Huberman, 1994; Denzin & Lincoln, 1994), the themes described in the findings and discussion sections can be used to inform the development of a quantitative instrument (Durham, Tan & White, 2011; Onwuegbuzie, Bustamante & Nelson, 2010; Ungar & Liebenburg, 2011).

The methodology section-describes the constructivist epistemology used, the technology context for the study, the participants, how trustworthiness and credibility were established, and finally the analysis procedure.

Methodology

Epistemology

Constructivist epistemology states that cognition is re-conceptualized not to find truth but rather to construct something that fits together cognitively (Schwandt, 1994). Further, constructivism posits that individuals construct social reality differently and express it through different manners and processes (Gall, Gall & Borg, 2006). Researchers use constructivism to describe the perspectives, experiences, values and beliefs of an individual or group of individuals (Koro-Ljungberg, Yendol-Hoppey, Smith

& Hayes, 2009).

Thus this researcher used a constructivist epistemology, since the goal for phase one was to understand the beliefs, perspectives, values and experiences of the teachers and teacher researchers with the knowledge encompassed in the TPACK framework as defined by their particular social realities. Specifically, this researcher wanted to understand the differences between in-service teachers and teacher educators in knowledge, attitudes and beliefs related to teaching in a K-12 classroom.

To do this investigation within a constructivist epistemology, a naturalistic inquiry was used, allowing the researcher and the object of inquiry to interact in a manner that fully exploits the natural advantages of the human research instrument (Lincoln & Guba, 1985). Naturalistic inquiry also encourages purposeful sampling, so the researcher is fully aware of how bias can impact the findings of the study (Appleton & King, 1997).

Within this study the researcher had previously established relationships with all but one of the participants by working with the in-service teachers in the DL Connect workshop (described in more detail below) and through interactions with two of the three teacher educators in meetings of a science methods research group. The researcher could draw on previous interactions during the interviews and the focus groups. The purposeful sampling and reasoning for it is also described in more detail below.

Procedures

A semi-structured focus group was used for the three teachers. Since much of teacher knowledge is tacit (Kagan, 1990; Lawless & Pellegrino, 2007), it was assumed that a group setting would help the teachers put voice to that knowledge. The focal point was a web-based tool called the Instructional Architect (IA) and online learning resources. See Appendix A for the focus group protocol.

The teacher educators were also interviewed individually using semi-structured interviews, not focusing on the specific technology context of the IA and online learning resources, but instead on how teacher educators teach pre-service teachers to think about integrating technology into the classroom. See Appendix B for the protocol for the interviews with the teacher educators.

Trustworthiness and Credibility

Trustworthiness and credibility (Lincoln & Guba, 1985) of the findings were established through triangulation across the literature, triangulation across the cases, member checking during data collection and after analysis, and having a baseline set of questions given during the interviews and focus group.

Member checking was achieved during the interview and focus group process with follow-up questions such as “What I am hearing is that all of you think about content first when you are designing your instruction” followed by an affirmative answer. If questions like this were not answered with a yes, further questioning occurred so that the researcher could change any misconceptions. Also, during the analysis phase, emails were sent to two out of the three teacher educators to follow up on comments made during interviews.

Triangulation occurred as a part of the analysis phase. When similar statements were noticed across the focus group and interviews, the data was examined to see if the statements appeared in three out of the four data sets (three interviews and one focus group). Triangulation with the literature occurs in the discussion section of this chapter, The main body of literature coming from works related to the TPACK framework. One theme, on lesson design, also pulled from instructional design literature as well.

Finally, during the interviews and the focus group, a scenario was given to all participants and the same questions were asked of the teacher educators as well as the in-service teachers. This helped to establish a baseline across the participants and helped to establish the credibility of the themes and added rigor during the analysis phase (Shoefelder, 2011). See figure 3-1 for the scenario given, and Appendices A and B for the interview and focus group protocols where the questions about the scenario can be found.

> Jyoti has been teaching a unit on the ocean as a part of the 6th grade core curriculum for science. One lesson in the unit is about wave formation. Recently there was a tsunami in the southern Indian Ocean and so Jyoti decided to have her students write mock news articles on the tsunami. In their news articles they would need to describe what a tsunami is, different ways that they form, why this recent one happened and what it was it was like to be in its path. In order to write their articles Jyoti's students would need to turn to the web – where there was information about what caused the tsunami, videos of what the tsunami looked like, and reports from those who were in its path – and to resources in the library. The students would have the option of turning in their articles on paper, or to write them on a webpage. In order to help her students accomplish this task Jyoti has already searched the web for resources and provides lists of them for each area to be covered. To accomplish the task she has her students work in groups of four, each finding information on one area to be covered in the mock article. After finding the information they need on their own the members of the group come back together to share the information with each other and then write the article.

Figure 3-1. Scenario presented to all participants.

Analysis

Analysis Procedure. Using a deductive process, data from the interviews and the focus group was analyzed using the constant comparative method (Glaser & Strauss, 1977). The data was coded using predefined categories (Corbin & Strauss, 2008) that were TPACK and its constituent parts. This is similar to the method used by Hughes (2010), Niess (2010) and Polly (2011) to identify descriptions of TPACK by participants. A six-stage process was used to derive themes from the data. See table 3-1 for a summary of the analysis steps detailed below.

One area coded for but not described as a specific part of the framework, was the teaching and learning context. As stated in the literature review, the teaching and learning context is seen as influencing the framework (Cox, 2008; Mishra & Koehler, 2006). Coding for the teaching and learning context was done based on findings from prior research completed by this researcher (M. Robertshaw, 2010) and comments made during the focus group with teachers. The teaching and learning context includes access to technology, nature of school environment, demographics of students, and support of teachers using technology (Cox; Kelly, 2008; Mishra & Koehler).

The first round of analysis was conducted to become more familiar with the data. In this round the data was coded for instances of the TPACK framework; these instances included all seven parts of the framework (TK, PK, CK, TCK, TPK, PCK, & TPACK) and the teaching and learning context. During the second round of analysis the focal point continued to be on the TPACK framework and the teaching and learning context, but some coding of subcategories began. These subcategories included utterances about development of TPACK, PK, and TPK; pedagogical issues concerning classroom management and types of pedagogies used in the classroom (PK); designing instruction with technology (TPACK) and use of technology in the classroom (TPK). It was during the third and fourth rounds of coding that exploration of subcategories occurred more in depth. In the third round of coding there were a total of 45 categories and subcategories.

These subcategories included topics such as the lesson planning process in pedagogical, technological pedagogical, and technological pedagogical contentment knowledge situations; finding online learning resources in TPACK situations; student issues in TPK; PK, and TPACK situations; student assessment in PK, and development of TPCK, PK and TPK. During this round of coding there were eight categories with only one utterance. There was one category with twenty-three utterances (development and decision making in TPK), and one with 21 utterances (developing TPACK). In the fourth round of coding there were 44 total categories including most of the same topics covered during the third round. During this round there were five categories with only one utterance and two categories with twenty-four utterances each (delivering instruction in TPACK, and developing instruction in TPACK).

It was during the fourth round of coding that it became apparent that this strategy for coding would not work well in producing adequate themes for construction questions and answers during phase two. The reasons were because there were too many categories to work with for constructing questions and answers for phase two, the great disparity of utterances across the categories, and the researcher's concern that using TPACK, TK, and other parts of the framework as final themes would make question construction difficult. This conclusion was reinforced by feedback given after a presentation of findings to the DLConnect research group after fourth round of coding. Categories were collapsed during the final two rounds of coding. They were collapsed into themes that represented not only parts of the TPACK framework, but also behaviors, attitudes and kinds of knowledge, that are a part of the framework and that would be more useful in constructing questions in phase two of this study. The collapsing of themes during these last two rounds of coding led to six themes related to teaching and learning, which are aligned with the TPACK framework. See table 3-3 for the final six themes and samples from the data that represent each theme.

Table 3-2 illustrates a specific example of how one utterance used in this study was coded through all six steps of the analysis. The utterance used in the example in Table 3-2 is “It's okay if it presents materials, but it should go beyond that, so it shouldn't be just learning from technology, it should be learning with technology.” In step one the utterance was simply coded as TPACK as it addresses teaching with technology and was said in a Science teaching context. Step two, where some sub-categories began appearing, shows the utterance coded as “TPACK-pedagogical practice.” In step three the sub-categories expanded to be more specific and thus the utterance was coded as “TPACK–pedagogical practice-teaching with. The utterance remained in the same category in step four of the analysis. In step five only those utterances labeled “TPACK – pedagogical practices – active” or “TPACK – pedagogical practices – passive” were kept and were combined into one category. It was in step five that the dichotomy between in-service teachers and teacher educators appeared. In the final step of the analysis, step six, this category remained but was renamed to “passive versus active learning with technology.”

It is important to note that through all rounds of coding, there was a dearth of utterances related to content knowledge, and technological content knowledge. Although technological pedagogical knowledge and pedagogical knowledge were represented more thoroughly in all phases of the analysis, as the final categories were being formed it was decided by the researcher to focus on themes related to TPACK, TK, and context. This was due to two major factors: researcher bias towards particular themes and triangulation across the data. The final themes that came from the data were of most interest to the researcher partially due to the illustration of the disconnect between what the teachers are doing in the classroom versus what teacher educators think should be happening in daily practice. These six themes were also most strongly triangulated across all four data sources and all participants.

Table 3-1
Summary of data analysis steps

Step	Purpose
1	Analysis of focus group and interview data for illustration of the TPACK framework constituent parts, as well as the teaching and learning context, within responses. This was a first coding to become familiar with the data.
2	Re-coding data for representations of the TPACK framework and the teaching and learning context. Some subcategories showed up in this coding round.
3	Coding for representations of the TPACK framework, the teaching and learning context occurred, as well as expansion of the number of subcategories. Total number of categories coded for in this step was 45.
4	Continued coding representations of the TPACK framework, the teaching and learning context and exploration of subcategories. Total number of categories coded for in this step was 44.
5	Coding data to collapse elements of teaching categories within each part of the TPACK framework in order to make the data easier to work with in creating questions in phase two of this study.
6	Final step in coding data and collapsing categories and subcategories. This round led to six themes found within the data. These themes align with both parts of the TPACK framework as well as elements of teaching.

Table 3-2
Example of how one utterance was coded throughout analysis steps

Utterance

“It's okay if it presents materials, but it should go beyond that, so it shouldn't be just learning from technology, it should be learning with technology.”	
Step	How utterance was coded in each step
1	TPACK
2	TPACK – Pedagogical practice
3	TPACK – Pedagogical practices – active
4	TPACK – Pedagogical practices – active
5	TPACK – Pedagogical practices – active and passive
6	Passive versus active learning with technology

Table 3-3

The six themes derived, alignment to the TPACK framework, and data samples for each.

Theme		
TPACK alignment	Data sample from teacher educator interview	Data sample from in-service teacher focus group
Passive versus active learning with technology		
TPACK	“It's okay if it presents materials, but it should go beyond that, so it shouldn't be just learning from technology, it should be learning with technology.”	“A lot of it is, for me, it's enrichment type stuff. It’s a little bit harder for me to get all 140 students more for them to do.“
The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there.		
TPACK	“I think that sometimes teachers will find a website and say I'm going to use it with my students and they don't consider the pedagogical issues.”	“One day when she [the student teacher] was gone they asked, "Why doesn't she use this? It's so much better, much more fun." I said - we're teaching the exact same thing, the same material in the same way and they said, "Yes, but you are using the computer and she's not.
Access to technology		
Teaching and learning context	“This [referring to digital microscopes] would be something that I could see not being very hard at all for a group of elementary education teachers to pool $25.00, especially if you could find them cheap and buying 3-4 of these things and then it could be a grade level resource. It's not just this; it’s having access to the computer. One thing I've found is that you just take these things to the computer lab and it's simple to load the software and what I used to do is give it to the IT guy and they load it.”	“I'm sure it's this way at your [referring to the other two teachers] school - you sign up for a day in the lab for your classes. I've got four of the same class and I'd like all of us to go in on the same day. My classes are bigger and sometimes there's not enough computers. Sometimes it's just a matter of scheduling the lab.”
How instructional materials are designed		

TPACK	Jack, a science methods professor, concurred about the focus on content first when he described one of his pre-service teacher's thoughts about planning a lesson. "She just thought 'I would like for them to go back there, run some reactions, have their hand at designing, find out the answer to a question they have.' " The content in this case was the scientific experiment process.	"We are really driven by core, we really are driven by that, and so, we say I need to teach this, how do I teach it best, what sounds cool, what's exciting, how are they best going to respond to this."
View of technology as it relates to teaching today.		
TPACK	"If you think about what they used to do in educational media, it was basically supplemental things to the learning - filmstrips, bulletin boards - all that stuff - you could [now] do it online."	Sonia, a middle grades in-service English language teacher, was very direct about this. She commented about the new versus the old media, "No, it's not different. It's how can it assist me to make it more interesting in my classroom."
Need to learn basic technological skills		
TK	"Sometimes we run into big problems because I take for granted that, because I feel like if the technology is important to me I'll learn how to use it. I don't think that pre-service teachers-- some will be more capable than me and some will be less, and because of that wide range, one of my problems so far is that I just assume that it's going to take care of itself and it doesn't."	On use of clickers: "They sat in a box for 6 months until I learned how to use them."

Definitional lens of analysis. The definitions used to examine the data aligned as much as possible to the definitions of the framework given by Cox (2008). See Table 3-4 for a summary of Cox's definitions. Cox derived these definitions from a careful analysis of the, then, existing literature and interviews with experts on the framework. This researcher used Cox's work to make a set from the many different definitions of the framework and its parts.

Table 3-4
Cox's Definitions of the TPACK Framework

TPACK framework part	Cox definition
Technological Knowledge	"Technological knowledge is defined as knowledge of how to use emerging technologies. The definition is confined to emerging technologies in order to illustrate the difference between TPACK and PCK (p. 73)."
Pedagogical Knowledge	"Pedagogical knowledge is the knowledge of general pedagogical activities utilized by a teacher. General activities are independent of a specific content or topic (meaning they can be used with any content) and may include strategies for motivating students, communicating with students and parents, presenting information to students, and classroom management among many other things. Additionally, this category includes general activities that could be applied across all content domains such as discovery learning, cooperative learning, problem-based learning, etc. (p. 71)."
Content Knowledge	"Content knowledge is simplified to indicate a knowledge of the possible topic-specific representations in a given subject area. These representations might include models of electron flow in science, graphs of data in mathematics, or timelines in social studies (p. 71)."
Pedagogical Content Knowledge	"Pedagogical content knowledge combines knowledge of activities and knowledge of representations in order to facilitate student learning. The knowledge of pedagogical activities here is content-specific rather than general because PCK is situated in a particular subject area (p. 72)."

Technological Pedagogical Knowledge	"[TPK] is a knowledge of the technology- pedagogy interaction independent of topic-specific representations or content-specific instructional strategies. An individual with this type of knowledge understands how technology could be used with general pedagogical strategies that could be applied independent of the specific content or topic being taught (p. 76).
Technological Content Knowledge	"[TCK] is a knowledge of the technology- content interaction independent of pedagogy. An individual with this type of knowledge understands the impact of technology on the representations of a discipline without a need to understand how those representations might be used in teaching (p. 75)."
Technological Pedagogical Content Knowledge	"Knowledge of the technology- pedagogy-content interaction in the context of content-specific instructional strategies and topic- specific representations. An individual with this type of knowledge understands the role of technology as part of content-specific instructional strategies to convey particular content representations. This definition quickly demonstrates that TPACK includes all three areas of knowledge. Additionally, it highlights the use of content-specific strategies, setting it apart from TPK (which utilizes general pedagogical strategies) and TCK which is independent of pedagogy (p. 78)."

Teacher professional development and technology context

The teacher professional development context of this study is a series of professional development (PD) workshops offered for in-service teachers delivered by the DLConnect research group, formed to aid teachers' classroom use of online learning resources. The PD series aimed to help teachers develop two main skills: a) to use the Instructional Architect tool and; b) to integrate online learning resources into instructional materials developed using the IA.

The IA is a simple, web-based tool that allows teachers to *find* resources, *annotate* around them, and *create* online materials with them, called IA projects (Recker, 2006).

Figure 3-1 shows an example of an IA project with one of the resources used in the project.

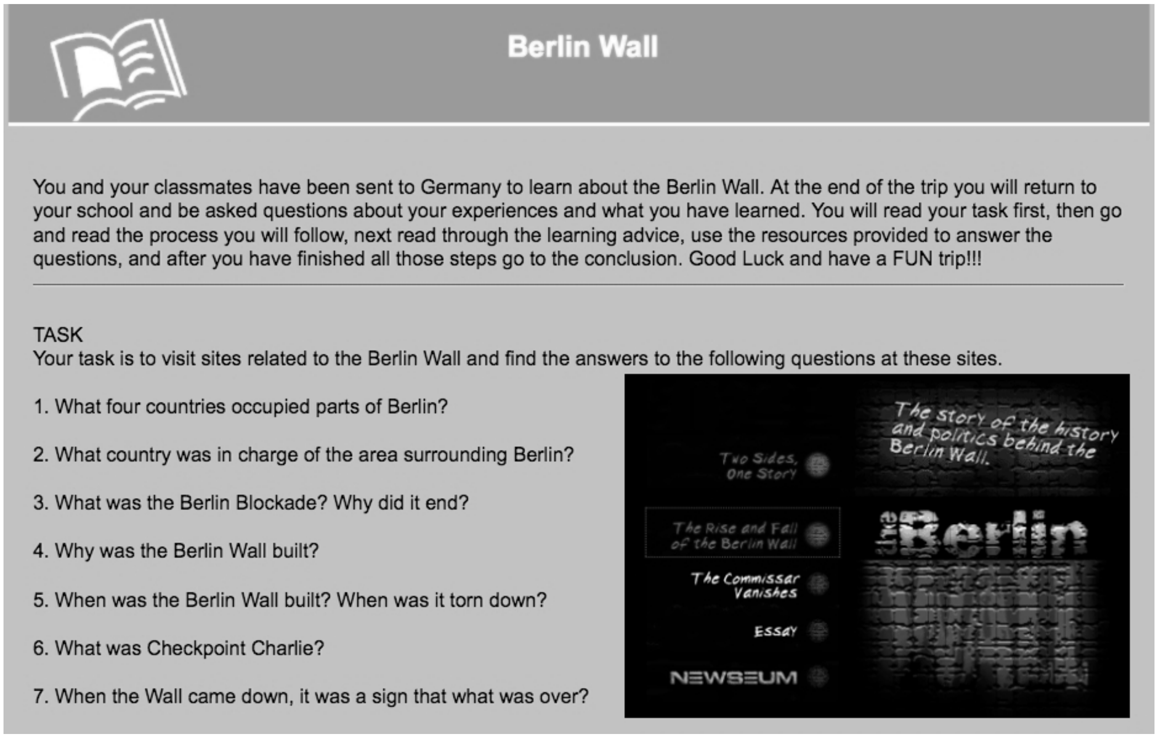

Figure 3-1. An IA project with a resource used in the project overlaid in the corner.

In-service teachers participating in the DLConnect PD attended a series of two to four workshops. The series took participants through a logical progression of learning basic technology skills, then technological pedagogical skills. They also had an opportunity to reflect on content through the use of a quality rubric designed to evaluate IA projects. The workshop series used groups, self- reflection, direct instruction, inquiry learning, and the IA to reinforce the skills taught. Participants were asked to fill out a pre- and post- workshop survey. The survey measured knowledge, attitude, and behaviors related to technology and, specifically, the use of online learning. The survey used a 0-4 point likert scale, with 0 indicating low knowledge, behavior, or attitude and 4 indicating high knowledge, behavior, or attitude. Teachers also provided demographic information about their current job.

Participants

Teachers were selected for this study based on their technology knowledge and assumed pedagogical knowledge based on number of years teaching, self-reported on the survey delivered by the DLConnect research group to workshop participants. For the pedagogical knowledge indicator, only teachers who had been teaching for more than three years were selected for participation in this study. According to Linda Darling-Hammond (1999), teachers who have less than three years of classroom experience are less effective. Another indication of teacher quality is participation in professional development opportunities (Darling-Hammond), a quality the participants possess. For technology knowledge, those with a self-reported mean of 2.5 and greater on technology knowledge questions on the survey were considered. The combined requirements meant that teachers to be considered had to have been teaching for 3 or more years and have a mean on self-reported technology knowledge of 2.5 or greater. The three teachers who participated in this study are as follows (pseudonyms used):

- Sonia is an English language learner teacher in middle grades at a rural school in the Rocky Mountain region of the United States. She had over 20 years of teaching experience, and scored 3.5 in self-reported technology knowledge on the DLConnect Survey. The researcher worked with Sonia during the DLConnect workshop she attended.
- Katherine teaches advanced placement English to 11^{th} and 12^{th} graders at a

rural high school in the Rocky Mountain region of the United States. She had eight years of teaching experience and scored 3.0 in self-reported technology knowledge on the DLConnect Survey. The researcher worked with Katherine during one DLConnect workshop as well as observed her teach with the Instructional Architect.

