DESIGNING AND VALIDATING A SURVEY TO MEASURE TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE AMONG PRE-SERVICE TEACHERS

by

Sule Yilmaz Ozden

An executive position paper submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Education in Educational Leadership

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DEDICATION

This study is dedicated to my son, Mustafa Kerem Ozden, who has been my mainstay and inspires me to do my best.

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ABSTRACT

This Executive Position Paper (EPP) presents the development of a survey to measure pre-service teachers' Technological Pedagogical Content Knowledge (TPACK). The survey was designed considering the transformative approach to the TPACK framework and was developed and vetted by professionals in the field. It was administered to 124 pre-service teachers within the context of an educational technology course at a Mid-Atlantic University. In order to investigate the construct validity and reliability of the survey, an exploratory factor analysis (EFA) was conducted. EFA results revealed a two-factor solution: Knowledge of Technology and Knowledge of Teaching with Curriculum Based Technology. The findings of this EPP provide support for the transformative approach to examining TPACK and suggest that pre-service teachers perceive TPACK as a unique body of knowledge as described in the transformative approach. Findings provide implications for researchers and teacher educators.

Chapter 1

INTRODUCTION

When one considers the communication and literacy demands of the 21st century, it is clear that today's students must be technologically literate (Partnership for 21st century Skills, 2004). Often described as *digital-natives*, K-12 students in modern classrooms are growing up with technologies such as smartphones, game consoles, and tablets and are comfortable using technology for their own purposes (Prensky, 2005). Yet, research indicates that despite their familiarity with technology this generation of students may not know how to use digital tools for learning (Karchmer-Klein & Shinas, 2012).

Similarly, today's young teachers are familiar with new emerging technologies but their technology competence is often insufficient to support the use of digital tools for the development and delivery of effective classroom instruction (Lei, 2009). As new and sophisticated educational technologies emerge, it is important to understand the knowledge and skills needed for teachers to integrate them effectively within pedagogically-sound, standards-based instruction (Lawless & Pellegrino, 2007). Specifically, today's teachers must be prepared to integrate technology in ways that prepare students to read, write, communicate and learn using digital tools (Leu, Zawilinski, Forzani & Timbrell, 2013).

Teacher education programs are key to enhancing the skills pre-service teachers need to employ digital tools in their practice. These programs must prepare tomorrow's teachers to integrate new and emerging educational technologies with specific content, thus allowing them to develop the competencies necessary to teach tomorrow's students (Hofer & Grandganett, 2012; Niess, 2008).

Technological Pedagogical Content Knowledge

In 2006, Mishra and Koehler introduced the Technological Pedagogical Content Knowledge (TPACK) framework that describes the knowledge and skills teachers need in order to effectively integrate technology into pedagogically-sound, content-based instruction. The framework built upon the Pedagogical Content Knowledge (PCK) conceptual model first introduced by Shulman (1986).

Shulman (1986) argued that proficient teachers demonstrate both strong pedagogical knowledge (PK) and strong content knowledge (CK) that allow them to teach content in pedagogically-appropriate ways. As teachers develop from novice to expert, these discrete domains converge to become PCK. Shulman (1986) described PCK as "the ways representing and formulating the subject that makes it comprehensible for others" (p. 9). Mishra and Koehler (2006) extended Shulman's PCK framework to include technological knowledge (TK), thus defining the complex interaction between three main knowledge domains, PK, CK, and TK. When combined, these result in four additional knowledge components: Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and TPACK (see Figure 1).

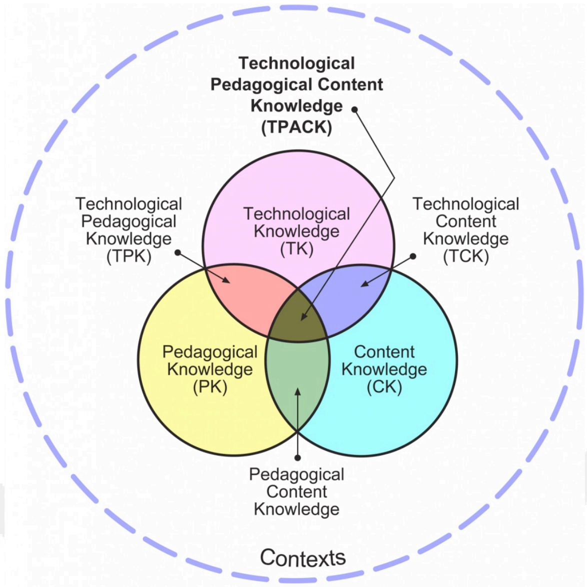

Figure 1.TPACK Framework (graphic from http://tpack.org)

The TPACK framework describes seven knowledge domains. Based upon descriptions in the literature (e.g., Mishra & Koehler, 2006; Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009) these are defined as follows:

1. TK refers to pre-service teachers' knowledge and proficiency with technology tools. These tools range from basic materials like pencil and paper to digital technologies such as the Internet, smartboards, and software.