- Maren is a science teacher at a rural middle school in the Rocky Mountain region of the United States. She had over 20 years of teaching experience and scored 3.5 in self-reported technology knowledge on the DLConnect Survey. The researcher worked with Maren during two DLConnect Workshops she attended, as well as observed her as a part of a research project conducted by the DLConnect group.

The demographics of the in-service teachers are important to note. All three were white women, part of the majority culture in this rural area of the Rocky Mountains. Having a more diverse group of in-service teachers may have shown different findings.

In addition to the in-service teachers, three teacher educators were selected because they are professors in a teacher education program and they instruct their pre-service teachers in technology use in the classroom. The sample was purposeful, two out of the three teacher educators were known to this researcher prior to interviewing them. The three teacher educators who participated in this study are as follows (pseudonyms used):

- Laura is an assistant professor at a research university in the Rocky Mountain region of the United States. She teaches elementary science methods and had taught at the K-12 level prior to entering academia. She does some instruction in using technology in her methods classes. The researcher knew

Laura through other projects.

- Peter is an assistant professor at a research university in the Mid-Atlantic region of the United States. Peter teaches elementary math methods and had taught at the K-12 level prior to entering academia. Among the courses Peter teaches is a technology for math course Peter was not known to the researcher prior to interviewing him. Peter was referred to this researcher by a professor at the researcher's institution, a former colleagues of Peter's.
- Jack is an associate professor at a research university in the Rocky Mountain region of the United States. Jack teaches secondary science methods and had taught secondary science in the United States prior to entering academia. He is working to include more instruction in the use of technology in his methods class. One of his research interests is the use of technology in science instruction. The researcher worked closely with Jack on a number of projects including acting as a teaching assistant for a Science methods course.

Findings

In seeking to answer the research questions, stated in the introduction to this chapter, as well as to create trustworthiness and credibility in the findings, triangulation across the teachers and teacher educators was sought out. Some of the discussion with the teacher educators was how they felt about the use of technology, not just about what they convey to their pre-service teachers. This created six themes, described in the next paragraph, across the combined data from the teachers and teacher educators. These themes convey behavior of and, knowledge used by teachers, as well as knowledge transmitted by the teacher educators and their attitudes towards use of technology. The themes also showed dissonance between the in-service teachers and the teacher educators in some areas related to using technology in the classroom.

Those themes showing dissonance between the in-service teachers and the teacher educators were:

- access to technology teaching and learning context;
- passive learning versus active learning with technology (TPACK);
- need to learn basic technological skills (TK); and
- the use of technology for specific, objective oriented, teaching and learning ends, rather than because it's there (TPACK).

The themes showing-alignment between the in-service teachers and teacher educators were: (a) how instructional materials are designed (TPACK); and (b) views of computer technology today as it relates to teaching (TPACK). See table 3-5 for the themes, and their alignment to the TPACK framework, and the research questions each theme answers. The next two sections will first discuss those themes and areas of tension between the two groups and then conclude with themes showing agreement.

Table 3-5
Themes and alignment to TPACK framework and research question answered

Theme	TPACK framework alignment	Research question addressed
Differences between in-service teachers and teacher educators		
Passive learning versus active learning with technology	TPACK	1, 3, 4
The use of technology for teaching and learning guided by specific learning	TPACK	1, 3, 4

objectives, rather than just because it's there.		
Access to technology	Teaching and learning context	2, 3, 4
Need to learn basic technological skills	TK	1, 3
Alignment between in-service teachers and teacher educators		
How instructional materials are designed	TPACK	2, 3
Views of computer technology today as it relates to teaching	TPACK	1, 3

Differences between the in-service teachers and teacher educators

Passive learning versus active learning. All the teacher educators indicated that they teach their students to use active learning pedagogies when teaching with technology. In active learning pedagogies, students are involved in constructing their own learning; inquiry-based pedagogies are examples. On the other hand, the in-service teachers consistently described using technology in more passive ways in their classroom. In passive learning pedagogies, the teacher delivers the knowledge, direct instruction is one example. In this pedagogical context active learning is defined as the use of inquiry based methods in which students create knowledge with facilitation from their teacher.

Laura, an elementary science methods professor, discussed the use of digital microscopes in small groups:

> "I think that this, that using technology has really the value for me is that this has forced to not have to just tell the students something, and you don't have to just say hey these are just parts of the flower. You can put the flower under the microscope and really see the parts of the flower. It helps to promote the inquiry learning. They can see the pollen and they're like wow, this is what this is there for to catch

> the pollen. Whereas before it would have been more difficult and the teacher would have been more inclined to just tell them."

In this statement Laura views the digital microscopes as a way of aiding teachers in using inquiry based methods. Further, this statement indicates that Laura views the technology as aiding, if not almost forcing, the teacher into an inquiry based, active learning and teaching methodology.

Laura illustrated, again, her wish for students to actively learn with the technology rather than passively acquire knowledge from it when she spoke about improving the scenario.

> "Are they just reading text or are they actually seeing a simulation on the computer, where you can see the wave coming in and it hits the shore? I guess more interactive things as to why they form and not just reading the text."

Jack, a secondary science methods professor, furthers this thought about active learning after observing a pre-service teacher using probeware technology with students (probeware: scientific equipment used to collect, analyze and interpret data).

> "I would like for them [the pre-service teacher's students] to go back there, run some reactions, have their hand at designing, find out the answer to a question they have. But the students went back there and they are so used to using technology and so they pulled out the probeware and they were doing it and grabbing instantly quick data."

Jack further clarified the role he thinks technology should play. "It's okay if it presents materials, but it should go beyond that, so it shouldn't be just learning from technology, it should be learning with technology."

On the other hand, Sonia, an in-service English language teacher, describes her use of technology in the classroom largely as being for whole class exercises with the technology mainly being controlled by her and the knowledge coming from her, in this example, she is using a Kindle [an electronic reader], and her overhead projector:

> "The kids were talking about Hunger Games and so I downloaded it to my Kindle, stuck it under my document camera, pushed the function button and it reads the book and they got so excited watching the words go through on the Kindle and having someone read it."

Another example from-Sonia's classroom: "All my vocabulary testing is done with the clickers. The tests are on my computer, they have 3 seconds, I just keep it true false, mine don't have the QWERTY keyboard."

Wheras this illustrates a time saving technique for assessment of student knowledge, she doesn't demonstrate in either example how her students are using technology to explore and learn with it. Her examples simply show that her behaviors with technology are on the passive end of the active-passive learning spectrum. The students are passively using clickers for assessment purposes as they answer-fixed-answer questions.

Katherine gives another example of the teachers using technology in passive learning. Katherine teaches advanced placement English to eleventh and twelfth graders. She describes her use of the computer lab with her students: "A lot of it is, for me, it's enrichment type stuff. It's a little bit harder for me to get all 140 students more for them to do." She also describes using technology for assessment:

> "There's the site - the clickers. I don't have clickers but I found Poll Everywhere,

> and they can use their cell phones and the kids love it and they can get their cell phones out and type in answers and it's great. They love to do it."

The in-service teacher participants continuously describe their behaviors with technology in passive learning pedagogical contexts, whereas the teacher educators get pre-service teachers to utilize active forms of pedagogies as the optimal method for teaching with technology.

This tension between active and passive pedagogies with technology most likely stems from the teaching and learning context from which the two groups come. Teachers face the day-to-day challenges of teaching students who have to perform well on nationally mandated, end of year testing. Teacher educators are working to change the face of teaching in the classroom and are thus focused on developing new ways to help increase achievement by K-12 students.

The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there. Teacher educators want teachers to use technology teaching specific learning objectives, not simply because the technology is there.

Peter, an elementary mathematics educator, addressed this issue when he talked about teachers not being as thoughtful about using technology as they could be.

> "You can have someone who knows, for example, iPhones left and right, but if they don't know how to use that to support good instruction, then there's no point in using an iPhone in the classroom, or a clicker, or survey monkey, or spreadsheets, or whatever the tool is."

He made this point more emphatically by saying:

> "You can't put the cart before the horse. You really need to think about your objective for the lesson and then can you find a technology tool that's going to support it. Sometimes teachers do the reverse. They pick a technology tool and then they try to find some obscure objective that might meet it or not."

He further illustrated his point in this comment about how teachers sometimes use websites they find: "Yes, I think that sometimes teachers will find a website and say I'm going to use it with my students and they don't consider the pedagogical issues."

Jack, a secondary science methods professor, illustrated this point through his discussion again about probeware – a technology used in science teaching– and how if it isn't the right technology to use for the specific pedagogical purpose, it shouldn't be used. He specifically said,

> "So I envision technology kind of taking, being in that role of probeware - "I love it, I've got it there and anytime I need to find something I'll try to use it, but if what I need to find out doesn't match that probeware, then I just go and look for something better." So it's kind of got a pay off to it, the dividends, it's got a pay off, there has to be more benefit to using the technology."

So, for Jack, as with Peter, when a teacher is using a technology to teach specific content to students, it should be integrated, rather than a stand-alone piece without any solid learning goals.

The ideas of both of these teacher educators stand in conflict with the descriptions of how technology is used by the teachers in this study. Although all the teachers described using technology to further their students' learning, the driving force for doing so appeared to be because they believe students will be far more motivated if they use technology, no matter what the pedagogy.

Sonia, an in-service English language teacher, described this incident in her classroom when she had a student teacher working with her:

> "I just had a student teacher and she's very good, but she's scared to death of the writing tablet and in teaching. When she's been teaching the writing stuff, she puts the prompts on the board, puts things on the white board, and once in awhile she's put stuff on the doc camera. I teach the same material, same way, but I've got my textbook online, I can alter it with my writing tablet. The kids respond better. One day when she was gone they asked, 'Why doesn't she use this? It's so much better, much more fun.' I said - we're teaching the exact same thing, the same material in the same way and they said, 'Yes, but you are using the computer and she's not.'"

In this statement, Sonia appears to be driven by her students' thinking that the use of the technology is more fun. She doesn't describe what she knows about how the technology is being used for specific learning objectives. It's almost as though what she knows about using technology is that it motivates the students because it's "fun" and "cool." Although motivation is one important and complex reason for using something in the classroom (Keller, 1987), use should be part of a more thoughtful pedagogical reasoning process.

Among the three teachers in the focus group for this study, Sonia wasn't the only one to talk about motivation as a reason for using technology in her classroom. Maren, a middle school science teacher, compared teaching now to teaching before technology became so prolific in western culture.

> "Pulling out stuff from previous years, that's not going to cut it anymore, we're going to teach it this way. So lots of revising to use technology in whatever way I do. But, kids give you such immediate feedback by attitude, by their disinterest or their excitement."

In this statement Maren implies that she believes her students' interests are driven by technology and that in order to be able to effectively teach today's students, she believes that technology needs to be used or else students will quickly loose interest.

While motivation is important, it should be a part of a more reasoned pedagogical process. When listening to the voices of Maren and Sonia versus Jack and Peter, how can teacher educators encourage seasoned teachers to combine the two reasons to use technology – to both motivate students while also using it for rich, learning experiences?

Access to technology. In-service teachers cited access to technology as a barrier and felt that this lack of access impacted their pedagogical decisions to use technology. Katherine, the advanced placement English teacher, commented about having access to the computer lab when talking to another teacher in the focus group:

> "I'm sure it's this way at your [referring to the other two teachers, Maren and Sonia] school - you sign up for a day in the lab for your classes. I've got four of the same class and I'd like all of us to go in on the same day. My classes are bigger and sometimes there's not enough computers. Sometimes it's just a matter of scheduling the lab."

Maren, a middle school science teacher, concurred with Katherine by bluntly stating "We are really hampered by that." To which Sonia, an English language teacher, also agreed, stating,

> "I'd bet it's more so for the science people, at least in my school. The English lab can handle two classes, so for science and math teachers, they're lucky to get in there once a month, whereas the English teachers can get in there once a week."

All three teachers agreed on a question about the lack of access impacting their pedagogical decisions, with Maren adding, "I'd have my kids all doing podcasts. I'd have the kids doing a lot of different things." Katherine also commented that because of the lack of time and access to computers that using technology simply becomes enrichment for her advanced placement students.

In addressing this access problem within the context of the interview, the teacher educators down played this issue. Peter, an elementary math teacher educator, in reference to the scenario presented to all participants, discussed creating videos to have the students interact more with the content.

> "Access - most schools have at least one computer if not two in the classroom where there's internet access, so it would just depend on the school's internet access. Now, with the revision [to the scenario] I described they would need several digital cameras, video recording cameras, but even then that shouldn't be too much of an issue."

His statement about getting access to digital cameras and video cameras being not "much of an issue" indicates a lack of knowledge, or awareness, of funding issues related to obtaining the necessary the technology to do this. Also, commenting about having a couple of computers in the classrooms displays a lack of understanding about the high numbers of students in each class and a teacher's inability to effectively use two computers for an entire class.

Laura, an elementary science methods educator, tried to be more empathetic towards teachers' lack of access to technology in a discussion about getting enough digital microscopes for students to use.

> "This [referring to digital microscopes] would be something that I could see not being very hard at all for a group of elementary education teachers to pool $25.00, especially if you could find them cheap and buying 3-4 of these things and then it could be a grade level resource. It's not just this; it's having access to the computer. One thing I've found is that you just take these things to the computer lab and it's simple to load the software and what I used to do is give it to the IT guy and they load it."

Although Laura does provide a solution to the access issue, having to buy the technology themselves is something not all teachers may be able to do. Also, since she states the microscopes have to be used in a computer lab, she doesn't express an awareness of the lab access problems noted by Maren, Sonia and Katherine.

Needing to learn basic technological skills. Technology knowledge (TK) is defined as how to use emerging technologies (Cox, 2008). The need to learn basic technological skills was another area of tension between the teachers and teacher educators. The in-service teachers spent time focusing on the need to learn the technology before they could use it in their classrooms. Sonia, an English language teacher in middle grades, discussed needing to learn basic skills before she teaches with new technology. Sonia has a writing tablet, which is technology she can connect to her overhead projector and teach content in different ways to the class. She commented that, although she was grateful her school gave her the tablet to use, they did not provide training and so she had to learn how to use it on her own. All three teachers, Sonia, Maren, and Katherine, agreed that they were struggling with understanding how to evaluate students when using technology. Not knowing how to do this indicates that they don't understand how to build basic technological skills such as copying and pasting into their pedagogical practices. Being able to utilize these skills, and teach them to their students, could give them a way to evaluate their students while using emerging digital technologies.

Maren, the middle grades in-service science teacher, received a Promethean board, an interactive whiteboard, to use in her classroom. Like Sonia she was grateful to have the technology, but she had to spend a lot of time learning the technological skills to use it effectively with her students, which she didn’t do until later in the school year.

The teacher educators had divided views about needing to learn technology. Peter, the mathematics methods educator, stated that his pre-service teachers are expected to know how to use programs such as spreadsheets and presentation software in his class. This means he doesn't need to spend time teaching the technology skills. On the other hand, Jack, a science methods educator, admitted to running into problems with technological skills.

> “Sometimes we run into big problems because I take for granted that, because I feel like if the technology is important to me, I'll learn how to use it. I don't think that pre-service teachers-- some will be more capable than me and some will be less, and because of that wide range, one of my problems so far is that I just assume that it's going to take care of itself and it doesn't.”

Laura, another science educator, did not have much to say about learning technology. Her comments seemed to imply that teachers would simply learn the technology as they had access to it.

Alignment between the in-service teachers and teacher educators

View of technology as it relates to teaching today. Throughout the interviews and the focus group sessions, the researcher drew from experiences from participating in the PD series offered by the DL Connect research group, her experiences during her elementary education training, and her brief teaching career. From the researcher's elementary education training in 1995 she remembered learning how to use overhead projectors, create transparencies, and how to laminate materials. In addition, she learned to brainstorm ways to help students use different kinds of non-digital media to put together projects, such as self-written books and science fair projects. When she discussed this with the participants, she found that they had all had similar experiences. Overheads, transparencies, and paper based materials were the educational media of the pre-digital world. As the interviews and the focus group progressed, the researcher brought up the notion that educational media was evolving from non-digital to digital technologies, and that digital technologies are the educational media of the 21st century. All the participants agreed with this idea.

Laura, an elementary science methods educator, said, "If you think about what they used to do in educational media, it was basically supplemental things to the learning - filmstrips, bulletin boards - all that stuff - you could [now] do it online." One of the teachers, Sonia, a middle grades in-service English language teacher, was very direct, commented about the new versus the old media, "No, it's [educational media] not different. It's how can it assist me to make it more interesting in my classroom." Another teacher, Maren, a middle grades science teacher, talked about how the technology makes things easier: "Most of the media is user friendly. We've come a long way from us having to create everything on our own. The user friendliness of it makes it simpler for us to see how it can be used." Although these statements can be seen as contradictions to their expressed need to have stronger technology knowledge, it also allows us to see what teachers have learned about digital technology over the years. These teachers have become comfortable enough with some basic technologies to be able to substitute them for older, non-digital technologies, while still being challenged by newer, emerging, digital technologies.

One of the teacher educators, Peter, the elementary mathematics educator, went so far as to talk about what pre-service teachers know now, and what they are expected to know when they enter his methods class:

> "I got my undergrad in 1998, in elementary education, and we had a similar class: this is how you use the overhead projector and this is how you use the VCR and all that stuff. Now it's more; I'm expected to know how to use PowerPoint when I'm doing my classes; I'm expected to know how to use a spreadsheet. We don't need to necessarily teach those technical skills anymore, but the focus is more on - now, we've got these skills, we've got these tools, how do we use them appropriately in our own courses and then the classes we'll be teaching some day with our own students."

These views of technology also reflect how media has been defined in the literature over the last 30 years, and especially ~~in~~ how it was framed in Shulman's (1987) description of the pedagogical content knowledge framework versus how digital media, technology, has led to a whole new framework − TPACK.

How instructional materials are designed. One area that is not given much coverage in the TPACK literature (Graham, Borup, & Smith, 2012) is how teachers and teacher educators undertake the process of designing instruction. It was this process that the researcher wanted to understand through the lens of the K-12 teacher. It was her hope that, if she was able to elicit a description of this process, the teachers and teacher educators would be better able to describe the knowledge they drew upon. Although this would have been in relation to the planning stages of teaching with technology, it may have allowed the researcher a view into the tacit knowledge held by both the in-service teachers and the teacher educators.

When first asked how they go about putting together a lesson, specifically how they know the technology they have chosen will work with the lesson and their students, all three teachers said that they "just know." They can look at an online resource and simply know if it will work with the particular students they are going to use it with. In that moment they couldn't elucidate how they put together lessons; how they know something will be motivating; or if there is a specific process for putting together a lesson. As the conversation continued to topics such as the core curriculum and specific instances of use of technology in the classroom, it became clear that teachers think first about the content they are going to teach. In fact, when asked whether their main concern is in planning around the content, all three emphatically said, "Absolutely." Maren, the middle grades science teacher, said,

"We are really driven by core, we really are driven by that, and so, we say I need to teach this, how do I teach it best, what sounds cool, what's exciting, how are they best going to respond to this."

Jack, a science methods professor, concurred about the focus on content first when he described one of his pre-service teacher's thoughts about planning a lesson. "She just thought 'I would like for them to go back there, run some reactions, have their hand at designing, find out the answer to a question they have.' " The content in this case was the scientific experiment process.

Peter agreed with Jack and the in-service teachers. It is the content that is thought about first when putting together a lesson plan. Laura, an elementary science methods professor, disagreed, however, stating that for her the first thing she thinks about, and encourages her students to think about, is the type of pedagogy that they will use.

Discussion

Active versus passive learning

The teachers in this sample described their behaviors with technology mainly in terms of passive learning modes. On the other hand, the teacher educators felt that the best uses of technology is in active learning pedagogical contexts. Hammond and Manfred (2009), using TPACK as their framework of understanding, describe passive use of technology as a pedagogy in which teachers use the technology to "give" knowledge to students. They describe active use of technology as pedagogies where teachers use technology to guide students in knowledge construction. Mishra & Koehler, in their 2006 seminal work on TPACK, state that the best use of technology is through the use active learning pedagogies.

Although there was some deviation from the notion of passive use of technology in their pedagogy, two out of the three teachers talked of passive learning in reference to online learning resources. Katherine, an advanced placement English teacher, mainly used online resources and technology for enrichment. Sonia, an English language learner teacher, primarily used technology, and online learning resources, while presenting material to a whole class in a lecture based format. This was opposed to the teacher educators who consistently discussed that the best use of technology is in active learning, pedagogical conditions. All three of the teacher educators felt that the use of technology and online resources should go beyond passive learning, in which it is used as encyclopedia, or presentation type experiences, to being able to interact with and solve problems using these resources. Further they described instances of their pre-service teachers using technology in active ways, as well as teaching them to use technology for this kind of teaching and learning.

Manfred and Hammond (2009) and the teacher educators in this study align with a developmental model for TPACK in math created by Niess et al. (2009), which was discussed in the literature review. Wheras this model is specifically targeted at mathematics teaching, this researcher believes it can be used as a model for other areas of teaching and learning. Niess et al. describe their teaching theme at the exploring phase as: “Engages students in high-level thinking activities (such as project-based, problem solving, and decision making activities) for learning mathematics using the technology as a learning tool (p. 20).” Their advanced phase in the environmental theme states: “Manages technology-enhanced activities in ways that maintains student engagement and self-direction in learning the mathematics (p. 20).” Although their model leaves room for using technology in ways that has students passively learning from the technology, it encourages teachers to guide students to engage and actively learn with the technology.

This notion of using technology in more active learning pedagogical contexts is further expressed in the new educational technology standards for teachers designed by the International Society for Technology in Education (2008). These standards focus on using emerging technologies in student-centered environments where the knowledge is learner-constructed and collaborative (ISTE). Other TPACK scholars consistently talk about teachers having to reconstruct their view of their own teaching when including technology in their practice (Harris & Hofer, 2009; Mishra & Koehler, 2008; Niess, 2011). In discussing their use of technology, the in-service teachers in this study imply that they just put the old media away and bring the new media out while not changing their pedagogical practices.

Use of the technology for solid pedagogical purposes

In one of the first studies to address technological pedagogical content knowledge, Pierson (2001) examined how teachers teach with technology. She used a stratified sample to select three teachers based on pedagogical knowledge and technological knowledge. Her study focused on three teachers who all approached teaching with technology in different ways. One teacher used technology because of his interest in using it. But that for this teacher, “technology remained a separate activity with regards to planning, management, and assessment; it, furthermore was not connected in a pedagogically sound way to other learning opportunities (p. 425).” Pierson’s description matches one given by Peter, the math education professor, about a student who found a website they wanted to use without having a solid pedagogical reason for doing so.

When the in-service teachers were asked what the driving force was in making decisions about what and how to teach, all three in-service teachers agreed that content was the main force. There were, however, comments such as “what sounds cool, what's exciting,” “some of it's just fun to do,” and “if there’s something out there [on the internet], I'll just take it and use it.” Many TPACK scholars say that when teachers start to use emerging digital technologies, such as online learning resources, they need to not only learn the technology, but how that technology impacts their teaching and the learning of their students (Harris & Hofer, 2009; Mishra & Koehler, 2008; Niess et al., 2009; Niess, 2011). In describing how they know why a technology will work in their classroom, or why they use it, are the teachers in this focus group changing their knowledge in any way? The responses given by these teachers as to why they use technology indicate that they may not be. Their responses indicate that they appear to be largely impacted by the societal push to use technology without really thinking about its greater implications on their pedagogical practices.

The teacher educators made dissenting statements about technology use. They made comments such as, “I don't want them to just go out and pick technology because it's cool,” “It’s not like "oh wow, let’s play with this microscope,” and “if what I need to find out doesn't match that probeware, then I just go and look for something better." These comments align more with discussions in the TPACK literature and with the conviction that pedagogical practices and approaches to subject matter need to be changed and re-formed, when choosing to teach with technology.

Pierson (2001) described an exemplary teacher who used technology for specific activities when it was the right way for her students to learn, which matches the comment made by Jack, the secondary science methods professor, about how a student teacher he observed was able to easily integrate probeware technology into a lesson the student teacher was conducting. Pierson went on to describe this exemplary teacher knowing when technology was not the appropriate way convey what the teacher was teaching, which is exactly the scenario described by Peter. Further descriptions of TPACK align with this belief of using technology in the classroom. Leatham (2008) described one facet of TPACK as being able to understand the versatility and constraints of technology and being able to decide how to use technology based on these understandings. Harris, Mishra & Koehler (2007) also state that teachers need to apply technology to their pedagogical practices in ways that will meet students' learning needs. These three descriptions of facets of TPACK in the classroom are in direct opposition to how the teachers' describe the fun of technology being their main influence for using it.

Access to technology

As mentioned in the description of the TPACK framework, the teaching and learning context, although not knowledge, is an important part of understanding the framework and the knowledge encompassed in it. In their seminal 2006 article, Mishra & Koehler discuss that TPACK cannot be considered outside the context in which the teacher is using the technology. In 2008 Mishra & Koehler expanded their visual model to include the teaching and learning context. Whereas they did not expand their definition of the teaching and learning context, and what it includes, Cox's (2008) analysis did discuss access to technology as part of context within the TPACK framework. Having access to technology is further described in the literature. Czerniak, Lumpe, Haney & Beck (1999) cited lack of resources as one factor that discourages the use of technology in the classroom. Ten years later, Brush & Saye (2009) relate their experiences of pre-service teachers who encounter school environments that do not have enough technology available in order to continue their TPACK development.

This aligns with the in-service teachers' descriptions of access issues. All of the teachers said that access to technology impacts how they use it with their students. When asked by the researcher, as a part of a member check, to verify what she had heard about access impacting pedagogical decisions for their students, all three stated an emphatic "absolutely." Maren, a middle grades science teacher, went on to say that if she had better access to technology she would be doing more things with it, like having her students create podcasts about science material they are learning. This discussion with the teachers showed stark contrast with the thoughts of the teacher educators. Laura, an elementary science methods educator, said that teachers could pool their money and buy electronic microscopes for a group of classrooms. Peter, an elementary math methods professor, dismissed access being an issue if there are at least one or two computers in a classroom and video cameras accessible for projects in which students were creating digital videos.

In their extensive review of the technology integration literature, Hew & Brush (2006) cite both lack of technology and access to available technology as being barriers and state, "Without adequate hardware and software, there is little opportunity for teachers to integrate technology into the curriculum. Even in cases where technology is abundant, there is no guarantee that teachers have easy access to those resources (p.226)."

They also give solutions to these problems, such as

- creating a technology set up that involves the use of cheaper technology solutions;
- getting rid of centralized computer labs and replacing those with wireless laptop labs;
- placing small labs of desktop computers in each classroom; and
- having teachers engage in cooperative learning so that students can use the technology in small groups rather than needing individual computers.

These are all valid solutions to the access problem, but it is likely that the in-service teachers interviewed for this study would agree about the impact these solutions would have on their access issues. For instance, Maren stated that her small school has two centralized labs and one roving wireless laptop lab, which is only three labs of computers for a rural, rocky mountain region school that serves approximately 450 students in two grades. One thought that arises is that it would be too costly to continue to provide up-to-date technology for an already cash-strapped school district. This comment is also echoed in the work completed by the researcher. When teachers were asked what kind of knowledge they needed to teach with technology, many sidestepped the question and answered with "access," which is not knowledge, but a teaching and learning context issue related to the TPACK framework (M. Robertshaw, 2010).

Technology knowledge

Technology knowledge (TK) is why the PCK framework was expanded to the TPACK framework. Once 21st century, digital technologies became more prevalent in the classroom, researchers began to explore how this new set of skills would impact teaching, and, thus theories of teaching and learning (Pierson, 2001). TPACK scholars have defined technology knowledge in many different ways. These definitions range from the use of pen and pencil to digital technologies (Graham et al., 2009; Graham, 2011; Mishra & Koehler, 2006; Niess, 2005; Pierson, 2001). The teachers and teacher educators in this study all focused on technology as digital, 21st century, computer-based technologies. This definition aligns with Cox's (2008) definition of what technology knowledge is, which is knowledge of emerging technologies. As teachers discussed how their pedagogical content decisions had changed throughout the years, they mentioned things like “throwing out old materials”, “scanning old materials so they could be used with their classroom based technology”, and “having boxes of old material that they no longer use in the back of their classroom.” When asked about the use of technology and what they teach pre-service teachers, none of the teacher educators discussed teaching them how to use chalkboards, filmstrips, or even whiteboards as they were instructing in technology use. Instead they focused on things like digital microscopes, online learning resources, and probeware.

Although the teachers and teacher educators agreed on the definition of technology, they disagreed on how to learn these skills so that the technology could be seamlessly integrated into classroom practices. M. Robertshaw et al. (2010) describe a focus group that was held with teachers after a professional development workshop in which the teachers were taught technology concurrently with pedagogical skills. One opinion that emerged from the focus group was that technology skills needed to be taught separately from pedagogy, which aligned with comments made by the teachers. One teacher commented that she did not use her clickers for 6 months: "They sat in a box for 6 months until I learned how to use them." Another teacher, Maren, commented that she had to learn the technical skills of using the interactive whiteboard before she was able to integrate it into her classroom practice.

These comments are at odds with preferred methods noted in much of the technology integration literature, and with comments by the teacher educators. The technology integration literature, of late, emphasizes that technology should not be taught devoid of a teacher's pedagogical content context (Graham et al., 2009; Lawless & Pellegrino, 2007; Mishra & Koehler, 2006). During the interview Peter, an elementary mathematics professor, talked about how at his university, they teach a technology course specifically focusing on technology for content (math, science, english, social studies). Jack's secondary science methods students have a course where the technology is taught separately from their content, but during his course he teaches its use alongside the content and the pedagogy. Graham et al. point out that this new view of teaching how to use technology is at odds with earlier views, which held that technology skills should be taught separately from any sort of pedagogical content context. A 2010 study though, posits that technology *should* be taught separately from the pedagogy (Walker, M. Robertshaw & Recker, 2010).

So, the conundrum for teachers and teacher educators is how best to teach and learn the basic technology skills in the face of the pedagogical content knowledge skills that they must teach (the teacher educators) and apply (the in-service teachers). Should it be assumed that pre-service teachers automatically know how to use spreadsheets and presentation software, as Peter discussed? As Jack noted, "this technology skill problem isn't just going to take care of itself; a teacher has to be motivated to over come it," as Sonia, an English language teacher, and Maren, a science teacher, have been.

Views of computer technology today as it relates to teaching

One remaining subject area in teacher education programs involves instruction in the media of pedagogy, that which conveys the teacher's message. As stated by this researcher, and supported by all who were interviewed for this study, how digital technologies have become the educational media of today arose in discussions with both the teachers and the teacher educators.

Graham et al. (2009) described what have become, in many ways, the media courses offered over the past decade, including instruction in such things as word processing programs, spreadsheet programs, blogs, and wikis. These courses are very different than courses in instructional media given as late as 1998. This researcher's own experience in 1995 was that she was the only pre-service teacher in her class using technology to help find and create resources. As late as 1995, her instructors were not considering the use of digital technologies in elementary education programs. Peter, the elementary math methods educator who completed his elementary education training in 1998, said he had the same experience, that he was not taught how to use digital technologies in his future classrooms.

This discussion aligns with Cox's (2008) definition of what media is included in the "technology" of TPACK. Although Mishra & Koehler (2006) define the technology of the classroom as being anything, including a chalkboard, Cox, and subsequently reinforced by Graham (2011), specifically defines the technology in TPACK as being emerging digital technologies. This definition also aligns with the views of educational media today posited by both the teachers and teacher educators.

Designing instructional materials

One area that has received little attention in the TPACK literature is how teachers and teacher educators go about the process of designing instruction (Graham, Borup & Smith, 2012). As stated above, the literature indicates that in order for technology to be learned best for a teaching and learning context, it should be learned together with content (Graham et al., 2009; Mishra & Koehler, 2006; Niess, 2005; Niess et al., 2009). The problem is that the literature doesn't specifically describe a lesson planning process or give a model – like the kind found in the instructional design and development literature (Branch, 2009; Gustafson & Branch, 2002) for designing instruction with technology. It was the instructional design process that the researcher wanted to understand through the lens of the K-12 teacher. It was the researcher's hope that she would be able to understand the way teachers think about their instruction in the integrated manner that the TPACK framework describes by understanding their lesson design process. The question asked, however, did not allow for that kind of integrated response. It *did* give a view into what teachers as well as teacher educators focus on when thinking about instruction: the content. This aligns with recommendations by Harris, Mishra & Koehler (2009) who state that teachers should first think about their curriculum and *then* think about technology to be used. The three teachers emphasized-that the driving force in lesson planning is content. In a study investigating technology use decisions in the classroom, Graham, Borup & Smith found that 42% of technology use decisions were made with content in mind, whereas 48% of the decisions were made only with pedagogical considerations in mind. The findings from this study reinforce the statements made by the teachers that content comes first in instructional design planning, but also reinforces Laura's statement about thinking about pedagogy first in instructional design decisions.

The recommendations by Harris, Mishra & Koehler (2009) align with Peter’s, an elementary math methods professor, who talked about how the university where he teaches has changed how it teaches technology. He said that they now teach technology from a content point of view rather than a technology point of view.

In light of the TPACK framework, comments about the content being the driving force in instructional design practices are aligned with what is being written in the literature. This is seen in the many articles and book chapters that focus on TPACK in specific content areas like math (Kersaint, 2007; Niess, 2005; Niess, 2008;), science (Guzey & Roehrig, 2009), english (Hughes, 2010), and social studies (Brush & Saye, 2009; Manfra & Hammond, 2008).

Considering the researcher’s question about the instructional design process, at some point lesson planning *must* simply become a skill that isn't thought about, *it is just done*; it becomes part of the tacit knowledge held by experienced teachers. Given this, the researcher may have been able to elucidate answers about lesson planning from more novice teachers, who are still building this skill.

Conclusion

The purpose of this phase of this dissertation study was to derive a better understanding of TPACK knowledge, behaviors expressed when TPACK is being utilized, and attitudes about technology use when TPACK is being used from the emic and etic perspectives. This understanding informed development of items in phase two of this study. Six themes came out of this study pertaining to TPACK knowledge, attitudes and behaviors. They describe the following attitudes, knowledge and behaviors:

- The teachers in this study were using technology in more passive learning settings than the teacher-educators would like and how the teacher educators convey teaching with technology to their pre-service teachers.
- The teachers struggled with learning technology knowledge whereas the teacher educators made assumptions about what their pre-service students know when they enter their methods classrooms.
- The teachers express their knowledge of why they use a particular technology in terms of motivation, not in terms of deep conceptual learning purposes. The teacher educators expressed their intent when instructing pre-service teachers in using technology, that it be used for solid learning objectives rather than simply because it is there or because it is fun.
- The teacher educators did not view access to technology to be an issue in using technology in the classroom, whereas the in-service teachers were emphatic that lack of access to technology impinges on their decisions on how to use technology.
- Everyone in this study agreed that digital technologies are the new media of today.

- All but one person in this study when asked about instructional design practices, thought about content first, then pedagogies. The one person to defer from this was an elementary science methods professor.

The tension between the in-service teachers and teacher educators provided content for the items to developed in this study. The reason that the tension provided content for the items developed is that the teacher-educators provide a snapshot of how attitudes and practices about technological pedagogical content practices are evolving. Although the in-service teachers are also evolving their pedagogical practices on their own, they also attend professional development workshop to learn new methods. If the teachers and the teacher educators agreed with each other, there would be no need to see what teachers know in relation to the evolving practices with technology. Although the point of these items will be to try to describe teachers' TPACK through these fixed-answer items, there is still likely to be a value judgment inherent within each question. Should the items created agree with the teachers or the teacher educators about how technology should be used (passive versus active learning)? Should the access issue that the teachers brought up be addressed? For the purpose of this study items created will reflect views held by the in-service teachers and the teacher educators. It is the hope of this researcher that this will reduce bias towards one view or another.

This researcher’s own biases appeared in the findings. She found herself not always siding with the teacher educators, all of whom are researchers. Although the researcher agrees that we should strive to help teachers truly capitalize on technology through the use of active learning pedagogies and using technology for reasons beyond motivation, she also believes that as a teacher educator and researcher, the issue of access to technology needs to be addressed in the research and professional development context.

Instruments are often created, unintentionally, with bias in the items and the instrument as a whole (Durham, Tan & White, 2011; Benson, 1987; Jensen, 1980; Onwuegbuzie, Bustamante & Nelson, 2011; Ungar & Liebenburg, 2011; Wolfle & D. Robertshaw, 1982). For example Wolfle & D. Robertshaw discovered that when all other variables are controlled for, aptitude tests still showed differences in performance between Hispanic and white males. As Hispanic and white males come from different cultures, one could posit that teacher educators and the teachers come to the issue of technology knowledge in teaching from two different cultural point of views. The trick, as a teacher educator, to creating items to measure TPACK, is to represent both perspectives – the in-service teachers (the emic) and the teacher educators (the etic). Items to be created need to not only accurately evaluate an in-service teachers' TPACK, but also take into consideration their contextual limitations. The items also need to reflect the work that teacher-educators are doing to help teachers move towards more student-centered teaching practices.

CHAPTER IV

PHASE 2 STUDY

The goal in phase two was two-fold: first to create fixed-answer (multiple choice and ranking) test items that reflected the themes from phase one (see table 4-1). The second part of phase two was for the items to be reviewed by others. The most important goal was to get reviews of the face validity of the items. Thus the research question-guiding phase two of this dissertation was simply: what is the face validity of the items developed?

Table 4-1
Themes and alignment to TPACK framework

Theme	TPACK framework alignment
Access to technology	Context
Passive learning versus active learning with technology	TPACK
Need to learn basic technological skills	TK
The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there.	TPACK
How instructional materials are designed	TPACK
Views of computer technology today as it relates to teaching	TPACK

What is Face Validity?

Face validity is a part of construct validity wherein items are examined by a panel of reviewers who judge whether they believe the items developed will measure what they have been designed to measure (Nunnally & Bernstein, 1994). The judgment as to whether items measure what they are supposed to is subjective and can be completed by experts or other stakeholders, e.g. potential test takers (Nunnally & Bernstein; Streiner & Norman, 1989). Finally, face validity is a form of validity that is assessed *after* items are constructed rather than a form of validity that can be measured before and during test/item construction (Nunnally & Bernstein; Streiner & Norman).

Methodology

Item development

Eleven items were developed, corresponding to a theme from phase one of this study. Specifically, eight out of the 11 items were created to measure TPACK, whereas the last three were created to address the context issue within TPACK. Having access to technology was a theme that emerged in the focus group and is within the area of context related to TPACK (Cox, 2008) (See Table 4-2 for a summary of the scenario presented, the question asked and the answers provided and alignment to TPACK or the content element of the framework and theme derived in phase one. See Appendix C for each full item, including scenario, question and answers provided, alignment of each item to TPACK or content element of the framework and themes derived in phase one.)

Following best practices for measuring teacher knowledge in fixed-answer questions (Carlson, 1990), scenarios were used to set up each question. Scenarios provide a picture of a classroom setting so that the test taker has a context within which to answer the question. Without this context, questions of this nature are unlikely to have meaning for the test taker. This method is used on the PRAXIS exam to measure the pedagogical content knowledge of elementary education teachers as well as by researchers developing measures for PCK and TPACK (Barnett, 2010; Carlson; Hill, Ball

& Schilling, 2008).

Each item was developed in alignment with a national or state (Utah, North Carolina, New York) standard in the grade range of 4-7. Ideas for classroom settings were drawn from prior research conducted with in-service teachers using online learning resources. Specifics about content described were drawn from websites such as the US Geological Survey, the United States Congress, university websites that deliver content to those outside the university, and websites created for teachers. Lastly, the TPACK developmental model created by Niess et al. (2009), discussed in the literature review, was used to guide how different pedagogies were valued in a developmental mindset.