2. CK is subject matter expertise as well as the ability to identify content-specific learning goals.

3. PK describes the theoretical and methodological knowledge needed to develop appropriate instruction.

4. TCK represents the reciprocal relationship between technology and content--the understanding that technology tools can be used to support content-specific learning goals.

5. PCK points to the relationship between pedagogy and content and is the practitioner's knowledge needed to develop and deliver effective content-specific instruction.

6. TPK relates to the understanding of how technology can influence teaching and learning.

7. TPACK characterizes a unique body of knowledge that supports a teacher's ability to situate technology knowledge within content and pedagogical knowledge to develop effective technology-integrated lessons (Harris, Mishra & Koehler, 2009).

The TPACK framework (Mishra & Koehler, 2006) has been widely used to frame research and teacher preparation programs. Yet, given the complexity of the model, different conceptualizations and epistemological perspectives have been proposed. More specifically, in a review of the TPACK literature, Voogt, Fisher, Pareja Roblin, Tondeur & van Braak (2012) identified three prevalent conceptualizations of the TPACK model:

1. TPACK as extended PCK (Niess, 2005; Cox & Graham, 2009)
2. TPACK as the interplay between three domains of knowledge and their intersections (Koehler & Mishra, 2008), (integrative perspective)
3. TPACK as a unique and distinct body of knowledge (Angeli & Valanides, 2009), (transformative perspective)

The first approach to TPACK, specified by Niess (2005) and Cox & Graham (2009), describes TPACK as an extension of PCK (Voogt et al., 2012). Cox and Graham (2009) argue that technology knowledge is embedded within Shulman's (1986) framework; they explain that because technology precipitously changes over time, TPACK has a vibrant nature and is, therefore, a "sliding framework" (Cox & Graham, 2009, p. 68) representing teachers' knowledge of how to employ content-specific activities with emerging technologies to assist student learning. They assert that "as the technologies used in those activities and representations become ubiquitous, TPACK transforms into PCK" (ibid, p. 64). But, teachers have not reached that level yet and, therefore, it is necessary to distinguish PCK from TPACK.

The integrative perspective (Mishra & Koehler, 2006) views TPACK as an interaction of three knowledge components (TK, PK, CK) and their intersections (TCK, TPK, PCK) within a content discipline. Research based on the integrative perspective tends to examine TPACK by measuring single knowledge domains independently. This type of research, however, yielded uncertainties related to measuring TPACK development, because teachers experience difficulty distinguishing individual knowledge constructs independent from one another (Graham, 2011, Mouza, in press).

In contrast, the transformative perspective views TPACK as a synthesized and single knowledge domain that can be developed and assessed as such (Angeli & Valanides, 2009). Angeli and Valanides (2009), for instance, suggested that "content, pedagogy, learners, and technology are contributing knowledge bases to TPACK, but knowledge and growth in each contributing knowledge base alone, without any specific instruction targeting exclusively TPACK as a unique body of knowledge, does not imply automatic growth in TPACK" (p. 158). Research based on the transformative perspective, which tends to assess TPACK development as a unique knowledge base independent of the contributing knowledge bases, uncovered more reliable results regarding TPACK development.

Differing approaches representing a combination of transformative and integrative perspectives (Mouza and Wong, 2009; Mouza, Karchmer-Klein, Nandakumar, Yilmaz Ozden & Hu, 2014) are also emerging in the literature that appear to reconcile these two views. For example, Mouza et al. (2014) studied prospective teachers' TPACK development by examining both the individual knowledge bases that form the foundation of TPACK and TPACK as a unique and distinct body of knowledge that represents more than a sum of subdomains.

Angeli and Valanides (2009) suggested that researchers need to study "whether TPACK is a distinct or unique body of knowledge that is constructed from other forms of teacher knowledge or whether TPACK is not a distinct form of knowledge, but is integrated from other forms of teacher knowledge- the integrative perspective" (p. 158). The literature did not provide clear empirical evidence related to these two considerations of the TPACK framework. In support of this argument, Graham (2011) claimed that even though the Venn diagram of the TPACK framework (see Figure 1) represents an integrative model, Mishra and Koehler (2006) narrated the framework with language that suggests a more transformative model. In order for researchers to develop valid and reliable instruments for examining and measuring TPACK, it is important to understand whether TPACK constructs are transformative or integrative (Graham, 2011).

Examining Pre-service Teachers' TPACK Using Survey Instruments

Because the TPACK framework has had a significant influence on research in the field of educational technology, developing instruments and measures to assess TPACK in teacher education settings is necessary (Koehler, Mishra, Kereluik, Shin, & Graham, 2014). To date, several studies have been conducted to measure pre-service teachers' TPACK development using a variety of instruments such as observations, interviews, and self-assessment surveys (Koehler, Shin & Mishra, 2011; Voogt et al., 2012). Self-assessment surveys are the most common method assessing TPACK knowledge development and a variety of survey instruments have been designed to measure the TPACK of pre-service teachers.