Table 4-2
Summary of scenarios created, questions asked and answers provided, and alignment to phase one theme and TPACK alignment

Item #	Scenario summary, question and answers provided	Phase one theme	TPACK alignment
1	**Scenario Summary:** a teacher is planning to use the computer lab, but at the last minute there is a technical issue and so the teacher can't use the lab. The content of this scenario was sentences and parts of speech. **Question:** Rank the following in order of what you believe is the best to worst alternative action Mr. Harris should take. **Answers:** Skip the lesson entirely and do it another day, even if he can't get access to the lab until after the unit is over. It can be used for enrichment after all. He does have a projector in his classroom, so he could teach the lesson as a whole-class exercise. Briefly instruct students in the parts of speech and then work together to create sentences and have students diagram them on the whiteboard.	Access	Context
2	**Scenario Summary:** A teacher plans to teach a lesson	The use of	TPACK

	about avalanches using online learning resources. **Question:** Besides basic computer skills, what will Arun need to think about as he is preparing for a lesson on the causes of avalanches? Choose the best answer below. **Answers:** a) When he will be able to access the computer lab, how to find online learning resources that will explain the causes of avalanches, teaching himself about the content he is teaching. b) When he will be able to access the computer lab, understanding how different online learning resources can help his students understand the basic concepts of how avalanches are caused, and how he will be able to assess what his students have learned? c) Knowing what online learning resources will be the most fun for his students, how to prepare a lecture about avalanche causes that will get them ready to use the online resources, how to manage his students' behavior as they are working in the lab.	technology for teaching and learning guided by specific learning objectives, rather than just because it's there.	
3	**Scenario Summary:** A teacher has decided to use a variety of online learning resources to teach students about avalanches. The students are working individually to learn the material, and will produce a product with a technology-based component to assess student knowledge. **Question:** Rank in order the best way he could do this. **Answers:** Have each student write a report that incorporates images and diagrams about how avalanches happen and how they can be safe in avalanche prone areas. Pair students together to create a power point presentation about avalanches and avalanche safety that they will then be able to present to other ninth grade health classes. Have his students work in groups of three to create	The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there.	TPACK

	posters, that include images and diagrams created on the computer or found online to put up around the school.		
4	**Scenario Summary:** The same as item 3. **Question:** Now that you've decided what Arun should think about how to prepare his lesson about avalanches using online learning resources, what would be the best kind of resources for Arun to look for in order to allow students to learn how avalanches happen? Rank the following resources he could use in order of best to the worst. **Answers:** Three videos that have a person explaining how temperature, wind, and recent snow fall can cause avalanches to happen and how people can be safe in avalanche prone areas. A series of images and age-appropriate diagrams with descriptions that explain how temperature, wind, and recent snow fall can cause avalanches to happen and how to be safe in avalanche prone areas. A series of games, which will engage his students more than the videos and images, but may not show the impact of temperature, wind and recent snow fall on avalanche prone areas.	The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there.	TPACK
5	**Scenario:** A teacher is looking for a new way to teach density. She has chosen to use online learning resources. **Question:** Below are a list of different ways that Susan can use the computer resources that she has discovered. Rank them in order of what you believe are the best to worst ways to use them with students. **Answers:** Project different online learning resources onto a screen in front of the class and have students work in groups to suggest possible solutions to density problems presented in the resources. The students, as a	Passive learning versus active learning with technology	TPACK

	group, will record their suggestions and explain them to the class. Take students to the computer lab and have them access the online learning resources individually, changing the variables that impact density. The directions that Susan gives are for them to go to each resource and fill out the part of the worksheet she has created for that resource and then moves on. Have students work in groups to figure out a problem that Jane has presented to them about figuring out how thick the wood of a doorframe needs to be, taking into consideration how the density of wood can change the fit of the doorframe. This problem will allow students to draw on previous knowledge, and has multiple correct answers. The students will use the online learning resources Susan found, as well as other online learning resources that they have searched for to answer the problem.		
6	**Scenario Summary:** A teacher has recently learned an inquiry-based method. She isn't full confident in the method and fears that if it backfires her students won't be prepared for end-of-year testing. **Question:** What should the teacher do? **Answers:** a) Wait until next year to implement this new inquiry-based instruction and instead use the online resources only. This will allow her students to learn the different properties of density better than if she had stuck with her original method for teaching density; use of the small labs in the classroom and demonstrations. She can also use in-class time for discussions about what the students are learning using the online resources. b) Use her old method of teaching density – small labs and demonstrations – which have proven effective in the past, as indicated by scores on end- of- year testing, but will not allow them to explore at all the multiple variables that impact the density of an object. c) Use the inquiry-based method with the online learning resources. This could potentially lead her	The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there.	TPACK

	students to developing misconceptions about the different factors that impact density, or even potentially learn wrong information. She can use in-class time, away from the computers; to work to correct any misconceptions her students may have developed.		
7	**Scenario Summary:** A teacher has reserved the computer lab for two consecutive days. On the first day the lab goes down. **Question:** What should Susan (the teacher) do? **Answers:** a) Go back to the classroom where the internet is working, project the online resources on to the white board and have the whole class work through the first half of the problems together. Students will suggest ways which variables (temperature and pressure on the object) should be manipulated and come to consensus about the best solution to each problem. The next day they will go back to the computer lab to finish the problems with a partner as Susan initially had planned. b) Go back to the classroom, pull out the small labs and have the students begin to explore density to give them some background information so that they will be prepared to work through the entire worksheet the next day in the computer lab. This will take time, though, and the students will not have long at all to work with the mini-labs. c) Go back to the classroom and give a lecture on density and plan to have the students work in the lab as she intended the next day.	Access	Context
8	**Scenario summary:** A teacher has found a simulation to teach students how a bill becomes a law. She has created an inquiry-based lesson to teach this process using the simulation. She discovers the lab is unavailable due to end of year testing. **Question:** Rank what Shannon should do from the best to worst possible actions. **Answers:**	Access	Context

	Teach the lesson as she has in the past without the online resources. She feels comfortable doing this and knows, through assessment of student performance, that this has been effective in having her students learn the different steps to how a bill becomes a law. Come back to the lesson after end- of- year testing has been completed so that students can complete the inquiry-based lesson using the online simulation. Create a whole-class inquiry-based lesson where each member of the class plays a different part in the process (sub- committee member, committee member, Minority Whip, Majority Whip, etc.) and use the online resources in the computer lab to reinforce what was learned after end- of- year testing is completed.		
9	**Scenario Summary:** A teacher is teaching students about earthquakes – including why they happen, how to be safe during one, and how to locate potential earthquake zones. She has found a simulation for teaching how earthquakes occur and the impact on city infrastructure. **Question:** What are the advantages of learning about using earthquakes using this simulation? **Answers:** a) Because students use computers so much outside of school, they are comfortable with them and enjoy using them. Therefore, they will learn the material using this method. b) The simulation allows the students to manipulate earthquake variables and see what how each impacts city buildings and infrastructure. This kind of involvement with the material will allow them to learn about earthquakes better than if they had not used the simulation. c) Because students are able to manipulate earthquake variables and learn how those variables impact city buildings and infrastructure, they can then apply what they've learned about the fictional city to their own city and neighborhoods, which will deepen their	The use of technology for teaching and learning guided by specific learning objectives, rather than just because it's there.	TPACK

	understanding of the causes of earthquakes and their effects.		
10	**Scenario summary:** Same scenario as item 9. **Question:** As stated above, Mrs. Rojas will assess how much her students have learned about earthquakes, how to be safe in earthquakes, and how earthquakes impact Seattle through a project that will be completed in pairs. The requirements for this final assignment are: * That students use at least one online learning resource that only contains text. This can be a video, a simulation, picture, diagram, etc. * That the project explains how earthquakes happen, how to be safe during an earthquake, and how earthquakes impact Seattle. *The project will be a resource that allows people to learn about earthquakes and their impact on Seattle on their own. The following are descriptions of what her students created for their final projects. Based on what is written, rank them from 1-3 from the best to the worst use of the online resources. **Answers:** An online power point presentation that uses pictures, diagrams, and text to explain how earthquakes happen, how to be safe, and how earthquakes impact Seattle. A website that brings the simulation that they used earlier, as well as pictures, diagrams and basic text about how to be safe and how earthquakes impact Seattle. A basic quiz is included at the end. A video that has a scientist talking about how earthquakes happen, an expert in earthquakes explaining how to be safe during earthquakes, and a video of a local official talking about how earthquakes impact Seattle.	Passive learning versus active learning with technology	TPACK
11	**Scenario summary:** A teacher is going to have students interview each other, and then introduce the person they interviewed, to practice English language fluency.	The use of technology for teaching and learning	TPACK

Question: Which of the following has the potential for helping the students for whom English is a second language performs well in this activity? **Answers:** (a) Showing a video of a model interview and an introduction in which a student from a previous year interviews Ms. Prestage and then introduces her. (b) Having students go through a website that has guidelines, videos, and a quiz at the end about how to interview someone. c) Having students discuss among themselves what completing the activity successfully will require.	guided by specific learning objectives, rather than just because it's there.

Face validity review procedure

Before the items were sent out to TPACK experts, two current teachers and one former teacher gave feedback about the language of the items, and how true to practice the scenarios were. Although there was recommended changes in wording, no content was changed based on this feedback. Initial requirements for choosing reviewers was that had been teachers in K-12 at some point in their career and that they had presented and published on the TPACK framework at least once. Due to the difficulty in recruiting reviewers the teaching requirement was dropped.

The face validity process was undertaken twice. In the first rating cycle, the items were sent out to three expert reviewers: two professors in instructional technology programs and a professor of math education. All three had published and presented on the TPACK framework. One of the reviewers said the instructions for validating the items was too confusing. The math education professor only felt comfortable rating items related to math content. The last reviewer never responded to three follow-up emails.

In the second cycle, the instructions were rewritten. Potential reviewers were specifically asked whether they felt comfortable rating items outside their content area. Four experts agreed to review the items. Each reviewer had published and presented on the TPACK framework at least once, including one who had tailored a pre-service secondary math education program around the development of TPACK since early 2000. Another reviewer had created an instrument to measure TPACK, which was the first to be able to find statistical discrimination between TK, TPK, and TPACK.

Each expert reviewer was asked to rate each item, on a likert-scale of 0-5, as to how well TPACK was represented in the scenario and the question. A six-point, bi-polar (Streiner and Norman, 1989), scale was used in this study. This meant that there was no neutral option with the division being between 2 and 3. According to Streiner and Norman the optimum likert scale is one that has between 5 and 7 points on the scale; this is because below 5 points reliability drops significantly. Evidence also shows that scales that have too many points on them can adversely impact reliability and that the upper-limit of the number of points on a likert-scale should be between 10-15. The bi-polar nature of the scale forced reviewers to dichotomize their responses, rather allowing for a neutral response (Streiner & Norman). Ratings of 0-2 were viewed on the non-reliable side of the scale and 3-5, on the reliable side. On the scale used in this study 0 indicated that the item did not assess potential test takers' TPACK, 2 indicated that the item moderately measured the potential test takers' TPACK and a 5 indicated that the item measured the potential test taker’s TPACK fully. Point 3 on the scale was not labeled, but should have been labeled “adequately assesses a potential test takers’ TPACK.” This limitation is discussed in the conclusion chapter of this dissertation. The reviewers were also asked to provide any comments about each item. See Appendix D for the instructions given to each reviewer as to how they were to rate the elements of the questions.

Analysis and Findings

In order to fully understand how the items were rated, a mixed-methods analytic process was undertaken (Teddlie & Tashakkori, 2009). First a quantitative analysis was completed on the numerical ratings. This analysis examined the inter-rater reliability among the four reviewers, the overall mean, median and standard deviation for each item and the mean, median and standard deviation across the eleven items for each reviewer.

A qualitative analysis was conducted to examine all reviewer comments for each item. A four-step deductive process was used to complete this analysis. First all the comments were read and examined for whether they pertained to the individual question, or whether they were general comments about the items. A second analysis was used to categorize the comments into five themes. A third analysis combined the five themes into three. A fourth analysis occurred while writing up these findings. Triangulation across reviewers' comments was also noted, but was not considered vital, as this phase of the study is not a *true* qualitative study. Themes stemming from this part of the analysis are reported as the researcher viewed their importance to the overall goal for creating valid fixed-answer items to measure TPACK and improving the items developed. These themes were then used in updating the items (see Appendix E). It is important to note that some individual comments made by the reviewers did not fall within the themes derived but were still considered valuable feedback while updating the items.

Quantitative findings and discussion

Kendall's W statistic was computed to assess the level of agreement among the four reviewers. Kendall's W is a non-parametric statistic to assess inter-class correlation (ICC). ICC can be used to assess agreement among quantitative measurements executed in units, including judgments made by people (Sheskin, 2004). The Kendall's W was computed due to the ordinal (rank-order) nature of the ratings, as well as having more than two reviewers (Sheskin, 2004). This analysis showed that there was moderate agreement across the four reviewers, W=.534, $p < .01$. Considering the exploratory nature of this study, this level of agreement was judged to be acceptable.

The mean, median and standard deviation were then computed for each item and for each reviewer. The means for each question indicated that seven out of the eleven items were on the valid side of the scale (a rating of 0-2 was considered not valid, whereas a score of 3-5 was considered valid), whereas the medians indicate that 9 out of the eleven items were judged to valid. Of note, though, are the large standard deviations, six being above 2, across the items. On a 0-5 scale, this indicates a high degree of variability of ratings for each item.

The means for the entire set of 11 items indicate that for Reviewer 1 the items were not valid (M=1.73), whereas two out of the four reviewers (Reviewers 2 and 3) showed the set of items just falling on the valid side of the scale (M=2.64 and M=2.82), and Reviewer 4 indicating that overall, the items held a high level of validity (M=4.64). This is also seen in examining the medians with Reviewer 1 having an overall median of

2.00, Reviewers 2 and 3 having a median of 3.00 and Reviewer 4 having a median of 5. Finally, there were large standard deviations across the set of ratings. Further detail about the ratings are provided in table 4-3, which lists the mean, median and standard deviation for each item as well as the, individual ratings for each reviewer.

Table 4-3
Mean, Median, and Standard Deviation for each item across all reviewers and across all items for each reviewer.

				Rating by each reviewer			
Item	Mean	Median	Standard Deviation	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4
1	3.00	3.00	.82	2	3	3	4
2	3.25	3.00	1.26	3	3	2	5
3	2.75	3.00	2.22	4	0	2	5
4	2.75	3.00	2.22	2	0	4	5
5	3.00	4.00	2.00	0	4	4	4
6	2.00	2.00	2.31	0	0	4	4
7	3.50	3.50	1.30	4	3	2	5
8	3.25	3.00	1.50	2	4	2	5
9	3.75	4.00	1.26	2	4	4	5
10	2.00	2.00	2.31	0	4	0	4
11	3.25	4.00	2.22	0	4	4	5

Mean across all items for each individual reviewer	1.73	2.64	2.82	4.64
Median across all items for individual reviewer	2.00	3.00	3.00	5.00
Standard Deviation across all items for each individual reviewer	1.55	1.75	1.33	.505

Qualitative analysis

A deductive analysis was completed to understand themes from the comments provided by the reviewers. The themes that were derived during the first three rounds of analysis reflected solely on *how the ratings were completed*. The fourth analysis of the comments concluded with two themes that discussed how the items could be improved to make them more valid and two themes discussed how the face validity process could be improved. The two themes that discussed how the items could be improved were: the complexity of the items was debatable, and how the answers to the items were ranked was not obvious. The two themes that discussed how the face validity process could be improved were: rankings of answers to the questions should have been included and how the Niess et al. (2009) framework was used to guide pedagogical values (see table 4-4 for the analysis phases and outcomes). Although three of the four themes are critical of the process or the items, the theme related to item complexity was encouraging to this kind of item design for this kind of measurement. Each theme is discussed separately below.

Table 4-4
Qualitative analysis steps of the comments provided by reviewers

Analys is Step	Outcome
1	Knowing whether a comment pertained to a specific item or the entire set of items.
2	Categorizing the comments into four themes
3	Categorizing comments into three themes
4	Re-categorizing the themes, ending up with the following four themes: a. Ranking of the answers provided should have been included for the reviewers. b. The complexity of the questions is debatable c. How the answers ranked was not obvious d. An explanation of the use of the Niess et al. developmental framework to guide pedagogical values

Qualitative findings and discussion

The form (see Appendix D) sent to the reviewers did not include instructions about how the answers to the questions were to be ranked. This proved to be a mistake that may have influenced the validity ratings. The reviewers made a number of comments that addressed the individual answers to the questions. Reviewer 1's first comment, about the first answer to the first item, was that "the first choice views the technology as an add-on to the topic." She continues this in addressing issues with the final two answers to item number 1 before giving an overall comment about the item as a whole. Other comments specifically asked which response was the correct or the best one. These included, from Reviewer 3, a very blunt "Do you have a response in mind that you feel most accurately would demonstrate TPACK in a teacher?" Reviewer 2 guessed which answer was supposed to be the best one, saying, “The end-of-year test is the only goal mentioned in the scenario and by that light, choice B is the best match.” Finally, in the same light, Reviewer 1 commented, “I could not determine what I would choose,” and Reviewer 4 stated about were the correct answers “I'd probably do a and then c.”

The comments about providing the rating for the answers are well founded. If the rankings had been given, the reviewers could have spent more time analyzing each question for TPACK. Instead they appeared to spend a lot of time trying to understand which was the best answer. I suspect ranking the answers would have provided richer feedback from the reviewers, and may have impacted the quantitative findings as well.

How the answers to the questions were ranked was not obvious. As stated above, the rankings to the individual answers were not provided. This led to a sense of consternation among the reviewers in considering how well the items measured TPACK. In her comments to item 1, Reviewer 1 commented on each individual answer. She said about the first answer:

> “The first choice views the technology as an add-on to the topic and is thus describing a low level of TPACK at best. There is no indication of the pedagogy that would be used so it is hard to say the knowledge used is TPACK.”

She continued onto the second possible answer stating,

> “The second choice does not provide the pedagogy of how he will engage the students in the item about the projector. Might he engage the students using some of the same instructions that would have been used in the lab? It is difficult to assess this item with respect to TPACK without some sense of the pedagogy that

> is intended. If this option were expanded, I could say this item would be a strong TPACK level – say a 4 or 5."

Finally, she comments about the third possible answer to item 1 that it doesn't even include technology, that "The third choice simply drops the technology from the instruction and would thus be making a decision to not use the technology."

Remarks like Reviewer 1's were prevalent across all the reviewers. About item 2, Reviewer 2 felt that those who would answer these questions in the future could see playing the 'game system' to pick the best answer, based on different length and complexity of the answers given. About answers to item 8, Reviewer 3 felt the answers seemed to be dichotomous, stating

> "In terms of assessing TPACK, the choices here seem almost dichotomous – Choice 1 is no tech, and Choice 2 and 3 are tech integrated. There are so many additional contextual factors at play that might influence a teacher to choose Option 1 for this question – and just because they select Option 1 doesn't necessarily mean that they have low or no TPACK."

These comments provide valuable feedback for updating the answers to the questions, in that they indicate that the possible responses need to be more differentiated from each other.

An explanation to how different pedagogies were valued should have been provided. The developmental scale created by Niess et al. (2009) guided analysis of the qualitative findings in phase one of this dissertation study as well as development of items for this phase. The pedagogical lens of this scale is that those teachers who are using TPACK in inquiry-based ways have a higher TPACK developmental level.

Although this can been seen as controversial, it is a lens held by the researcher as well. Thus, the items and answers developed attempt to reflect this value point. The reviewers were not informed of this, which led to comments about how pedagogies were valued within the items.

About the first two responses to item 4, Reviewer 1 said, “What is not clear to me is how to make a decision about the selected pedagogy between the first two items.” Item 4 asked about the best use of online learning resources to teach students about avalanche danger. The answers Niess is referring to are:

- Three videos that have a person explaining how temperature, wind, and recent snow fall can cause avalanches to happen and how people can be safe in avalanche prone areas.
- A series of images and age-appropriate diagrams with descriptions that explain how temperature, wind, and recent snow fall can cause avalanches to happen and how to be safe in avalanche prone areas.

Upon reflection, Reviewer 1’s confusion between the two answers is apparent. In rating the answers, the video answer was rated lower than the item on age-appropriate diagrams. This was stated because of the words “age-appropriate.” A better option for answer two would have been the use of an interactive diagram, which could be viewed as leaning towards the inquiry-based side of pedagogical methods, thus, leaning towards higher TPACK than simply watching videos, age-appropriate or not.