Consistent with the integrative perspective, Koehler et al. (2014) reported that most survey studies assessed seven individual knowledge domains that supported the overall TPACK development. Some studies, however, utilized modified sub-scales of TPACK based on the technologies under examination (Chai, Koh, Tsai & Tan, 2011; Lee & Tsai, 2010). For example, Lee and Tsai (2010) used five scales based on the framework to examine teachers' TPACK specific to web-based technologies. Table 1 presents the overview of self-assessment survey studies reported in the literature followed by explanations of some of these studies.

Table 1. Overview of self-assessment survey instruments (from Voogt et al., 2012, p. 9)

Authors	What is measured	Number of items	Scales	Reliability	Validity
Archambault and Crippen 2009;Archambault and Barnett 2010[1]	Perceptions of own TPACK	24	Three scales: (TK, PCK, Technological Curricular Knowledge); five-point Likert scale, poor–excellent	Cronbach's alpha ranged from 0.70–0.89 on seven TPACK constructs	Content validity expert appraisal; think aloud testing; construct analysis (EFA)
Archambault 2011	Perceptions of preparedness to teach with technology	24	Seven scales: (TK, PK, CK, TPK, TCK, PCK, TPCK); five-point Likert scale, not at all prepared–very well prepared	Cronbach's alpha ranged from 0.84–0.93 on seven TPACK constructs	Content validity Expert appraisal; think aloud testing
Chai et al. 2010	Perceptions of own TPACK	18	Four scales: TK, PK, CK, TPCK; seven-point Likert scale, strongly disagree–strongly agree; adapted from Schmidt et al.	Cronbach's alpha ranged from 0.85–0.94 on four TPACK constructs	Construct validity (EFA)
Chai et al. 2011	Perceptions of own TPACK	46	Seven scales: TK (Web-based competencies), CK, TPK, TCK, PCK, TPCK, PK for meaningful learning (PKML); seven-point Likert scale, strongly disagree–strongly agree; adapted from Schmidt et al.	Cronbach's alpha ranged from 0.86–0.95 on seven constructs	Construct validity (EFA/ CFA)
Doering et al. 2009	Perceptions of changes in own TPACK	4	TK, PK, CK (single items) Likert scale items (novice–expert) **+**1 open-ended question; TPACK: teachers depict themselves on a graphical representation of TPACK (Venn diagram – similar to Fig 1)	No	No
Koehler and Mishra 2005	Perceptions of own thinking about TPACK	5	Individual TPCK; seven-point Likert scale, strongly agree–strongly disagree	No	No
Koehler and Mishra 2005	Perceptions of one's group thinking about TPACK	9	Group TPCK; seven-point Likert scale, strongly agree– strongly disagree	No	No
Koh et al. 2010	Perceptions of own TPACK	27	Five scales: TK, CK, knowledge of pedagogy (KP); knowledge of teaching with technology (KTT), knowledge from critical reflection (KCR) (after factor analysis); seven-point Likert scale, strongly disagree–strongly agree; adapted from Schmidt et al.	Cronbach's alpha ranged from 0.83–0.96 on five constructs	Content validity (expert's appraisal); construct validity (EFA)

Authors	What is measured	Number of items	Scales	Reliability	Validity
Lee and Tsai 2010	Perceptions of confidence in TPACK-Web	30	Five scales: Web general, Web communicative, Web pedagogical knowledge; Web content knowledge, Web pedagogical content knowledge; six-point Likert scale, strongly unconfident–strongly confident	Cronbach's alpha ranged from 0.92–0.96 on five constructs	Content validity (expert appraisal); construct validity (EFA)
Schmidt et al. 2009	Perceptions of own TPACK	47	Seven scales: TK, PK, CK, TPK, TCK, PCK, TPCK; five-point Likert scale, strongly disagree–strongly agree	Cronbach's alpha ranged from 0.75–0.92 on seven TPACK constructs	Content analysis; construct analysis (EFA, but over subscale)

[1]These studies report about the same self-assessment instrument.
CFA, confirmatory factor analysis; EFA, exploratory factor analysis.

Archambault & Crippen (2009) designed a self-assessment survey grounded in the TPACK framework to measure online teachers' knowledge development. Survey items were developed based on definitions of TPACK constructs specified by Mishra and Koehler (2006) and Shulman (1986). After technology-education experts reviewed the survey and the survey was piloted for construct validity, it was administered to 596 online teachers from 25 different states. This 24-item survey measures TK, CK, PK, and combinations of these knowledge domains using a Likert-type scale 1 (poor) to 5 (excellent). Descriptive statistics revealed that online teachers rated their knowledge at the highest level for PK, CK, and TK. In addition, online teachers' TK related to troubleshooting problems was not as strong as their PK and CK. However, TK combined with TPK was rated higher than TK alone. Correlations among each of the domains were also calculated and the results showed that correlation between TK and PK and TK and CK was small; however, correlation between PK and CK was high. These results lead to questions regarding the distinctiveness of these domains.

Archambault and Barnett (2010) used the same survey and data (designed by Archambault & Crippen, 2009) to examine the validity of the TPACK model through the use of a factor analysis. Internal consistency (Cronbach's alpha) values were from 0.89 to 0.70 on seven TPACK constructs, which is acceptable. Factor analysis results indicated the existence of three factors: Pedagogical Content Knowledge, Technological-Curricular Content Knowledge, and Technological Knowledge. These results suggest that the original seven domains of the TPACK model may not exist in practice. Results revealed that teachers showed strong connections between CK and PK and a clear connection between technological content, technological pedagogy, and technological pedagogical content questions. However, it appears that respondents were not able to distinguish among these constructs. Archambault and Barnett (2010) concluded that, similar to Shulman's PCK framework, it is difficult to identify the boundaries between the TPACK domains.

Similar to Archambault and Crippen (2009), Schmidt et al. (2009) developed and validated the *Survey of Pre-service Teachers' Knowledge of Teaching and Technology* designed to measure pre-service teachers' self-assessment of their TPACK. This survey is the most widely used instrument to collect data about pre-service teachers' TPACK development. It is grounded in the integrated perspective of the TPACK framework as proposed by Mishra & Koehler (2006) and is designed to measure the seven domains of technological, pedagogical and content knowledge illustrated in Figure 1. The survey extends to general contexts, multiple content areas, and multiple approaches to professional development. Yet, it is specifically designed for pre-service teachers majoring in elementary or early childhood education and is focused on the content areas they will be teaching in their future classrooms. The development of the survey progressed through various stages; the authors reviewed other pilot instruments reported in the literature and solicited feedback from content experts. Based on that feedback a 75-item survey was constructed and administered to a group of 124 pre-service teachers. Subsequently, the authors examined construct validity for each knowledge domain using factor analysis. Given the small sample size, however, factor analysis was performed on the items within each subscale rather than the entire instrument. Based on this analysis, issues were identified and individual items were revised or eliminated. Reliability statistics were then repeated again with each knowledge domain and results demonstrated high levels of internal consistency reliability. The revised survey included 8 demographic data questions and 55 items focused on the seven knowledge components of the framework (CK, TK, PK, PCK, TCK, TPK, and TPACK). Additionally, 3 open-ended questions were included to assess pre-service teachers' understanding of instances where university faculty, cooperating teachers in their field placement, and the pre-service teachers effectively combine content, technology and pedagogy in the classroom.

The survey developed by Schmidt et al. (2009) provided an efficient instrument for research and assessment of TPACK among pre-service teachers and has been utilized in a number of empirical studies (e.g., Abbit, 2011; An, Wilder, & Lim, 2011). Chai, Koh and Tsai (2010), for instance, evaluated the development of Singapore pre-service teachers' TK, PK, CK and TPACK knowledge before and after attending an ICT course based on the TPACK framework. They used the survey designed by Schmidt et al. (2009) with some adaptations. Specifically, they did not use the items for TPK, TCK and PCK because these were not part of their ICT course design and they changed the five-point Likert scale to seven-points. A total of 439 pre-service teachers completed the pre-survey while a total of 365 pre-service teachers completed the post-survey. Cronbach alpha values for both the pre-survey and post-survey were adequate for internal reliability. Exploratory factor analysis (EFA) results confirmed four factors: TK, PK, CK, and TPACK. The t-test results showed that the ICT course supported pre-service teachers' TPACK development. In addition, stepwise regression analysis showed that PK had the largest impact on TPACK in both pre and post survey data.

Koh, Chai & Tsai (2010) also studied Singapore pre-service teachers in terms of their TPACK. Specifically, Koh et al. (2010) examined the construct validity of a TPACK survey through an EFA of a large sample (N=1185). They also examined the TPACK perceptions of these same teachers and the relationship with their demographic data. They used the survey designed by Schmidt et al. (2009) with some adaptations. They made some of the subject specific questions more general. For example, they used "in my curriculum area" statements rather than specific subjects such as "mathematics, science, etc." Also, they removed 11 questions related to pre-service teachers' assessment of their professors' TPACK, because these questions were not relevant to the objectives of the study. The five-point Likert scale employed by Schmidt et al. (2009) was revised to a seven-point scale ranging from strongly disagree to strongly agree.

Overall, reliability of the survey was high. Internal reliability of the survey items was established. The EFA confirmed construct validity for TK and CK items;

however the remaining items were interpreted as three factors. Thus, factor analysis results suggested five factors: Technology Knowledge, Content Knowledge, Knowledge of Pedagogy (KP), Knowledge of Teaching with Technology (KTT), and Knowledge from Critical Reflection (KCR). The participants of this study failed to distinguish between PK and PCK, which were interpreted as KP. Further, they failed to distinguish between TCK, TPK, and TPACK items, which were interpreted as KTT. The fifth factor KCR was composed of the items TPK3 and TPK4 that were related to reflection of technology integration. Authors concluded that there is a need for more studies that compare construct validation results between generic and contextualized TPACK surveys.