Reviewer 3 felt the three answers in figure 4-1 were loaded, specifically that choice b would lead students to being “short changed.”

a) Go back to the classroom where the internet is working, project the online resources on to the white board and have the whole class work through the first half of the problems together. Students will suggest ways which variables (temperature and pressure on the object) should be manipulated and come to consensus about the best solution to each problem. The next day they will go back to the computer lab to finish the problems with a partner as Susan initially had planned.

b) Go back to the classroom, pull out the small labs and have the students begin to explore density to give them some background information so that they will be prepared to work through the entire worksheet the next day in the computer lab. This will take time, though, and the students will not have long at all to work with the mini-labs.

c) Go back to the classroom and give a lecture on density and plan to have the students work in the lab as she intended the next day.

Figure 4-1. Answers to item 4

The context of this question is that the teacher is going to have students work in pairs in the computer lab to explore the resources, but then the internet goes down; the question asks what the teacher should do. The answers in the question *do* place a greater value on inquiry-based methods, with answer a being the best answer, and answer b being the worst answer and answer c being in the middle. Further, Reviewer 3 is right in stating that answer b is loaded, but he may have been more clear what the correct answer is if he had been informed about the value placed on different pedagogies and corresponding view of TPACK development.

The level of detail given was debatable as to whether it was too much or too little. Finally, the analysis showed disagreement across the reviewers about whether there was too much or too little detail in the items. Reviewer 3 consistently appreciated the level of detail. He stated about item 1,

> "First of all, I think the use of scenarios embedded within a context of authentic issues a teacher may face when designing tech-integrated instruction like lab

software issues and scheduling is great design. This context provides relevance and a connection for the test taker."

He then commented on item 4, "Good question -- the level of detail here could really support demonstration of a teacher's TPACK, " and then question 5, "Great question – the level detail provided in terms of T, P, and C (and clearly TPACK) is critical." Finally, he simply stated for items 6 and 9 that the "level of detail was great." Reviewer 4 felt that one "Could use more details on how teaching would occur in the last two options." In contradiction to Reviewer 3 and Reviewer 4 statements, Reviewer 2 repeatedly stated that the items were too long and complex. He specifically made this comment about items 9, 8, 7, 6 and 2.

Discussion

The qualitative findings showed that there were many issues with the items as well as mistakes made in the form asking for the ratings. If more information had been given to the reviewers, a richer set of comments may have been provided. There was also discussion among the reviewers about adding more environmental context to the answers and an explanation about how different pedagogies were valued. They also showed some conflict among the reviewers about the ideal level of complexity. An assessment expert did a brief review of the complexity of the items and felt that the items were adequately complex.

The comments that the reviewers gave provided valuable guidance for updating the items (See Appendix E for the updated items). Using the themes derived from the qualitative analysis, the first update that was made to all the items was to provide rankings for the answers provided. Although these items will not go out again to this set of reviewers (it is hoped that the items will be rated again) this alleviates a major problem in a next round of rating. Another change that was made to all the items was to provide more pedagogical context for the scenarios and answers where needed. A general explanation of what inquiry-based pedagogies are was also given as context to those question and answer sets where the pedagogy was an important focus of the item set. If the items are sent out again, an explanation of the value placed on inquiry-based pedagogies will be provided. As guided by the themes derived in the qualitative analysis, the last major change made to items was to provide more technology context for question and answer sets where the technology was a focus.

As stated above, there were some changes made to the items based on comments that did not fall into the themes. For example, one comment was made concerning scientific misconceptions, and that it wasn’t clear why misconceptions would be developed by using technology in a particular way. This comment was addressed by adding a sentence explaining why misconceptions could be developed. Another example is a comment that was made pointing out that not all the responses to item five were equally complex. All three responses were re-written and complexity was added where needed. Finally through reviewing each item closely wording was changed not because of specific comments, but rather as a part of the normal editing process.

Conclusion

The purpose of this phase was to create and validate fixed-answer items to measure teachers' TPACK, based on themes derived from phase 1. This was not only challenging due to the difficulty of item writing, but also particularly challenging considering that some experts on TPACK have stated that fixed-answer questions to measure *TPACK* cannot be created (Cox, 2008; TPCK.org, 2009). This phase also continued to incorporate both the emic and the etic perspectives through using the themes derived in phase one as well as through getting feedback from in-service teachers (emic) and researchers of TPACK (etic).

Although the items are not ready to be piloted yet, the results from this phase showed that there is promise in creating items to measure teachers' TPACK using fixed-answer questions. Feedback received from the in-service teachers was helpful, and the wording changes that were suggested may help make the items more accessible to teachers. The items need to be written in a language more familiar to teachers, rather than in the language of the teacher researcher.

An examination of the means and the medians of the items showed that the majority of the items fell on the valid side of the six-point scale.

Finally, whereas the reviewers' comments were mostly critical in nature, there were some positive ones. Reviewer 3 stated, "I think the use of scenarios embedded within a context of authentic issues a teacher may face when designing tech-integrated instruction like lab software issues and scheduling is great design," and "Great question – the level of detail provided in terms of T, P, and C (and clearly TPACK) is critical." These statements indicate that the design of the items overcomes issues of context-free teacher assessment. They also indicate that there could be promise in this item design for future work on the use of this kind of measurement of TPACK.

CHAPTER V

CONCLUSION

The goal of this study was to work towards a way of measuring technological pedagogical content knowledge through fixed-answer questions. It has been said that measuring TPACK is difficult and this task must not be context-free (Cox, 2008; Graham, 2011; Tpck.org, 2009). As of this writing, and based on the literature the researcher accessed, self-report and case studies have thus far been the most popular and researched methods for measuring TPACK (Mishra & Koehler, 2011). Whereas these methods provide researchers, instructors, and professors with valuable information about TPACK progression, they ~~do~~ have their limitations. As discussed in earlier chapters of this dissertation, self-report can be fallible due to social pressures or lack of metacognitive knowledge about the information being transmitted (Darling-Hammond, 2006; Kagan, 1990; Mabe & West, 1983; Wise & Pease, 1983). Case studies, although more objective and less reliant on metacognitive abilities, are too time consuming to be useful in many settings (Mishra & Koehler). This study therefore set out to work towards creating a TPACK measurement instrument that utilizes fixed-answer type questions. While acknowledging the limitations of this type of measurement fixed-answer questions can be coupled with other kinds of measurements to assess TPACK leading to more robust measurement (Nunnally & Bernstein, 1994).

To develop fixed-answer questions this dissertation used a sequential mixed methodology (Greene & Caracelli, 2003; Morse, 2003). Data collection and analysis utilized techniques from all three research paradigms – qualitative, quantitative, and mixed methods (Onwuegbuzie & Combs, in press; Teddlie & Tashakkori, 2009). In following recommendations from the mixed methods instrument development literature, emic and etic perspectives on the types of knowledge encompassed in the TPACK framework was captured. The emic perspective (inside) perspective was captured through a focus group with in-service teachers during phase one. In phase two the emic perspective was represented by having in-service teachers review the items that were created. The etic perspective (outside) was captured in interviews with teacher educators in phase one. In phase two the etic perspective was represented by having researchers of the TPACK framework review the items developed.

Phase one consisted of interviews with teacher educators and a focus group with three teachers. The data was analyzed using a constructivist epistemology and the constant comparative technique (Glaser & Strauss, 1977) using pre-defined categories (Corbin & Strauss, 2008). Six themes were detected across the interviews and focus group. These themes included descriptions of knowledge (how to use technology, how to use technology for solid conceptual reasons, technology is the educational media of the 21st century), behaviors (use of technology in active learning and passive learning environments, instructional design practices), and attitudes (access to technology). Within these phases dissonance was seen in the analysis between the in-service teachers and the teacher-educators. For example the teachers cited access to technology as impinging on their ability to use technology in their pedagogical practices, whereas the teacher educators didn't see access as an issue that needed to be addressed. It was the tension in the two perspectives that provided context for the development of the items in phase two.

Phase two consisted of developing items based on the themes from phase one and then having those items reviewed. Eleven items were developed during phase two. Each item consisted of a scenario and multiple-choice or ranking question based on the scenario (see Appendix D). After development was finished, two in-service teachers and one in-service former teacher reviewed the items. This was completed to assure alignment to classroom practices and language used by teachers. Changes were then made to the items based on their recommendations. Four teacher educators, all of whom had conducted research on the TPACK framework, then rated the items for face validity. These reviewers were asked to rate the items on a six point, bipolar likert scale that did not allow for a neutral rating (Streiner & Norman, 1987). Examination of the means and the medians for each item indicated that three out of the four reviewers rated the majority of the items on the valid side of the scale. It must be noted that two out of those three reviewers had means and medians on the low end of the valid side of the scale. Comments were also provided by all the reviewers, which provided excellent feedback for revising the items.

Limitations

There are many limitations to this dissertation study. I will delineate these by phase.

Phase 1

The first limitation is in the small sample size. In qualitative research it is recommended that saturation should be reached in data collection (Denzin & Lincoln, 1994; Miles & Huberman, 1994; Onwuegbuzie, Bustamante & Nelson, 2011; Teddlie & Tashakkori, 2009). There were only three interviews with teacher educators and one focus group with in-service teachers, a sample size that this researcher does not believe allows for saturation to occur. Another focus group and at least two more interviews could have improved saturation. This added data likely would have increased rigor (Lincoln & Guba 1985). Rigor could have also been increased through analysis of other forms of data such as syllabi of the teacher educators, lesson plans by the teachers, and observations of teaching.

Second, this study could have included in-service teachers in other parts of the United States and either interviewed them or formed a focus group. Having data from different cultural regions in the US would make the findings stronger.

Finally, although a modicum of trustworthiness and credibility was established through member checking, the use of the scenario, and triangulation, having another researcher analyze parts of the data to see if s/he saw the same things would have also made phase one stronger.

Phase 2

Two limitations that were discussed at length in phase two were that the ranking of the answers to the raters of the individual items was not provided. Had this limitation not occurred, the face validity process would have been more cogent.

Completing only one round of validation with the reviewers is another limitation. Revising the items and then having at least one more round of review could have led to items that may be ready to pilot test. Even in their revised state the items are not ready to pilot test. This is a limitation that can be overcome in future work with continuing rounds of face validity checks.

Finally, descriptions of all six points of the likert scale presented to the reviewers should have been provided. This is particularly important because of the dichotomy set up between points 2 and 3. Point 2 had a verbal label, whereas point 3 did not. This is potentially a critical mistake.

Future research

First and foremost is to complete the item validation process. As stated above, this is one of the limitations of this study. If given the opportunity to continue this line of research, this will be one of the first tasks the researcher will undertake.

Expanding phase one into a study on to its own could help in defining TPACK and its constituent parts. This could lead to more agreement on these constructs across scholars. This would also serve to improve measurement instruments of all types. Having knowledge and behaviors better defined could help this model and this knowledge ~~to~~ move towards being prescriptive, which it currently is not (Archambault & Barnett, 2010; Graham, 2011).

Using fixed-answer, open-ended and self-report measures together, is the best way to go about measuring and assessing TPACK. Developing a valid and reliable instrument for this could prove valuable to the TPACK community. Also equally important would be to describe the development of such an instrument so that others could do the same for other contexts, just as Hill, Ball & Schilling (2008) did with their pedagogical content knowledge measurement.

During the writing of this dissertation, the researcher discovered the Instrument Development and Criterion Validity (IDCV) model (Onwuegbuzie, Bustamante & Nelson, 2011). The IDCV is a 10-step model that incorporates both qualitative and quantitative methodologies during the instrument development process. It provides a systematic way to bring the emic and the etic perspectives to the process. Purposefully using this model in creating measurements of TPACK could make them more valid and more useful for other scholars. By creating stronger instruments to measure TPACK, there is potential to make the framework more useful to the practitioner and scholarly community working in the area of teaching with technology. This could potentially lead to improvement in student learning, which is the end goal of all work in teacher technology education.

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APPENDICIES

APPENDIX A

IN-SERVICE TEACHER FOCUS GROUP PROTOCOL

The following questions are simply a guide.

Group Description:
The following questions have been developed to be used for in-service teachers who have participated in the DLConnect research group's workshop series and have taught a lesson using the Instructional Architect.

Topic domain one: Technology knowledge
Lead off questions: How comfortable did you feel with using online resources before you started planning your lesson? How about the Instructional Architect? Did your comfort level change at all during your lesson planning?

Was there a point when you stopped thinking about the technology and was able to focus on the lesson planning – how you were going to teach it and the subject matter you were teaching? Describe it.

Possible follow up questions:
How did your comfort with the technology impact your decisions about how to teach with it?
During implementation, how did you handle technology problems?

> Did you have anyone on call in case something broke? Did you feel comfortable in handling problems on your own?

Topic domain two: Technological content knowledge
Lead off question: How do you know that an online resource will help to convey the topic you are teaching about?

Possible follow up questions
Did your thinking about how technology can represent subject matter evolve as you spent time looking at different online resources? If so, how so?

How do you decide what to teach using online resources? Why did you choose one topic versus another possible to teach using the IA and online resources?

After you decide what content you want to teach using OLRs, what do you look for in selecting the resources for using in your lesson?

When you are looking for resources to use are you thinking about specific facets of the content you are going to teach that you want to find a resource for? e.g. if you are teaching about Thomas Jefferson and one thing you want students to know is that he wrote the Declaration of Independence - would you go looking for something specifically about the Declaration of Independence or would you just generally look for things about his life?

Topic domain three: Technological pedagogical knowledge
Lead off question: Tell me how your thinking about teaching with technology evolved during your participation in the workshop. Do you think there are better ways then others to teach with technology?

Possible follow up questions:

Briefly tell me about a lesson you taught using the IA and online resources.

When you are looking at a resource that you may use in an IA lesson are you thinking about how you will teach with it? E.g. are you thinking that it may be good to use in a lesson where the students are working in groups or individuals, in a direct instruction type learning environment or a more inquiry based lesson?

When you implemented your lesson did you make contingency plans for if the technology failed? If so, what were they?

While you were teaching with the technology what were some of the challenges you had? how did you solve them?

Topic domain four: Technological pedagogical content knowledge
Lead off question: Tell me about how well you think your students learned the subject material with the IA and online resources.

Possible follow up questions
Did how the resources represent the subject matter you were teaching influence how you chose to teach it? re: large group, small group, individual, or did you look for resources that would help you to teach the material in the way that you planned?

When you were implementing your lesson, do you remember any decisions you made on the fly about changing how you were teaching with the technology?

> Did you have to make any changes in your lesson plan because the students weren't learning as you wanted them too?
> Were there any questions about the subject matter or the technology you weren't prepared for?

Was there an instance where the resources you chose didn't convey the subject matter as you thought it would? Tell me about that.

Topic domain five: Pedagogical content knowledge

While you were teaching what were some of the struggles the students had with the material you were teaching? How did you resolve those issues?

APPENDIX B
TEACHER EDUCATOR INTERVIEW PROTOCOL

This is a semi-structured interview. The questions will be used as a guide only, as the participant responds, other questions may be asked to explore important points brought by these responses.

General interviewee description
These questions are to be asked of professors who teach teaching methods classes for specific content areas to pre-service teachers.

Topic domain one: General technology integration
What do you hope that they will learn when you discuss technology integration in your classes?

> Do you hope that they will learn that there are better ways to use the technology than others?
>
> > If there are better ways - can you describe a few ways on a continuum - okay, good, great technology integration?

Give me an example of an assignment that you have given your students related to technology integration skills.

> How did you grade it?
>
> Will you describe a couple of the projects created - one on the 'could be better' end of the spectrum and one at the 'this was great' end?

Topic domain two: Technological pedagogical knowledge
Do you teach your students specific teaching methods to use with specific technology? Give me some examples of this.

What about contingency plans if the technology breaks? I know that this is something teachers have to face in all situations, but with technology specifically how do you prepare them for making other plans on the fly?

What about behavior management when using technology?

Topic domain three: Technological content knowledge
How do you talk about knowledge of content and how to know whether it is being represented correctly with the technology? Some of this is obvious, but with some simulations it may not be so obvious.

Topic domain four: Technological pedagogical content knowledge
When you are teaching your students technology - do you try to get your students to view technology, teaching methods, and the subject matter interacting? (Explain the framework if necessary) Or is this not how you view teaching with technology? Why not?

APPENDIX C

QUESTIONS DEVELOPED, THEME AND TPACK FRAMEWORK ALIGNMENT

Question	Theme	TPACK alignment
1. Read the following scenario and then respond to the statement that follows. Mr. Harris has planned a lesson that will use online learning resources to explore grammatical parts of speech. He has found many online learning resources that will help his students learn the parts of speech that include things like interactive games, diagrams, interactive sentence diagraming and a quiz at the end. He has planned to use the computer lab. At the last minute he can't use the lab because the software that runs the lab has broken. **Rank the following in order of what you e is the best to worst alternative action Mr. s should take:** __ Skip the lesson entirely and do it another day, even if he can't get access to the lab until after the unit is over. It can be used for enrichment after all. ___ He does have a projector in his classroom, so he could teach the lesson as a whole-class exercise. ___ Briefly instruct students in the parts of speech and then work together to create sentences and have students diagram them on the whiteboard.	Access to technology	Context
2. Refer to the scenario below and answer the question that follows. Arun is a ninth grade health teacher at Sarah Smith High School, a school in the Wasatch Mountains of Utah. At Sarah Smith he has access to a full computer lab that is shared by the whole school and each classroom has a small lab of three to four older computers. All the computers in the school are internet accessible. One of the core objectives for health is learning about	How instructional materials are designed Technology should be used for solid teaching and learning ends, rather than because it's there.	TPACK TPACK

personal safety. In Utah one important way to keep safe is knowing about avalanches – what causes them, how to avoid them, and what to do if you get caught in one. Arun has decided that since winter is coming, that he is going to teach a unit on avalanches, the first lesson being on what causes them.

Arun wants to use online learning resources to teach the lesson because he's noticed that his students have more fun when they get to work on computers.

[Avalanches are caused by weather (heavy storms are particularly dangerous times to be in the back country), recent snow fall which puts pressure on existing snowpack, large changes in temperature, wind, and the kind of terrain. People can trigger avalanches by causing vibrations which can set one off].

Besides basic computer skills, what will Arun need to think about as he is preparing for a lesson on the causes of avalanches? Choose the best answer below.

a) When he will be able to access the computer lab, how to find online learning resources that will explain the causes of avalanches, teaching himself about the content he is teaching.

b)When he will be able to access the computer lab, understanding how different online learning resources can help his students understand the basic concepts of how avalanches are caused, and how he will be able to assess what his students have learned.

c) Knowing what online learning resources will be the most fun for his students, how to prepare a lecture about avalanche causes that will get them ready to use the online resources, how to manage his students' behavior as they are working in the lab.

3. Read the following scenario and then respond to the statements that follow. Arun has decided to use a variety of resources to teach students how avalanches happen and how	Technology should be used for solid teaching and learning ends,	TPACK

they can be safe in avalanche prone areas. He has decided that students will work individually to go through the online learning resources and work through a basic worksheet asking questions about the impacts of temperature, wind and recent snowfall in causing avalanches, as well as questions about how to be safe in avalanche prone areas. This will let him best assess what students have learned in the exercise. To assess their understanding of the information, he wants students to create a product with some sort of technology-based component. **Rank in order the best way he could do this.** ___ Have each student write a report that incorporates images and diagrams about how avalanches happen and how they can be safe in avalanche prone areas. ___ Pair students together to create a power point presentation about avalanches and avalanche safety that they will then be able to present to other ninth grade health classes. ___ Have his students work in groups of three to create posters, that include images and diagrams created on the computer or found online to put up around the school.	rather than because it's there.	
4. Now that you've decided what Arun should think about how to prepare his lesson about avalanches using online learning resources, what would be the best kind of resources for Arun to look for in order to allow students to learn how avalanches happen? **Rank the following resources he could use in order of best to the worst.** ____ Three videos that have a person explaining how temperature, wind, and recent snow fall can cause avalanches to happen and how people can be safe in avalanche prone areas. ____ A series of images and age-appropriate diagrams with descriptions that explain how temperature, wind, and recent snow fall can cause avalanches to happen and how to be safe in avalanche prone areas. ____ A series of games which will engage his students more than the videos and images, but	Technology should be used for solid teaching and learning ends, rather than because it's there.	TPACK

may not show the impact of temperature, wind and recent snow fall on avalanche prone areas.		
5. Read the following scenario and respond to the statement below. [The density of a material is defined as its mass per unit of volume. If two things can't mix (e.g. a piece of metal and water in a tub) then the less dense material will float on top of above the more dense material. (or in the case of the water and the metal, the metal will sink to the bottom of the water in the tub). While density is thought to be stable, if the pressure is applied to an object or its temperature is changed, or temperature of an object is changed, the density of the object is changed.will change. For example, instance heating wrought iron something up will decrease its density]. Susan has been looking for new ways to teach the concept of density to her students. In the past she has used demonstrations and mini labs in order to help her students understand that things have different densities (e.g. styrofoam and concrete) but she wants her seventh grade students to be able to change pressure and temperature to see the impact of the density of the material. This isn't something that she can do easily through mini-labs because of the time it takes to heat and cool things and the ability to add and remove pressure of materials. Susan's school now has enough access to computers that it will be easy to schedule time in a full computer lab for an extended period of time, and while she feels that the demonstrations she has done in the past have been effective in teaching her students the concept of density, she believes that using online resources can help her students learn it even better. Jane searches the web and discovers several different simulations that allow students to explore density in different ways including being able to manipulate all the variables that contribute to the density of an object.	Passive vs active learning	TPACK

Below are a list of different ways that Susan can use the computer resources that she has discovered. Rank them in order of what you believe are the best to worst ways to use them with students.