Additionally, Chai et al. (2011) examined the construct validity of a TPACK survey that was generated based on instructional practices within a 12-week ICT course for Singapore pre-service teachers aligned with the TPACK framework. The survey had 46 items; 28 survey items were adapted from the survey designed by Schmidt et al. (2009) with some adjustments. The teaching subjects in CK and TCK survey items were replaced with “first teaching subject” and “second teaching subject” because Singapore teachers are trained in at least two teaching subjects (e.g. the teacher can respond to the idea--I can think about the subject matter like an expert who specializes in my first teaching subject). They also developed 13 survey items to replace the original PK items; these were labeled as PK for Meaningful Learning (PKML). They employed a seven-point Likert scale; from strongly disagree to strongly agree. They conducted EFA that suggested five factors: TK, CK, TPK, PKML, and TPACK. The TCK and PCK scale was not loaded.

Building upon these studies, Lee and Tsai (2010) developed a new survey based on their Technological Pedagogical Content Knowledge-Web (TPCK-W) framework to measure the teachers' self-assessment of their TPCK-W and to assess teachers' attitudes toward Web-based instruction. Their framework included three knowledge areas: web, pedagogy and content. Web knowledge refers to knowledge of the general use of the Web including Web tools, and also knowledge of Web-based communication and interaction. TPCK-W includes four components including Web Knowledge, Web-Content Knowledge (WCK), Web-Pedagogical Knowledge (WPK), and Web-Pedagogical Content Knowledge (WPCK). Web and Content Knowledge produce WCK, meaning an understanding of how to use the features and advantages of the Web as it pertains to content. The combination of Web and Pedagogy results in WPK, which emphasizes presence, constituents and competencies of the Web as it is used in educational settings. Lastly, Web Pedagogy and Content forms WPCK, which refers to knowledge of pedagogical strategies to teach subject-specific content within the Web.

Subsequently, Lee and Tsai (2010) administered the survey to 558 teachers in Taiwan from elementary to high school level. To measure participants' self-efficacy of their TPCK-W (Web-general, Web-communicative, Web-Content Knowledge (WCK), WPK, and WPCK), they used the five scales presented in a six-point Likert rating scale ranging from strongly unconfident to strongly confident. Factor analysis demonstrated the reliability and validity of the survey. Importantly, the items of WPK and WPCK scales were loaded on a single factor. Participants had difficulty distinguishing WPK and WPCK items. Moreover, teachers with more years of teaching experience were found to have lower self-efficacy with regards to use of the Web and integration of the Web into instruction. Teachers who have experienced Web and Web-based instruction had higher self-efficacy with regard to using the Web as part of instruction.

Collectively these studies employed an integrative perspective to measuring TPACK relying heavily on the survey developed by Schmidt et al. (2009). Findings of these studies consistently failed to confirm the seven knowledge components of TPACK as proposed by Mishra and Koehler (2006). In contrast, Yurdakul, Odabasi, Kilicer, Coklar, Birinci, & Kurt (2012) designed the TPACK-deep scale by using a transformative perspective. They also examined the validity and reliability of the scale with 995 pre-service teachers in Turkey. Both EFA and CFA results confirmed a 33-item scale with four factors. These factors are design, exertion, ethics, and proficiency. Results showed that the survey was valid and reliable. However, this survey does not explicitly focus on the domains of TPACK as described in the widely accepted framework proposed by Mishra and Koehler (2006).

Problem Statement and Rationale

At first look, the TPACK framework appears to be simple and clear because it describes the integration of three main knowledge domains and their intersections (Graham, 2011). However, Graham notes "the simplicity of the model hides a deep underlying level of complexity, in part because all of the constructs being integrated are broad and ill-defined" (2011, p. 1955). Specifically, it is important to note that scholars have not drawn clear boundaries or provided consistent definitions for the

TPACK constructs (Cox, 2008; Hofer & Harris, 2012; Shinas, Yilmaz-Ozden, Mouza, Karchmer-Klein, & Glutting 2013). Therefore, it is difficult to create valid and reliable instruments that measure TPACK.

Measuring TPACK domains among pre-service teachers has proven to be especially problematic (Archaumbault & Barnett, 2010; Brantley-Dias & Ertmer, 2013). Studies of pre-service teachers' TPACK using the Schmidt et al. (2009) survey revealed that pre-service teachers are not able to easily discern the differences between and among domains (Shinas et al., 2013). An examination of other instruments reveals that most of the surveys used to study pre-service teachers' TPACK are grounded in an integrative approach to the framework that views TPACK as the synthesis of seven different knowledge components (Graham, 2011; Yurdakul et al., 2012). These studies could not establish acceptable discriminant validity for the TPACK constructs (Graham, 2011; Voogt et al., 2012).

Shinas et al. (2013) focused explicitly on examining the construct validity of the *Survey of Pre-service Teachers' Knowledge of Teaching and Technology* (Schmidt et al., 2009) through an EFA. Data were collected from 365 pre-service teachers at the conclusion of a required educational technology course *Integrating Technology in Education*, a 15-week course taught every semester between Fall 2009 and Fall 2011. Results of the study indicated that pre-service teachers were not able to distinguish between the TPACK domains; therefore, findings reported by Schmidt and her colleagues (2009) could not be confirmed. Furthermore, pre-service teachers had difficulty conceptualizing TCK as a distinct knowledge domain, and distinguishing between PK and PCK. These results are supported by the work of Hofer and Harris

(2012) and others (Koh et al., 2010). Findings reported by Shinas and colleagues (2013) suggest that there is a need to develop more concrete definitions of the TPACK constructs and create more precise survey items to measure TPACK domains. Thus, examining the TPACK framework using a transformative lens will add important insight into the ways that TPACK develops among pre-service teachers (Shinas et al., 2013).