____ Project different online learning resources onto a screen in front of the class and have students work in groups to suggest possible solutions to density problems presented in the resources. The students, as a group, will record their suggestions and explain them to the class.

___ Take students to the computer lab and have them access the online learning resources individually, changing the variables that impact density. The directions that Susan gives are for them to go to each resource and fill out the part of a the worksheet she has created for that resource and then move on.

___ Have students work in groups to figure out a problem that Jane has presented to them about figuring out how thick the wood of a door frame needs to be, taking into consideration how the density of wood can change the fit of the door frame. This problem will allow students to draw on previous knowledge, and has multiple correct answers. The students will use the online learning resources Susan found, as well as other online learning resources that they have searched for; to answer the problem.

6. Read the scenario below about Susan and then identify what her next move should be. Susan has recently learned an inquiry-based method that will enable her students to fully explore the concept of density with the online learning resources that she has discovered. She feels that this method coupled with the online resources will allow her students to learn the important concepts about density more easily and be better prepared for the end- of- year test. However, she is not fully confident yet in her skills using this method and fears that the lesson may backfire leaving her students with misconceptions about the topic.	Passive vs active learning	TPACK

What should Susan do?
a) Wait until next year to implement this new inquiry-based instruction and instead use the online resources only. This will allow her students to learn the different properties of density better than if she had stuck with her original method for teaching density; use of the small labs in the classroom and demonstrations. She can also use in-class time for discussions about what the students are learning using the online resources.

b) Use her old method of teaching density – small labs and demonstrations – which have proven effective in the past, as indicated by scores on end- of- year testing, but will not allow them to explore at all the multiple variables that impact the density of an object.

c) Use the inquiry-based method with the online learning resources. This could potentially lead her students to developing misconceptions about the different factors that impact density, or even potentially learn wrong information. She can use in-class time, away from the computers, to work to correct any misconceptions her students may have developed.

7. **Read the scenario below about Susan and then identify what she should do.** Susan has reserved the computer lab for two consecutive days. She will have students work in pairs to complete a worksheet of density probleMs. The way to solve the problems will be to manipulate the different variables that affect density using online resources and come up with the best solution to each problem. She tells her students to meet her in the computer lab in order for them to be able to have as much time working through the resources as possible. Suddenly the internet goes down in the lab and she's told it won't come back up for the rest of the day.	Access to technology Passive vs active learning	Context TPACK

What should Susan do?

a) Go back to the classroom where the internet is working, project the online resources on to the white board and have the whole class work through the first half of the problems together. Students will suggest ways which variables (temperature and pressure on the object) should be manipulated and come to consensus about the best solution to each problem. The next day they will go back to the computer lab to finish the problems with a partner as Susan initially had planned. b) Go back to the classroom, pull out the small labs and have the students begin to explore density to give them some background information so that they will be prepared to work through the entire worksheet the next day in the computer lab. This will take time, though, and the students will not have long at all to work with the mini-labs. c) Go back to the classroom and give a lecture on density and plan to have the students work in the lab as she intended the next day.		
8. Read the scenario below and the respond to the question below. Shannon is a U.S. government teacher and has recently discovered a website of great online learning resources to teach the process by which a bill becomes a law. Some of the online learning resources are basic diagrams, but exciting one is a simulation where students get to act as congressmen and women to follow their bill through committee and subcommittee meetings, and then onto the floor of the House of Representatives for the vote. At each juncture in this simulation, students must answer questions about their bill before it is able to move on through the process. Shannon decides to create an inquiry-based lesson using this online simulation for his students. Unfortunately, it is the end of the year and all the computer labs are being used for end-of-year testing. She won't have access to a computer lab and he doesn't have an LCD projector in his class to do it as a whole class activity.	Access to technology	Context

Rank what should Shannon should do from the best to worst possible actions. ___ Teach the lesson as she has in the past without the online resources. She feels comfortable doing this and knows, through assessment of student performance, that this has been effective in having her students learn the different steps to how a bill becomes a law. ___ Come back to the lesson after end- of- year testing has been completed so that students can complete the inquiry-based lesson using the online simulation. ___ Create a whole-class inquiry-based lesson where each member of the class plays a different part in the process (sub- committee member, committee member, Minority Whip, Majority Whip, etc.) and use the online resources in the computer lab to reinforce what was learned after end- of- year testing is completed.		
9. Read the following scenario and then respond to the question and statement below. Mrs. Rojas teaches fifth grade at Mt. Hull Elementary School in Seattle, WA. She likes teaching elementary school because she gets to teach all subjects to her students. Recently there have been a few earthquakes around Seattle, and so she has decided to create multidisciplinary unit about earthquakes across health, science, social studies, math and language arts. She wants her students to be able to identify how earthquakes happen, how they can prepare for safety during an earthquake, and how to use maps to locate potential earthquake zones. She plans to assess what they have learned at the end of the unit through projects that they have done in pairs. Mrs. Rojas has found a simulation that will allow students to manipulate the magnitude, depth and location of an earthquake in relation to a fictional city. This will allow them to better understand how earthquakes occur and what the impact is to city buildings and infrastructure. [Earthquakes happen when the edges of tectonic	Technology should be used for solid teaching and learning ends, rather than because it's there.	TPACK

plates, known as faults, move. The amount of shaking on land that happens depends on many things, including how much energy is released by the earthquake, how deep the earthquake is and, in relation to human structures, how far away they are from the where the earthquake takes place (this is called the epicenter).]

What are the advantages of learning about using earthquakes using this simulation?

a) Because students use computers so much outside of school, they are comfortable with them and enjoy using them. Therefore, they will learn the material using this method.

b)The simulation allows the students to manipulate earthquake variables and see what how each impacts city buildings and infrastructure. This kind of involvement with the material will allow them to learn about earthquakes better than if they had not used the simulation.

c) Because students are able to manipulate earthquake variables and learn how those variables impact city buildings and infrastructure, they can then apply what they've learned about the fictional city to their own city and neighborhoods which will deepen their understanding of the causes of earthquakes and their effects.

10. As stated in question 9, Mrs. Rojas will assess how much her students have learned about earthquakes, how to be safe in earthquakes, and how earthquakes impact Seattle through a project that will be completed in pairs. The requirements for this final assignment are: * That students use at least one online learning resource, that only contains text. This can be a video, a simulation, picture, diagram, etc. * That the project explain how	Technology should be used for solid teaching and learning ends, rather than because it's there.	TPACK

earthquakes happen, how to be safe during an earthquake, and how earthquakes impact Seattle. *The project will be a resource that allows people to learn about earthquakes and their impact on Seattle on their own. **The following are descriptions of what her students created for their final projects. Based on what is written, rank them from 1-3 from the best to the worst use of the online resources.** ___ An online power point presentation that uses pictures, diagrams, and text to explain how earthquakes happen, how to be safe, and how earthquakes impact Seattle. ___ A website that brings the simulation that they used earlier, as well as pictures, diagrams and basic text about how to be safe and how earthquakes impact Seattle. A basic quiz is included at the end.		
11. Read the scenario below and answer the question that follows. In Ms. Prestage's ninth-grade English class, English is the second language for 11 of the 25 students. They represent four different language groups and have a wide range of English proficiency. One of Ms. Prestage's goals for this class is that "Students will develop speaking and listening skills, both in formal presentations and informal discussions." To address this goal, she plans to have pairs of students interview each other and then introduce each other to the rest of the class. **Which of the following has the potential for helping the students for whom English is a second language perform well in this activity?** (A) Showing a video of a model interview and an introduction in which a student from a previous year interviews Ms. Prestage and then introduces her. (B) Having students go through a website that	Technology should be used for solid teaching and learning ends, rather than because it's there.	TPACK

has guidelines, videos, and a quiz at the end about how to interview someone.

(C) Having students discuss among themselves what completing the activity successfully will require.

APPENDIX D

FACE VALIDITY FORM SENT TO EXPERTS IN TPACK

Face validity of items to measure TPACK for M. Brooke Robertshaw

Background

The goal of my dissertation is to take two initial steps toward creating a valid and reliable instrument to measure the TPACK of in-service teachers. The first step was to create the instrument. The second step is to establish the face validity of the instrument. It is for this latter step that I am enlisting your expertise.

The Instrument

The instrument itself presents eleven questions. Each question is composed of a scenario followed by a series of possible responses. In later steps, a teacher's responses to each scenario will combine to indicate the teacher's level of TPACK. The presentation of scenarios was used as they have been shown to be an effective way to assess teacher knowledge.

The technological (T) context of the questions is online learning resources. The content (C) areas are health, language arts, social studies, science, and math. Specific information about these subject areas may be considered accurate, and was drawn from a variety of resources. Questions are based on national or state core objectives from grades 4-7. Pedagogical (P) aspects of the questions (i.e. student measurement when using online learning resources, knowledge necessary to teach with online learning resources, knowing what kinds of online learning resources convey the content best) came from the teachers themselves. Teacher input was obtained primarily via a focus group, with additional input received during discussions with teachers participating in a professional development workshop. One item, item 11, was adapted from a previously created measure.

Face Validity

I am requesting that you read each question (the scenario and the possible responses). Both will be in italics to indicate that all you need to do is to read these sections. You are not being asked to complete the response items themselves. <u>After each question, there is a box for you to indicate the degree to which you believe the entire question, scenario and responses, are valid for measuring TPACK.</u> There is space for you to comment as well. Your comments about specific scenarios and response items would be greatly appreciated to assist in fine tuning questions during the next stage of development.

Please do not hesitate to call me if there is any confusion about what you are being asked to do. It is my hope that the measurement I am requesting of you will not take much time.

Directions

1. Read each question (the scenario and response possibilities) and place an x in the box provided at the end to indicate your rating (0-5) of the question's alignment to TPACK. Note: The same scenario may be used with more than one question. This is indicated where applicable.

2. Leave any comments about the question as a whole, the specific scenarios, or response items that may assist in further development of the instrument.

THANK YOU VERY MUCH FOR DOING THIS!

Question 1

Read the following scenario and then respond to the statement that follows. [This sentence is a direction those who take this test.]

Mr. Harris has planned a lesson that will use online learning resources to explore grammatical parts of speech. He has found many online learning resources that will help his students learn the parts of speech that include things like interactive games, diagrams, interactive sentence diagraming and a quiz at the end. He has planned to use the computer lab. At the last minute he can't use the lab because the software that runs the lab has broken.

Rank the following in order of what you believe is the best to worst alternative action Mr. Harris should take:

__ Skip the lesson entirely and do it another day, even if he can't get access to the lab until after the unit is over. It can be used for enrichment after all.

___ He does have a projector in his classroom, so he could teach the lesson as a whole-class exercise.

___ Briefly instruct students in the parts of speech and then work together to create sentences and have students diagram them on the whiteboard.

Scenario, Question 1 and Response set measurement of TPACK						
	Does not assess the TPACK of a test taker.		Moderately measures the TPACK of a test taker			measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

Question 2

Refer to the scenario below and answer the question that follows. [Direction to teachers]

Arun is a ninth grade health teacher at Sarah Smith High School, a school in the Wasatch Mountains of Utah. At Sarah Smith he has access to a full computer lab that is shared by the whole school and each classroom has a small lab of three to four older computers. All the computers in the school are internet accessible. One of the core objectives for health is learning about personal safety. In Utah one important way to keep safe is knowing about avalanches – what causes them, how to avoid them, and what to do if you get caught in one. Arun has decided that since winter is coming, that he is going to teach a unit on avalanches, the first lesson being on what causes them.

Arun wants to use online learning resources to teach the lesson because he's noticed that his students have more fun when they get to work on computers.

[Avalanches are caused by weather (heavy storms are particularly dangerous times to be in the back country), recent snow fall which puts pressure on existing snowpack, large changes in temperature, wind, and the kind of terrain. People can trigger avalanches by causing vibrations which can set one off].

Besides basic computer skills, what will Arun need to think about as he is preparing for a lesson on the causes of avalanches? Choose the best answer below.

a) When he will be able to access the computer lab, how to find online learning resources that will explain the causes of avalanches, teaching himself about the content he is teaching.

b)When he will be able to access the computer lab, understanding how different online learning resources can help his students understand the basic concepts of how avalanches are caused, and how he will be able to assess what his students have learned.

c) Knowing what online learning resources will be the most fun for his students, how to prepare a lecture about avalanche causes that will get them ready to use the online resources, how to manage his students' behavior as they are working in the lab.

Scenario, Question 2 and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

Question 3

Read the following scenario and then respond to the statements that follow. [Direction to teachers.]

Arun has decided to use a variety of resources to teach students how avalanches happen and how they can be safe in avalanche prone areas. He has decided that students will work individually to go through the online learning resources and work through a basic worksheet asking questions about the impacts of temperature, wind and recent snowfall in causing avalanches, as well as questions about how to be safe in avalanche prone areas. This will let him best assess what students have learned in the exercise. To assess their understanding of the information, he wants students to create a product with some sort of technology-based component.

Rank in order the best way he could do this.

___ Have each student write a report that incorporates images and diagrams about how avalanches happen and how they can be safe in avalanche prone areas.

___ Pair students together to create a power point presentation about avalanches and avalanche safety that they will then be able to present to other ninth grade health classes.

___ Have his students work in groups of three to create posters, that include images and diagrams created on the computer or found online to put up around the school.

Scenario, Question 3 and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

<u>Question 4</u>

Note to those assessing for face validity: This question builds on question 3 and utilizes information from the same scenario (below).

Arun has decided to use a variety of resources to teach students how avalanches happen and how they can be safe in avalanche prone areas. He has decided that students will work individually to go through the online learning resources and work through a basic worksheet asking questions about the impacts of temperature, wind and recent snowfall in causing avalanches, as well as questions about how to be safe in avalanche prone areas. This will let him best assess what students have learned in the exercise. To assess their understanding of the information, he wants students to create a product with some sort of technology-based component.

Now that you've decided what Arun should think about how to prepare his lesson about avalanches using online learning resources, what would be the best kind of resources for Arun to look for in order to allow students to learn how avalanches happen?

Rank the following resources he could use in order of best to the worst.

____ Three videos that have a person explaining how temperature, wind, and recent snow fall can cause avalanches to happen and how people can be safe in avalanche prone areas.

____ A series of images and age-appropriate diagrams with descriptions that explain how temperature, wind, and recent snow fall can cause avalanches to happen and how to be safe in avalanche prone areas.

____ A series of games which will engage his students more than the videos and images, but may not show the impact of temperature, wind and recent snow fall on avalanche prone areas.

Scenario, <u>Question 4</u> and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

Question 5

Read the following scenario and respond to the statement below. [Directions to teachers]

[The density of a material is defined as its mass per unit of volume. If two things can't mix (e.g. a piece of metal and water in a tub) then the less dense material will float on top of above the more dense material. (or in the case of the water and the metal, the metal will sink to the bottom of the water in the tub). While density is thought to be stable, if the pressure is applied to an object or its temperature is changed, or temperature of an object is changed, the density of the object is changed.will change. For example, instance heating wrought iron something up will decrease its density].

Susan has been looking for new ways to teach the concept of density to her students. In the past she has used demonstrations and mini labs in order to help her students understand that things have different densities (e.g. styrofoam and concrete) but she wants her seventh grade students to be able to change pressure and temperature to see the impact of the density of the material. This isn't something that she can do easily through mini-labs because of the time it takes to heat and cool things and the ability to add and remove pressure of materials.

Susan's school now has enough access to computers that it will be easy to schedule time in a full computer lab for an extended period of time, and while she feels that the demonstrations she has done in the past have been effective in teaching her students the concept of density, she believes that using online resources can help her students learn it even better. Jane searches the web and discovers several different simulations that allow students to explore density in different ways including being able to manipulate all the variables that contribute to the density of an object.

Below are a list of different ways that Susan can use the computer resources that she has discovered. Rank them in order of what you believe are the best to worst ways to use them with students.

____ Project different online learning resources onto a screen in front of the class and have students work in groups to suggest possible solutions to density problems presented in the resources. The students, as a group, will record their suggestions and explain them to the class.

___ Take students to the computer lab and have them access the online learning resources individually, changing the variables that impact density. The directions that Susan gives are for them to go to each resource and fill out the part of a the worksheet she has created for that resource and then move on.

___ Have students work in groups to figure out a problem that Jane has presented to them about figuring out how thick the wood of a door frame needs to be, taking into consideration how the density of wood can change the fit of the door frame. This problem will allow students to draw on previous knowledge, and has multiple correct answers. The students will use the online learning resources Susan found, as well as other online learning resources that they have searched for; to answer the problem.

Scenario, Question 5 and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			Measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

Question 6

Read the scenario below about Susan and then identify what her next move should be. [Directions to teachers]

Susan has recently learned an inquiry-based method that will enable her students to fully explore the concept of density with the online learning resources that she has discovered. She feels that this method coupled with the online resources will allow her students to learn the important concepts about density more easily and be better prepared for the end- of- year test. However, she is not fully confident yet in her skills using this method and fears that the lesson may backfire leaving her students with misconceptions about the topic.

What should Susan do?

a) Wait until next year to implement this new inquiry-based instruction and instead use the online resources only. This will allow her students to learn the different properties of density better than if she had stuck with her original method for teaching density; use of the small labs in the classroom and demonstrations. She can also use in-class time for discussions about what the students are learning using the online resources.

b) Use her old method of teaching density – small labs and demonstrations – which have proven effective in the past, as indicated by scores on end- of- year testing, but will not allow them to explore at all the multiple variables that impact the density of an object.

c) Use the inquiry-based method with the online learning resources. This could potentially lead her students to developing misconceptions about the different factors that impact density, or even potentially learn wrong information. She can use in-class time, away from the computers, to work to correct any misconceptions her students may have developed.

Scenario, Question 6 and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			Measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

Question 7

Read the scenario below about Susan and then identify what she should do. [Directions to teachers]

Susan has reserved the computer lab for two consecutive days. She will have students work in pairs to complete a worksheet of density problems. The way to solve the problems will be to manipulate the different variables that affect density using online resources and come up with the best solution to each problem. She tells her students to meet her in the computer lab in order for them to be able to have as much time working through the resources as possible. Suddenly the internet goes down in the lab and she's told it won't come back up for the rest of the day.

What should Susan do?

a) Go back to the classroom where the internet is working, project the online resources on to the white board and have the whole class work through the first half of the problems together. Students will suggest ways which variables (temperature and pressure on the object) should be manipulated and come to consensus about the best solution to each problem. The next day they will go back to the computer lab to finish the problems with a partner as Susan initially had planned.

b) Go back to the classroom, pull out the small labs and have the students begin to explore density to give them some background information so that they will be prepared to work through the entire worksheet the next day in the computer lab. This will take time, though, and the students will not have long at all to work with the mini-labs.

c) Go back to the classroom and give a lecture on density and plan to have the students work in the lab as she intended the next day.

Scenario, <u>Question 7</u> and Response set measurement of TPACK						
	Does not measures the TPACK of a test taker.		Moderately measures the TPACK of a test taker			Measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

<u>Question 8</u>

Read the scenario below and the respond to the question below. [Direction to teachers]

Shannon is a U.S. government teacher and has recently discovered a website of great online learning resources to teach the process by which a bill becomes a law. Some of the online learning resources are basic diagrams, but exciting one is a simulation where students get to act as congressmen and women to follow their bill through committee and subcommittee meetings, and then onto the floor of the House of Representatives for the vote. At each juncture in this simulation, students must answer questions about their bill before it is able to move on through the process. Shannon decides to create an inquiry-based lesson using this online simulation for his students. Unfortunately, it is the end of the year and all the computer labs are being used for end-of-year testing. She won't have access to a computer lab and he doesn't have an LCD projector in his class to do it as a whole class activity.