Purpose of the Study and Research Questions

Given the need to measure pre-service teachers' TPACK using reliable instruments, the purpose of this Executive Position Paper (EPP) is twofold: design a survey that measures TPACK development among pre-service teachers using the transformative approach; and investigate the validity and reliability of the survey using a sample of pre-service teachers at a Mid-Atlantic University. This work is important given the demand for data that will guide the development and reshaping of teacher preparation programs to better provide technology integration instruction for pre-service teachers, who must learn to teach in an increasingly technologically dominant environment (Voogt et al., 2012).

As a result of this work, teacher education programs will be able to evaluate and improve their educational technology training by using the survey results. In addition to serving as a tool for evaluating the effectiveness of educational technology training within teacher preparation programs, the survey will also provide a more reliable measure of improvements in pre-service teachers' TPACK across courses or entire teacher education programs.

The following questions guide this work:

1. In what ways can the transformative approach to TPACK inform the development of a new self-report survey instrument?
2. Is the new survey developed in this study reliable and valid for measuring pre-service teachers' TPACK?

Chapter 2

METHODOLOGY

The purpose of this EPP was twofold: first, to design a survey instrument to measure pre-service teachers' self-assessment of TPACK considering the transformative view of the TPACK framework and second, to investigate the validity and reliability of the survey. Once the survey was developed, it was distributed to participants enrolled in an educational technology course at a Mid-Atlantic University to test its validity and reliability using factor analysis. This chapter presents the survey development phases, the context of the teacher education program, the participants, the data collection procedures, the data analysis procedures, and the limitations of the study.

Survey Development

The current survey was developed in response to results from the factor analysis research by Shinas et al. (2013) introduced in Chapter 1, as well as literature focusing on a transformative view to TPACK. The transformative approach to measuring TPACK does not require researchers to measure all knowledge sub-constructs, but rather that they focus on the identification of items that capture TPACK as a unique knowledge domain (Shinas et al., 2013).

The first step of developing the current survey was examination of the prior study results (Shinas et al., 2013), a comprehensive review of the literature, and the development of a set of preliminary survey items. The specific survey items were initially generated based on the results of the study (Shinas et al., 2013). Prior literature describing the development of self-assessment surveys was also examined during the initial phase (Archambault & Barnett, 2010; Lee & Tsai, 2010). Specifically, the results of the study (Shinas et al., 2013) indicated that pre-service teachers did not always make conceptual distinctions between the TPACK domains. To address this issue, the survey was developed to be clear enough to allow pre-service teachers to distinguish between constructs. The survey, however, was intended to focus on TPACK as a unique and transformed knowledge base rather than on the individual constructs of PK, CK, TK, and even PCK, TCK, and TPK. As a result, the survey was reorganized according to four domains based on how factors loaded in the study by Shinas et al. (2013): *Knowledge of Technology (KT)* associated with TK, *Knowledge of Curriculum-Based Technology (KCT)* associated with TCK, *Knowledge of Teaching with Technology* (KTT) associated with *TPK*, and *Knowledge of Teaching with Curriculum-Based Technology (KTCT)* associated with TPACK. This survey was generated with these four knowledge constructs and each was measured with seven items so a total of twenty-eight items were created. All items were revised in an iterative process and subsequently sent out for expert content validity analysis.

In the second step, the survey was initially sent to two colleagues who were involved in the study conducted by Shinas et al. (2013) for feedback and suggestions for improvement. Based on their feedback, some items were rewritten, some items were removed, and some new items were added. As a result, the survey was reduced to twenty-five items. After this initial internal review, the survey was sent out to three independent researchers who are widely recognized as TPACK experts. Two of the researchers (Reviewer A and Reviewer B) replied and provided extensive feedback. In the last step, the survey was revised again based on this expert feedback. Some new items were added and the revised survey again included four domains with seven items in each domain for a total of twenty-eight items (see Appendix A).

Knowledge of Technology (KT)

The results of the study (Shinas et al., 2013) confirmed that all TK items were loaded in the same manner described in the Schmidt et al. (2009) survey. Therefore, the TK items were reliable and were adapted from that survey without any change as a first domain titled "Knowledge of Technology." However, reviewers provided insights in this category regarding the order and wording of the items. As a result, items in this category were reordered and some items were slightly reworded. Table 2 presents the original survey items (Schmidt et al., 2009) and the accompanied revised items. Specifically, Reviewer A questioned the last item. She commented that it "seems like the respondents will be really describing their confidence in working with different technologies." Therefore the seventh item was changed as recommended by reviewer A, who recommended "I have confidence in my ability to work with different technologies" (see Table 2).

Table 2. Item Revisions for KT Domain

Original Items (Schmidt et al. (2009)	**Revised Items**
1. I know how to solve my own technical problems.	I know how to solve my own technical problems.
2. I can learn new technologies easily.	I learn to use new technologies easily.
3. I keep up with important new technologies.	My knowledge of new technologies is up to date.

Original Items (Schmidt et al. (2009)	Revised Items
4. I frequently play around with the technology.	I explore new technologies frequently.
5. I know about a lot of different technologies.	I know about a lot of different technologies.
6. I have the technical skills I need to use technology.	I have the technical skills needed to use different technologies.
7. I have had sufficient opportunities to work with different technologies.	I have confidence in my ability to work with different technologies.

The revised items were reordered and presented in the survey as shown on Table 3.

Table 3. Survey Items in KT domain

1. I know about a lot of different technologies.
2. I have the technical skills needed to use different technologies.
3. I know how to solve my own technical problems.
4. My knowledge of new technologies is up to date.
5. I learn to use new technologies easily.
6. I explore new technologies frequently.
7. I have confidence in my ability to work with different technologies.

Knowledge of Curriculum Based Technology (KCT)

The second domain was initially entitled “Knowledge of Content and Technology” but was subsequently changed to “Knowledge of Curriculum-Based Technology” based on the expert reviews. This domain included items from the TCK and TPACK scales of the Schmidt et al. (2009) survey. First, all four TCK items in the Schmidt et al. (2009) survey were synthesized and included as the first item in the new survey (see Table 4) in response to results of the prior study (Shinas et al., 2013), which revealed that these four TCK items in the Schmidt et al. (2009) survey loaded with four TPACK items (see Table 4).

Table 4. Revision of TCK items from Schmidt et al. (2009)’s survey

Original TCK Items (Schmidt et al.	Revision of TCK items

(2009)	
1. I know about technologies that I can use for understanding and doing mathematics. 2. I know about technologies that I can use for understanding and doing literacy. 3. I know about technologies that I can use for understanding and doing science. 4. I know about technologies that I can use for understanding and doing social studies.	I know about technologies that I can use for student learning in my content area.

Next, four additional items were written that associated with the rest of the TPACK items in the Schmidt et al. (2009) survey (see Table 5). A second revision was made based on expert reviews. Specifically, reviewer B noted that because teachers are more familiar with "curriculum" than "content" in terms of the requirements they have to meet, "curriculum" was used in place of "content" throughout the survey items. Furthermore, because elementary teachers are responsible for multiple curriculum areas, it was suggested that all instances of "area" were changed to "area(s)" (see Table 5). Some initial items (1.1, 1.2, and 1.3 in Table 5) were reworded without critical changes. Item 1.4 was expanded with some examples. Item 1.5 was removed because both reviewers recommended that it not be included in the survey. Reviewer B stated that this item was more aligned with TPK rather than TCK. Reviewer A also commented that "this is vague and doesn't describe how it might be used. Is it learning with content specific technologies?" and she suggested rewording the item. Considering the expert reviews, a new item was created (2.5 in Table 5). The additional two items were written considering suggestions made by Reviewer A (2.6 and 2.7 in Table 5).

Table 5. Item Revision for KCT

Initial Items Adapted from the Schmidt Survey	**Revised Items**
1.1. I know about technologies that I can use for student learning in my content area.	2.1. I know about technologies that I can use for student learning in my curriculum area(s).
1.2. I can choose technology tools that fit with content and learning goals.	2.2. I can choose technologies that fit with learning goals in my curriculum area(s).
1.3. I can use technologies that are specific to my content area.	2.3. I can use technologies that are specific to my curriculum area(s).
1.4. I can design lesson plans that include content specific technologies.	2.4. I can design lessons, projects and unit plans that include curriculum-specific technologies (GPS unit, Google Sketchup, etc.).
1.5. I can implement classroom activities in which students use content specific technologies.	2.5. I can use technologies to support student learning in my curriculum area(s).
	2.6. I can identify specific topics in my curriculum area(s) where technologies support learning of the topics.
	2.7. I can envision how students reason when using technology in my curriculum area(s).

Knowledge of Teaching with Technology (KTT)

The third domain of the survey was created to focus on the pedagogical aspect of the TPACK framework. Factor analysis results of the prior study (Shinas et al., 2013) revealed that PK and PCK items loaded together, indicating that pre-service teachers did not distinguish separate domains of PK and PCK. Thus, the PK and PCK items were not included in the current survey. Instead, seven new items were adapted from Hughes (2010) and Mouza (2011) and titled “Knowledge of Pedagogy and Technology.” These items were more closely associated with TPK. This third domain with seven items was later titled “Knowledge of Teaching with Technology” (KTT).

Table 6 shows the original TPK items in the Schmidt et al. survey (2009).

Table 6. Original TPK items from Schmidt et al. (2009) survey

Original TPK Items (Schmidt et al. (2009)
1. I can choose technologies that enhance the teaching approaches for a lesson.
2. I can choose technologies that enhance students' learning for a lesson.

3.	My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
4.	I am thinking critically about how to use technology in my classroom.
5.	I can adapt the use of the technologies that I am learning about to different teaching activities.