Rank what should Shannon should do from the best to worst possible actions.

___ Teach the lesson as she has in the past without the online resources. She feels comfortable doing this and knows, through assessment of student performance, that this has been effective in having her students learn the different steps to how a bill becomes a law.

___ Come back to the lesson after end- of- year testing has been completed so that students can complete the inquiry-based lesson using the online simulation.

___ Create a whole-class inquiry-based lesson where each member of the class plays a different part in the process (sub- committee member, committee member, Minority Whip, Majority Whip, etc.) and use the online resources in the computer lab to reinforce what was learned after end- of- year testing is completed.

Scenario, <u>Question 8</u> and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			Measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

<u>Question 9</u>

Read the following scenario and then respond to the question and statement below.

[Direction to teachers]

Mrs. Rojas teaches fifth grade at Mt. Hull Elementary School in Seattle, WA. She likes teaching elementary school because she gets to teach all subjects to her students. Recently there have been a few earthquakes around Seattle, and so she has decided to create multidisciplinary unit about earthquakes across health, science, social studies, math and language arts. She wants her students to be able to identify how earthquakes happen, how they can prepare for safety during an earthquake, and how to use maps to locate potential earthquake zones. She plans to assess what they have learned at the end of the unit through projects that they have done in pairs.

Mrs. Rojas has found a simulation that will allow students to manipulate the magnitude, depth and location of an earthquake in relation to a fictional city. This will allow them to better understand how earthquakes occur and what the impact is to city buildings and infrastructure.

[Earthquakes happen when the edges of tectonic plates, known as faults, move. The amount of shaking on land that happens depends on many things, including how much energy is released by the earthquake, how deep the earthquake is and, in relation to human structures, how far away they are from the where the earthquake takes place (this is called the epicenter).]

What are the advantages of learning about using earthquakes using this simulation?

a) Because students use computers so much outside of school, they are comfortable with them and enjoy using them. Therefore, they will learn the material using this method.

b)The simulation allows the students to manipulate earthquake variables and see what how each impacts city buildings and infrastructure. This kind of involvement with the material will allow them to learn about earthquakes better than if they had not used the simulation.

c) Because students are able to manipulate earthquake variables and learn how those variables impact city buildings and infrastructure, they can then apply what they've learned about the fictional city to their own city and neighborhoods which will deepen their understanding of the causes of earthquakes and their effects.

Scenario, Question 9 and Response set measurement of TPACK						
	Does not measure the		Moderately measures the			Measures the TPACK of a

	TPACK of a test taker.		TPACK of a test taker			test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

<u>Question 10</u>

Note to those assessing for face validity: This question builds on question 9 and utilizes information from the same scenario (below).

Mrs. Rojas teaches fifth grade at Mt. Hull Elementary School in Seattle, WA. She likes teaching elementary school because she gets to teach all subjects to her students. Recently there have been a few earthquakes around Seattle, and so she has decided to create multidisciplinary unit about earthquakes across health, science, social studies, math and language arts. She wants her students to be able to identify how earthquakes happen, how they can prepare for safety during an earthquake, and how to use maps to locate potential earthquake zones. She plans to assess what they have learned at the end of the unit through projects that they have done in pairs.

Mrs. Rojas has found a simulation that will allow students to manipulate the magnitude, depth and location of an earthquake in relation to a fictional city. This will allow them to better understand how earthquakes occur and what the impact is to city buildings and infrastructure.

[Earthquakes happen when the edges of tectonic plates, known as faults, move. The amount of shaking on land that happens depends on many things, including how much energy is released by the earthquake, how deep the earthquake is and, in relation to human structures, how far away they are from the where the earthquake takes place (this is called the epicenter).]

As stated above, Mrs. Rojas will assess how much her students have learned about earthquakes, how to be safe in earthquakes, and how earthquakes impact Seattle through a project that will be completed in pairs. The requirements for this final assignment are:

- That students use at least one online learning resource, that only contains text. This can be a video, a simulation, picture, diagram, etc.
- That the project explain how earthquakes happen, how to be safe during an earthquake, and how earthquakes impact Seattle.
- The project will be a resource that allows people to learn about earthquakes and their impact on Seattle on their own.

The following are descriptions of what her students created for their final projects. Based on what is written, rank them from 1-3 from the best to the worst use of the online resources.

___ An online power point presentation that uses pictures, diagrams, and text to explain how earthquakes happen, how to be safe, and how earthquakes impact Seattle.

___ A website that brings the simulation that they used earlier, as well as pictures, diagrams and basic text about how to be safe and how earthquakes impact Seattle. A basic quiz is included at the end.

___ A video that has a scientist talking about how earthquakes happen, an expert in earthquakes explaining how to be safe during earthquakes, and a video of a local official talking about how earthquakes impact Seattle.

Scenario, Question 10 and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			Measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

Question 11

Read the scenario below and answer the question that follows. [Directions to teachers]

In Ms. Prestage's ninth-grade English class, English is the second language for 11 of the 25 students. They represent four different language groups and have a wide range of English proficiency. One of Ms. Prestage's goals for this class is that "Students will develop speaking and listening skills, both in formal presentations and informal discussions." To address this goal, she plans to have pairs of students interview each other and then introduce each other to the rest of the class.

Which of the following has the potential for helping the students for whom English is a second language perform well in this activity?

(a) Showing a video of a model interview and an introduction in which a student from a previous year interviews Ms. Prestage and then introduces her.

(b) Having students go through a website that has guidelines, videos, and a quiz at the end about how to interview someone.

c) Having students discuss among themselves what completing the activity successfully will require.

Scenario, Question 11 and Response set measurement of TPACK						
	Does not measure the TPACK of a test taker.		Moderately measures the TPACK of a test taker			Measures the TPACK of a test taker fully.
	0	1	2	3	4	5
Your response:						
Comments (if any):						

APPENDIX E

UPDATED ITEMS BASED ON FEEDBACK

<u>Question 1</u>

Read the following scenario and then respond to the statement that follows. [This sentence is a direction those who take this test.]

Mr. Harris has planned a lesson that will use online learning resources to explore grammatical parts of speech. He has found many online learning resources that will help his students learn the parts of speech that include things like interactive games, diagrams, interactive sentence diagraming and a quiz at the end. He has planned to use the computer lab. At the last minute he can't use the lab because the software that runs the lab has broken.

Rank the following in order of what you believe is the best to worst alternative action Mr. Harris should take:

__ Skip the lesson entirely and do it another day, even if he can't get access to the lab until after the unit is over. It can be used for enrichment after all. [3]

___ He does have a projector in his classroom, so he could teach the lesson as a whole-class exercise. [2]

___ Briefly instruct students in the parts of speech and then work together to create sentences and have students diagram them on the whiteboard. [1]

<u>Question 2</u>

Refer to the scenario below and answer the question that follows. [Direction to teachers]

Arun is a ninth grade health teacher at Sarah Smith High School, a school in the Wasatch Mountains of Utah. At Sarah Smith he has access to a full computer lab that is shared by the whole school and each classroom has a small lab of three to four older computers. All the computers in the school are internet accessible. One of the core objectives for health is learning about personal safety. In Utah one important way to keep safe is knowing about avalanches – what causes them, how to avoid them, and what to do if you get caught in one. Arun has decided that since winter is coming, that he is going to teach a unit on avalanches, the first lesson being on what causes them.

Arun wants to use online learning resources to teach the lesson because he's noticed that his students have more fun when they get to work on computers.

[Avalanches are caused by weather (heavy storms are particularly dangerous times to be in the back country), recent snow fall which puts pressure on existing snowpack, large changes in temperature, wind, and the kind of terrain. People can trigger avalanches by causing vibrations which can set one off].

Besides basic computer skills, what will Arun need to think about as he is preparing for a lesson on the causes of avalanches? Choose the best answer below.

a) When he will be able to access the computer lab, how to find online learning resources that will explain the causes of avalanches, teaching himself about the content he is teaching. [2]

b)When he will be able to access the computer lab, understanding how different online learning resources can help his students understand the basic concepts of how avalanches are caused, and how he will be able to assess what his students have learned. [1]

c) Knowing what online learning resources will be the most fun for his students, how to prepare a lecture about avalanche causes that will get them ready to use the online resources, how to manage his students' behavior as they are working in the lab. [3.

<u>Question 3</u>

Read the following scenario and then respond to the statements that follow. [Direction to teachers.]

Arun has decided to use a variety of resources to teach students how avalanches happen and how they can be safe in avalanche prone areas. He has decided that students will work individually to go through the online learning resources and work through a basic worksheet asking questions about the impacts of temperature, wind and recent snowfall in causing avalanches, as well as questions about how to be safe in avalanche prone areas. This will let him best assess what students have learned in the exercise. To assess their understanding of the information, he wants students to create a product with some sort of technology-based component.

Rank in order the best way he could do this.

___ Have each student write a report that incorporates images and diagrams about how avalanches happen and how they can be safe in avalanche prone areas. [1]

___ Pair students together to create a power point presentation about avalanches and avalanche safety that they will then be able to present to other ninth grade health classes. [2]

___ Have his students work in groups of three to create posters, that include images and diagrams created on the computer or found online to put up around the school. [3]

<u>Question 4</u>

Arun has decided to use a variety of resources to teach students how avalanches happen and how they can be safe in avalanche prone areas. He has decided that students will work individually to go through the online learning resources and work through a basic worksheet asking questions about the impacts of temperature, wind and recent snowfall in causing avalanches, as well as questions about how to be safe in avalanche prone areas. This will let him best assess what students have learned in the exercise. To assess their understanding of the information, he wants students to create a product with some sort of technology-based component.

Now that you've decided what Arun should think about how to prepare his lesson about avalanches using online learning resources, what would be the best kind of resources for Arun to look for in order to allow students to learn how avalanches happen?

Rank the following resources he could use in order of best to the worst.

____ Three videos that have a person explaining how temperature, wind, and recent snow fall can cause avalanches to happen and how people can be safe in avalanche prone areas. [2]

____ A series of images and age-appropriate diagrams with descriptions that explain how temperature, wind, and recent snow fall can cause avalanches to happen and how to be safe in avalanche prone areas. [1]

____ A series of games which will engage his students more than the videos and images, but may not show the impact of temperature, wind and recent snow fall on avalanche prone areas. [3]

<u>Question 5</u>

Read the following scenario and respond to the statement below. [Directions to teachers]

[The density of a material is defined as its mass per unit of volume. If two things can't mix (e.g. a piece of metal and water in a tub) then the less dense material will float on top of above the more dense material. (or in the case of the water and the metal, the metal will sink to the bottom of the water in the tub). While density is thought to be stable, if the pressure is applied to an object or its temperature is changed, or temperature of an object is changed, the density of the object is changed will change. For example, instance heating wrought iron something up will decrease its density].

Susan has been looking for new ways to teach the concept of density to her students. In the past she has used demonstrations and mini labs in order to help her students understand that things have different densities (e.g. styrofoam and concrete) but she wants her seventh grade students to be able to change pressure and temperature to see the impact of the density of the material. This isn't something that she can do easily through mini-labs because of the time it takes to heat and cool things and the ability to add and remove pressure of materials.

Susan's school now has enough access to computers that it will be easy to schedule time in a full computer lab for an extended period of time, and while she feels that the demonstrations she has done in the past have been effective in teaching her students the concept of density, she believes that using online resources can help her students learn it even better. Jane searches the web and discovers several different simulations that allow students to explore density in different ways including being able to manipulate all the variables that contribute to the density of an object.

Below are a list of different ways that Susan can use the computer resources that she has discovered. Rank them in order of what you believe are the best to worst ways to use them with students.

____ Project different online learning resources onto a screen in front of the class and have students work in groups to suggest possible solutions to density problems presented in the resources. The students, as a group, will record their suggestions and explain them to the class. [2]

___ Take students to the computer lab and have them access the online learning resources individually, changing the variables that impact density. The directions that Susan gives are for them to go to each resource and fill out the part of a the worksheet she has created for that resource and then move on. [3]

___ Have students work in groups to figure out a problem that Susan has presented to them about figuring out how thick the wood of a door frame needs to be, taking into consideration how the density of wood can change the fit of the door frame. This problem will allow students to draw on previous knowledge, and has multiple correct answers. The students will use the online learning resources Susan found, as well as other online learning resources that they have searched for to answer the problem. [1]

Question 6

Read the scenario below about Susan and then identify what her next move should be. [Directions to teachers]

Susan has recently learned an inquiry-based method that will enable her students to fully explore the concept of density with the online learning resources that she has discovered. She feels that this method coupled with the online resources will allow her students to learn the important concepts about density more easily and be better prepared for the end- of- year test. However, she is not fully confident yet in her skills using this method and fears that the lesson may backfire leaving her students with misconceptions about the topic.

What should Susan do?

a) Wait until next year to implement this new inquiry-based instruction and instead use the online resources only. This will allow her students to learn the different properties of density better than if she had stuck with her original method for teaching density; use of the small labs in the classroom and demonstrations. She can also use in-class time for discussions about what the students are learning using the online resources. [2]

b) Use her old method of teaching density – small labs and demonstrations – which have proven effective in the past, as indicated by scores on end- of- year testing, but will not allow them to explore at all the multiple variables that impact the density of an object. [3]

c) Use the inquiry-based method with the online learning resources. This could potentially lead her students to developing misconceptions about the different factors that impact density, or even potentially learn wrong information. She can use in-class time, away from the computers, to work to correct any misconceptions her students may have developed. [1]

Question 7

Read the scenario below about Susan and then identify what she should do. [Directions to teachers]

Susan has reserved the computer lab for two consecutive days. She will have students work in pairs to complete a worksheet of density problems. The way to solve the problems will be to manipulate the different variables that affect density using online resources and come up with the best solution to each problem. She tells her students to meet her in the computer lab in order for them to be able to have as much time working through the resources as possible. Suddenly the internet goes down in the lab and she's told it won't come back up for the rest of the day.

What should Susan do?

a) Go back to the classroom where the internet is working, project the online resources on to the white board and have the whole class work through the first half of the problems together. Students will suggest ways which variables (temperature and pressure on the object) should be manipulated and come to consensus about the best solution to each problem. The next day they will go back to the computer lab to finish the problems with a partner as Susan initially had planned. [1]

b) Go back to the classroom, pull out the small labs and have the students begin to explore density to give them some background information so that they will be prepared to work through the entire worksheet the next day in the computer lab. This will take time, though, and the students will not have long at all to work with the mini-labs. [3]

c) Go back to the classroom and give a lecture on density and plan to have the students work in the lab as she intended the next day. [2]

Question 8

Read the scenario below and the respond to the question below. [Direction to teachers]

Shannon is a U.S. government teacher and has recently discovered a website of great online learning resources to teach the process by which a bill becomes a law. Some of the online learning resources are basic diagrams, but exciting one is a simulation where students get to act as congressmen and women to follow their bill through committee and subcommittee meetings, and then onto the floor of the House of Representatives for the vote. At each juncture in this simulation, students must answer questions about their bill before it is able to move on through the process. Shannon decides to create an inquiry-based lesson using this online simulation for his students. Unfortunately, it is the end of the year and all the computer labs are being used for end-of-year testing. She won't have access to a computer lab and he doesn't have an LCD projector in his class to do it as a whole class activity.

Rank what should Shannon should do from the best to worst possible actions.

___ Teach the lesson as she has in the past without the online resources. She feels comfortable doing this and knows, through assessment of student performance, that this has been effective in having her students learn the different steps to how a bill becomes a law. [1]

___ Come back to the lesson after end- of- year testing has been completed so that students can complete the inquiry-based lesson using the online simulation. [3]

___ Create a whole-class inquiry-based lesson where each member of the class plays a different part in the process (sub- committee member, committee member, Minority Whip, Majority Whip, etc.) and use the online resources in the computer lab to reinforce what was learned after end- of- year testing is completed. [2]

Question 9

Read the following scenario and then respond to the question and statement below. [Direction to teachers]

Mrs. Rojas teaches fifth grade at Mt. Hull Elementary School in Seattle, WA. She likes teaching elementary school because she gets to teach all subjects to her students. Recently there have been a few earthquakes around Seattle, and so she has decided to create multidisciplinary unit about earthquakes across health, science, social studies, math and language arts. She wants her students to be able to identify how earthquakes happen, how they can prepare for safety during an earthquake, and how to use maps to locate potential earthquake zones. She plans to assess what they have learned at the end of the unit through projects that they have done in pairs.

Mrs. Rojas has found a simulation that will allow students to manipulate the magnitude, depth and location of an earthquake in relation to a fictional city. This will allow them to better understand how earthquakes occur and what the impact is to city buildings and infrastructure.

[Earthquakes happen when the edges of tectonic plates, known as faults, move. The amount of shaking on land that happens depends on many things, including how much energy is released by the earthquake, how deep the earthquake is and, in relation to human structures, how far away they are from the where the earthquake takes place (this is called the epicenter).]

What are the advantages of learning about using earthquakes using this simulation?

a) Because students use computers so much outside of school, they are comfortable with them and enjoy using them. Therefore, they will learn the material using this method. [3]

b)The simulation allows the students to manipulate earthquake variables and see what how each impacts city buildings and infrastructure. This kind of involvement with the material will allow them to learn about earthquakes better than if they had not used the simulation. [2]

c) Because students are able to manipulate earthquake variables and learn how those variables impact city buildings and infrastructure, they can then apply what they've learned about the fictional city to their own city and neighborhoods which will deepen their understanding of the causes of earthquakes and their effects. [1]

Question 10

Mrs. Rojas teaches fifth grade at Mt. Hull Elementary School in Seattle, WA. She likes teaching elementary school because she gets to teach all subjects to her students. Recently there have been a few earthquakes around Seattle, and so she has decided to create multidisciplinary unit about earthquakes across health, science, social studies, math and language arts. She wants her students to be able to identify how earthquakes happen, how they can prepare for safety during an earthquake, and how to use maps to locate potential earthquake zones. She plans to assess what they have learned at the end of the unit through projects that they have done in pairs.

Mrs. Rojas has found a simulation that will allow students to manipulate the magnitude, depth and location of an earthquake in relation to a fictional city. This will allow them to better understand how earthquakes occur and what the impact is to city buildings and infrastructure.

[Earthquakes happen when the edges of tectonic plates, known as faults, move.

The amount of shaking on land that happens depends on many things, including how much energy is released by the earthquake, how deep the earthquake is and, in relation to human structures, how far away they are from the where the earthquake takes place (this is called the epicenter).]

As stated above, Mrs. Rojas will assess how much her students have learned about earthquakes, how to be safe in earthquakes, and how earthquakes impact Seattle through a project that will be completed in pairs. The requirements for this final assignment are:

- That students use at least one online learning resource, that only contains text. This can be a video, a simulation, picture, diagram, etc.
- That the project explain how earthquakes happen, how to be safe during an earthquake, and how earthquakes impact Seattle.
- The project will be a resource that allows people to learn about earthquakes and their impact on Seattle on their own.

The following are descriptions of what her students created for their final projects. Based on what is written, rank them from 1-3 from the best to the worst use of the online resources.

___ An online power point presentation that uses pictures, diagrams, and text to explain how earthquakes happen, how to be safe, and how earthquakes impact Seattle. [2]

___ A website that brings the simulation that they used earlier, as well as pictures, diagrams and basic text about how to be safe and how earthquakes impact Seattle. A basic quiz is included at the end. [1]

___ A video that has a scientist talking about how earthquakes happen, an expert in earthquakes explaining how to be safe during earthquakes, and a video of a local official talking about how earthquakes impact Seattle. [3]

Question 11

Read the scenario below and answer the question that follows. [Directions to teachers]

In Ms. Prestage's ninth-grade English class, English is the second language for 11 of the 25 students. They represent four different language groups and have a wide range of English proficiency. One of Ms. Prestage's goals for this class is that "Students will develop speaking and listening skills, both in formal presentations and informal discussions." To address this goal, she plans to have pairs of students interview each other and then introduce each other to the rest of the class.

Which of the following has the potential for helping the students for whom English is a second language perform well in this activity?

(a) Showing a video of a model interview and an introduction in which a student from a previous year interviews Ms. Prestage and then introduces her. [3]

(b) Having students go through a website that has guidelines, videos, and a quiz at the end about how to interview someone. [2]

c) Having students discuss among themselves what completing the activity successfully will require. [1]

CURRICULUM VITAE

M. Brooke Robertshaw

QUALIFICATIONS

- Knowledge of how to use a variety of technologies in teaching and learning contexts with adults and children.
- Experience developing, conducting, and assessing technology professional development for K-12 teachers.
- Experience with teaching and mentoring diverse populations from K-12 – practicing teaching professionals.
- Knowledge of, and experience teaching with, inquiry-based pedagogies in technology rich and non-technology rich settings.
- Knowledge of, and experience using, qualitative, quantitative and mixed-methodologies from a variety of epistemic lenses in the behavioral sciences.
- Ability, and experience in, collaboration in research and teaching across the disciplines in behavioral sciences.
- Experience in grant writing.

EDUCATION

Spring 2013
PhD, Instructional Technology & Learning Sciences
Dissertation research: Mixing the emic and etic perspectives: A study exploring the development of fixed-answer questions to measure in-service teachers' technological pedagogical content knowledge

1998
University of Georgia, Masters of Education, Instructional Technology

August 1991 – August 1995
Oglethorpe University, Bachelor of Arts, Elementary Education

TEACHING EXPERIENCE

September 2012-December 2012: Instructor at the Modern Languages Center, Amman, Jordan.

Responsible for teaching English grammar and conversation to non-English speakers.

Summer 2012: Instructor for the "Science, Inquiry and Technology" course for Utah State University's Global Academy.

Course material covered exploration of science through hands on, student driven, experiments, discussion of the nature of science and its applicability to all areas of study and work, and scientific argumentation and its application to all areas of study, work, as well as moral and political decision making. It integrated technology into different areas of exploration including the use of probeware to measure speed and distance of objects, digital microscopes for examining specimens found on outings, and hand held technologies to record data during an outing to an amusement park.

Fall 2011: Co-taught, with Eric Packenham, the Science Education Cohort of teachers from 8, non-western, countries who were participants in the IREX-Teaching Excellence and Achievement program.

This professional development course focused on teaching science as inquiry, scientific misconceptions, and the nature of science while also understanding the many different teaching contexts that the participants came from. Participants were encouraged to learn inquiry and discuss how inquiry could be applied to their classrooms.

Spring 2011: Teaching Assistant for Dr. Todd Campbell: Science and Society, a required Science Teaching Methods course.

Contribution: Assessment of students understanding of the nature of science through the use of the VNOS-C survey; assessment of students abilities to understand the nature of science and scientific argumentation in blog posts on current events in science; assisting in leading final class action project; in class helping to guide discussions about topics covered related to science in society.

Spring, 2009: Teaching Assistant for Dr. Nick Eastmond, Special Topics: Culture and Instructional Technology

Contribution: Knowledge of working with, advocating for, and creating instruction for diverse populations within the United States; ran supplemental instruction once a week outside of class; helped with the IRB process for research articles being written in class; helped with research articles.

Fall 2007 – Spring 2010: Instructional Architect & Online Learning Resources for Pre-Service Methods Classes.

Created 1-3 hour workshops and assignments to teach pre-service teachers how to use online learning resources and the Instructional Architect.

January 1994-December 1995: Pre-School and Pre-Kindergarten Teacher, Oglethorpe Presbyterian Church Pre-School.

Worked part-time January 1994-May 1995 teaching in a three-year old classroom; then moved to working full time from May 1995-December 1995 teaching one of two new Pre-Kindergarten classes.

MENTORING

Summer 2012: Worked with a doctoral student in Psychology to verify statistical tests run for dissertation research. Also helped student to understand all statistical methods so that he could adequately defend is work to his doctoral committee.

Fall 2011-Spring 2012: Worked extensively with an Instructional Technology and Learning Sciences PhD student on methods and results section for dissertation. This work includes: teaching student basic stats from what a significance level is to ANCOVA and generalized estimating equation, understanding the difference between parametric and non-parametric tests, understanding validity and reliability, and guiding them through writing methods and results section of dissertation in coordination with student's dissertation chair and director of the Office of Methodological and Data Services. I will also help the student re-validate a beginning stats course through devising two more ways dissertation data could be analyzed and putting together a presentation explaining this for their doctoral committee.

Fall 2011: Worked with a Management Information Systems student on data analysis for dissertation.

Fall 2011: Helped an Educational Leadership PhD student with data analysis using generalized estimating equation for dissertation.

Fall 2009 – Spring 2010: Undergraduate researchers on my 'Examining the Validity of the TPACK Framework From the Ground Up' project.

RESEARCH EXPERIENCE

January 2013-Present

Statistician, Eugene Free Mobile Medical Clinic

Responsible for creating, and updating, a database of de-identified patient data, analyzing data, and writing reports for grant writing and publicity purposes and for reports to local government officials and agencies.

September – December 2012

Data Analyst, Read-It-Again Project

Department of Special Education, College of Education and Human Services, Utah State University

Statistical analysis completed for project: exploring data using descriptives, normality testing and one way ANOVAs, t-tests, running exploratory and confirmatory factor analyses on survey data, using cluster analyses to investigate the ability for parents to be able to predict children's language ability, using generalized estimating equations to run MANOVA and ANCOVA models, running effect sizes to check for magnitude of differences found in the data. Also responsible for making recommendations for tests to be run, working collaboratively with three other researchers, and writing up analysis and findings sections of conference and journal papers submitted.

March 2012-June 2012

Data Analyst, Math Engineering Science Achievement Project

Department of Mechanical and Aerospace Engineering, College of Engineering, Utah State University

Statistical analysis completed for project: cleaning data and running multiple imputation on data to be used in analysis; exploring data using descriptives normality testing and one way ANOVAs, t-tests, running reliability tests on surveys; completing exploratory and confirmatory factor analyses on survey data to make recommendations for what survey items to remove and which to leave in; using ANOVAs, generalized estimating equations, and regression analysis to investigate any impact program had on participants. Also responsible for writing up a report of analysis and findings for project manager to be used in future presentations.

July 2011-June 2012

Intern, Office of Methodological and Data Services, College of Education and Human Services, Utah State University.

Responsible for: participating in consultation meetings with faculty and staff about the correct statistics that should be run for their project; learning new statistical methods as needed; helping faculty and students learn new statistical methods; helping faculty and students learn how to run statistics in SPSS, R Stats program and G*Power.

January 2007 – June 2011

Research Associate, Digital Libraries Go to School Project, Utah State University.

Research areas: Measurement of technological pedagogical content knowledge; reciprocal mentoring between pre-service and in-service teachers in technology professional development in K -12 schools; K-12 teachers pedagogical design capacity when using online educational resources; the impact of culture on various uses of technology; localization of open educational resources.

August 2006 – May 2007

Research Assistant, the Center for Open and Sustainable Learning, Utah State University.

Responsibilities: designing a research study to investigate the localization of parenting materials that were initially created for middle class, highly educated parents to teen parents. Study conducted but not enough data was collected to run any analysis.

OTHER PROFESSIONAL EXPERIENCE

January 2013-Present

Organizer, Eugene Free Mobile Medical Clinic, Eugene, OR, USA

Responsibilities: working with clinic manager to recruit and manage medical and non-medical volunteers; registering patients for clinic visits; working with patients with mental health concerns; working with local service agencies to fill prescriptions; working with local governmental officials; writing reports on activities of the clinic.

June 2002 – September 2006

Community Organizer, Peace and Human Justice communities, Eugene, Oregon

Responsibilities: Coordinating volunteers, writing press releases, collaborating with different organizations within the peace and human justice communities, running statistical analyses to assess where to send volunteers as a part of electoral campaigns, teaching volunteers about different political issues and how to talk to members of the public about these issues, working with local, state and federal politicians across the political spectrum to pass legislation, organizing fundraisers, designing and delivering workshops on different political issues, facilitating public meetings.

December 2005 – August 2006

Technical Coordinator, LEAD: Leadership, Education, Adventure, Direction, Eugene, Oregon.

Work included: grant writing, website redesign with the help of a committee of teen participants and adults, creation of a three-year technology plan for the organization, volunteer coordination, technology support, and work with the teen participants in a variety of capacities.

March 1999 – June 2002

Webmaster, Linn Benton Lincoln Education Service District, Albany, Oregon

Work included: design, programming and maintenance of the organization's website and troubleshooting of server issues.

September 1998 – March 1999

Instructional Technologist, Oregon Public Education Network, Albany, Oregon

Work included: development of a web based technical toolkit for school and district technology support personnel, technical support to schools using a pilot library information system, committee participation for the management of a statewide pilot library information system, data collection for an elementary ergonomics program, development of recommendations for delivery of technology training to teachers in Oregon.

JOURNAL PUBLICATIONS

Durán, L., Innocenti, M.R., Robertshaw, M.B., Shea, K. (accepted). Exploring the fidelity of the bilingual early language assessment (BELA): A pilot exploration to move beyond face validity. *NHSA Dialog: A Research-to-Practice Journal for the Early Childhood Field.*

Durán, L, Robertshaw, M.B. & Gorman, B. (accepted). Implemeting 'Read it again!' with bilingual preschoolers in Migrant Head Start. *Journal of Early Intervention.*

Ye, L., Walker, A., Recker, M., Robertshaw, M.B., Sellers, L. & Leary, H. (2012). Designing for problem-based learning: A comparative study of technology professional development. *US-China Education Review B, 5, 510-520.*

Walker, A., Recker M., Robertshaw, M.B., Olsen, J., Leary, H. (2012). Integrating technology and problem-based learning: A mixed methods study of two teacher professional development approaches. *International Journal of Problem-Based Learning.*

Recker, M., Walker, A., Giersch, S., Mao, X., Halioris, S., Palmer, B., Johnson, D., Leary, H., Robertshaw, M.B. (2007). A Study of Teachers' Use of Online Learning Resources to Design Classroom Activities. *New Review of Hypermedia and Multimedia*, 13(2), 117-134.

Orey, M., Fan, H.F., Scott, E., Thuma, T**.** Robertshaw, B., Hogle, J., Tzeng, S.C., & Crenshaw, K. (2000). Stories about children and teachers as they create multimedia documents in a university influenced small city and a large inner-city. *Meridian, 3*(1).

BOOK CHAPTERS

Robertshaw, M.B., Walker A., Recker, M., Leary, H., & Sellers, L. (2010). Experiences in the Field: The evolution of a technology-oriented teacher professional development model. In *New Science of Learning: Computers, Cognition and Collaboration in Education*, Myint Swe Khine and Issa M. Saleh, Eds. New York: Springer

Robertshaw, M.B., Leary, H., Walker, A., Bloxham, K., & Recker, M. (2009). Reciprocal mentoring "in the wild": A retrospective, comparative case study of ICT teacher professional development. In *Effective Blended Learning Practices: Evidence-Based Perspectives in ICT- Facilitated Education* (pp. 280-297), Philippa Gerbic & Elizabeth Stacey, Eds. Hershey, PA: IGI Global.

JOURNAL PUBLICATIONS IN PROCESS

Robertshaw, M. B. & Campbell, T. (submitted). Talking science in the wild: Investigating secondary science education students' argumentation skills in a socio-scientific context. *Research in Science and Technological Education.*

Robertshaw, M.B. (to be submitted). Listening to the tension in technological pedagogical content knowledge (TPACK): Understanding the differences between teacher educators and teachers in use of technology in K-12 classrooms as described by the TPACK framework.

DATA BEING COLLECTED TO BE ANALYZED

Data from a three-year science teacher technology professional development workshop will be collected and analyzed to answer the following questions questions about teachers' development of technological pedagogical content knowledge (TPACK), the impacts of informal learning experiences on teachers' development of TPACK, the impact of teachers' TPACK development on student knowledge and attitudes. Data collection began Summer 2011 and ends Summer 2013. This is a solo project, but may include Dr. Todd Campbell on some publications and presentations as well.

PLANNED CONTINUATION OF DISSERTATION RESEARCH

Dissertation was ended after a single round of content validity was completed on items developed to assess teachers' TPACK. Future rounds of content validity are planned, as well as pilot testing in order to examine the fidelity of the instrument. If this proves fruitful development will continue in hopes that the instrument can lead to it becoming a prescriptive and summative tool for teacher educators.

CONFERENCE PROCEEDINGS

Robertshaw, M.B., & Gillam, R.B. (2010). Examining the validity of the TPACK framework from the ground up: Viewing technology integration through teachers' eyes. *Proceedings of the Society for Information Technology and Teacher Education Conferenc*e, San Diego, CA.

Rogers, P. C., Robertshaw, M.B**.** & Lopez, J. (2008) Analysis of CATC: What do we know? Where next do we go? *Proceedings of the Cultural Attitudes Towards Technology and Communication Conference*, Nimes, France.

Robertshaw, M.B. & Bentley, J. (2007) OpenCourseWare and Localization: Bringing Together Old and New Technology to Increase Accessibility. *Proceedings of the 2007 Open Education Conference.* Logan, UT.

TECHNICAL REPORT

Gardner, J., Sanders, N., Haddock J., Freeman J., Hjorten, E., Robertshaw, M.B**.**, et al. (2007) *Evaluation Report for the LSTA.* Salt Lake City, UT: Utah Library Division.

INVITED PRESENTATION

Robertshaw, M.B. & Awadh, M. (2012) Inquiry based learning and science education. Presentation to science faculty at Alqadsia Mixed Elementary and Secondary School, Safut, Al Balqa Governorate, Jordan.

INTERNATIONAL CONFERENCE PRESENTATIONS

Robertshaw, M.B. & Campbell, T. (2012, April). *Talking science in the wild: Investigating pre-service science educators' argumentation skills in a socio-scientific context.* Paper presented at the American Educational Research Association Conference, Vancouver, BC, Canada.

Durán, L., Innocenti, M.R., Robertshaw, M.B., Shea, K. (2012, February). *Exploration of the validity of the bilingual early assessment.* Paper presented at the Conference on Research Innovations in Early Interventions, San Diego, CA.

Durán, L., Innocenti, M.R., Robertshaw, M.B., Shea, K. (2011, November). Psychometric properties of the bilingual early assessment. Paper presented at the Young Children with Special Needs and their Families Conference, National Harbor, MD.

Banas, J., Robertshaw, M.B., Campbell, T. (2011, November). *Behavior and knowledge: Using behavior models to describe and influence teachers' technology integration proficiency*. Paper presented at the Association for Educational Communications and Technology Conference, Jacksonville, FL.

Walker, A., Recker, M., Robertshaw, M. B., Olsen, J., Sellers, L., Leary, H., Kuo, Y. (2011, April). *Integrating technology and problem-based learning: A mixed-methods study of two teacher professional development approaches.* Paper presented at the American Educational Research Association, New Orleans, La.

Robertshaw, M.B. (2010, October). *Teacher professional development: Describing teacher technological pedagogical content knowledge through the use of a rubric*. Paper presented at the Association for Educational Communications and Technology Conference, Anaheim, Ca.

Robertshaw, M.B., Olsen, J., Walker, A. (2010, October). *Teacher professional development models: Inquiry into concurrent versus separate technology and pedagogical knowledge and use.* Paper presented at the Association for Educational Communications and Technology Conference, Anaheim, Ca.

Walker, A. Robertshaw, M.B., Recker, M. (2010, April). *Problem-Based Design: A Technology-Oriented Teacher Professional Development Model.* Poster presented at the American Educational Research Association Annual Conference, Denver, Co.

Walker, A., Recker, M., Robertshaw, M.B., & Leary, H. (2010, April**).** *Integrating Technology and Problem-Based Learning: A Professional Development Model for Teachers***.** Paper presented at the American Educational Research Association Annual Conference, Denver, Co.

Robertshaw, M.B., & Gillam, R.B. (2010, March*). Examining the validity of the TPACK framework from the ground up: Viewing technology integration through teachers' eyes.* Paper presented at the Society for Information Technology and Teacher Education Conference, San Diego, CA.

Robertshaw, M.B., Leary, H. & Bloxham, K. (2008, November). *Reciprocal Mentoring and Technological Pedagogical Content Knowledge: An emerging model of technology professional development for K-12 teachers*. Presentation at the Association for Educational Communications and Technology Conference, Orlando, FL.

Rogers, P. C., Robertshaw, M.B**.** & Lopez, J. (2008, June) *Analysis of CATC: What do we know? Where next do we go?* Paper presented at Cultural Attitudes Towards Technology and Communication Conference, Nimes, France.

NATIONAL PRESENTATIONS

Robertshaw, M.B**.,** Walker, A. & Leary, H. (2009, October). Crossing Paths to Connect Educators and Learners with Online Resources. Presentation at the Library and Information Technology Association Annual Conference, Salt Lake City, UT.

Robertshaw, M. B.**,** Leary, H., Gardner, J. & Bentley, J. (2007, November). *Listening to the Librarians: Lessons from a 5 year program evaluation*. Paper presented at the American Evaluation Association Conference, Baltimore, MD.

Robertshaw, M. B. & Bentley, J. (2007, September) *OpenCourseWare and Localization: Bringing Together Old and New Technology to Increase Accessibility.* Paper presented at Open Education, Logan, UT.

REGIONAL PRESENTATIONS

Leary, H., Robertshaw, M.B., Walker, A., Bloxham, K. (2008, May*). Crossing paths to connect educators and learners with online resources*. Presentation at the Utah Library Association Annual Conference, Salt Lake City, Utah.

Robertshaw, M.B., Leary, H., Bloxham, K. (2008, March) *The Instructional Architect: A blueprint for connecting teachers and students to online resources*. Workshop at the Utah Coalition for Educational Technology Annual Conference, Salt Lake City, UT.

Eastmond, N., & Robertshaw, M. B. (2007, March). *Evaluation of the LSTA.* Report of evaluation findings to the Utah State Library Board, Salt Lake City, UT.

GRANT EXPERIENCE

December 2011: Application submitted for a small grant to the Utah State University office of Global Engagement. The proposal is teach a course to international students who are a part of the summer “Global Academy.” The course proposed will explore the nature of science and scientific argumentation using technology and inquiry-based pedagogies.

Awarded: $1875 for teaching, $75 per student for expenses.

October 2009: Applied for the Spencer Foundation dissertation grant.

January 2008: “CyberConnect: Extending a Technology-Based Professional Development Model to Support Cyber-Enabled STEM Educators.” Grant submitted to NSF: Sat in on meetings & offered suggestions, managed references, wrote a paragraph about reciprocal mentoring.

August 2006: Grant written and submitted to the Symantec Corporation Foundation for funding for the Nuestro Lugar / Our Place Teen Center Computer Lab.
Awarded: $5,000

GRANTS BEING WRITTEN
IREX/TEA: Small collaborative grant with Mai Adnan Awadh, a secondary Science teacher at the Alqadsia Mixed Elementary and Secondary School, Safut, Al Balqa Governorate, Jordan to explore the use of hand-held technologies for teaching science in a newly built school in a third world country.

AWARDS & SCHOLARSHIPS

2009-2010 College of Education and Human Services Ambassador for the Department of Instructional Technology & Learning Sciences

2008-2009 College of Education and Human Services Ambassador for the Department of Instructional Technology

SERVICE

Conference paper reviewer

Summer 2012: Reviewer for the American Educational Research Association Annual Conference for the following divisions and special interest groups:
Instructional Technology Special Interest Group
Division K (Teaching and Teacher Education): Technology and Science Education

Spring 2011: Reviewer for the Association for Educational Communications and Technology 2011 Conference for the following division:
Teacher Education Division

Other service

Winter-Summer 2012: Chair, North Eastern Services Human Rights Committee. Responsibilities: Responsible for evaluating any human rights restrictions that program director, case workers, and behaviorist need to set to help a disabled client more safe in their living conditions as to whether it impinges on their human rights in a non-just manner.

Spring 2012, Spring 2010: Volunteer Science Fair Judge, Hillcrest Elementary, Logan, UT

Spring 2010, 2011: Judge for the State of Utah Mathematics, Engineering, Science Achievement competition.

Fall 2010-Spring 2011: Member, Utah State University Department Teaching Excellence Award Committee

Spring 2010: Member, Utah State University Department Teaching Excellence Award Committee

Fall 2009: Consulted with the Science Teaching group in the department of Teacher Education and Leadership about the best ways to use internet technologies to facilitate a focus group.

2007 – 2009: Graduate Student Assembly of the Association for Educational Communications and Technology

07-08 President

07 – President Elect

January 2007 – April 2007: Volunteer research assistant, Digital Libraries go to School project.

PROFESSIONAL AFFILIATIONS

Association for Educational Communications and Technology

American Educational Research Association

American Psychological Association Division 45: Society for the Scientific Study of Ethnic Minority Issues