These items were considered but not included in the survey. As noted, the initial items for the KTT domain were adapted from the literature (Hughes, 2010; Mouza, 2011) and later revised by considering expert feedback. The first item (1.1 in Table 7) was reworded considering suggestions made by reviewer A (2.1 in Table 7). In addition, "Classroom activities" was used instead of "lesson plans" and "…technologies as learning tools" was added to focus on the purpose of integrating technologies (2.1 in Table 7). Item 1.2 (see Table 7) was rewritten to change the focus from engagement to motivation (2.2 in Table 7). The last item 1.7 (Table 7) including "computer procedures" was changed to "technologies" to be broader as suggested by reviewer B (2.7 in Table 7). The remaining items in KTT were slightly reworded.

Table 7. Item Revision for Knowledge of Teaching with Technology

Initial Items	**Revised Items**
1.1. I can design lesson plans that integrate a wide range of technologies.	2.1. I know how to design classroom activities that integrate technologies as learning tools.
1.2. I know how to engage students using technology.	2.2. I know how to design technology-based classroom activities that motivate students.
1.3. I know how to use technology tools to differentiate instruction among students.	2.3. I know how to use technologies to differentiate instruction.
1.4. I know how to design collaborative class activities using technology.	2.4. I know how to design technology-based classroom activities to support student collaboration.

Initial Items	Revised Items
1.5. I know how to assess student work with technology.	2.5. I know how to use technology to assess student work.
1.6. I can envision potential student problems with particular technologies and plan relevant activities to support those student.	2.6. I know how to envision potential student problems with particular technologies and plan relevant activities to address those problems.
1.7. I know how to explain computer procedures to students.	2.7. I know how to explain the specifics of using different technologies to students.

Knowledge of Teaching with Curriculum-Based Technology (KTCT)

Factor analysis results (Shinas et al., 2013) indicated that three TPACK items loaded with the TPK items while the remaining items loaded with TCK. These three TPACK items were included in the survey with some adjustments in the fourth domain. Table 8 shows all eight TPACK items from the Schmidt et al. (2009) survey including the items revised from TPACK domains (Items 5 to 8) and the new revised items (5.a, 6.a, 7.a, and 8.a). Although item 7 did not load to any factor in the study (Shinas et al., 2013), it was revised and included in the initial current survey. However, it was later removed based on the two reviewers' feedback who thought it is beyond the scope of this particular survey.

Table 8. Items Adapted from Schmidt et al. Survey

Original TPACK Items	Revised Items
1. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.	N/A
2. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.	N/A
3. I can teach lessons that appropriately combine science, technologies and teaching approaches.	N/A
4. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.	N/A

5. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.	5.a. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn
6. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.	6.a. I can use strategies that combine content, technologies and teaching approaches
7. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.	7.a. I can provide leadership in helping my colleagues combine content, technology and teaching approaches at my school and/or district
8. I can choose technologies that enhance the content for a lesson.	8.a. I can choose technologies that enhance students' learning for a lesson in my content area

When identifying TPACK related items, four TPACK components described by Niess (2013) were considered. These four components included: "1. Overarching conceptions of teaching content with technologies; 2. Knowledge of students' understandings, thinking, and learning with technologies; 3. Knowledge of curriculum and curriculum materials; and 4. Knowledge of instruction and instructional representations" (Niess, 2013, p. 176).

The fourth domain associated with TPACK was initially called "Knowledge of Teaching Content with Pedagogy and Technology" but was later changed to "Knowledge of Teaching with Curriculum-Based Technology (KTCT)." Preliminary items in this domain were revised for a second time after considering expert suggestions and the four TPACK components identified by Niess (2013). Table 9 illustrates the initial proposed items followed by the revised items.

Reviewer A provided detailed feedback and suggestions for this domain. For example, for item 1.1 (in Table 9) it was suggested that using "instructional strategies" rather than just "strategies" would emphasize that the item was directed toward instruction and adding the purpose for these strategies being used (2.1 in Table 9). This item was more closely related to the fourth TPACK component. Item 1.2 was revised to include emphasis on students' learning, which was related to the fourth TPACK component. Item 1.3 which was closely related to the second TPACK component was strengthened by including students' understanding and thinking of the content (2.3 in Table 9). Furthermore, reviewer A suggested that Item 1.4. was "directed more toward the curriculum and how the technologies might shift that curriculum because of the features of the technologies. With this change the emphasis on instructional strategies is mitigated." She suggested that the investigator "adapt the content curriculum to take advantage of technology features for learning the key content objectives." However, item 1.4 was slightly changed and the suggested item was added as an additional item (2.6 in Table 9). Item 1.5 was slightly reworded (2.5 in Table 9). Item 1.6 was removed because both reviewers noted that leadership was not directly connected with TPACK. Moreover, they indicated that this item was vague and beyond the scope of this survey. Reviewer A suggested the addition of two items, but only one of those items was adapted and included in the new survey (2.7 in Table 9).

Table 9. Item Revisions for KTCT

Items with First Revision/Initial Items	**Items with Second Revision/Revised Items.**
1.1. I can use strategies that combine content, technologies and teaching approaches.	2.1. I can use instructional strategies that combine curriculum, technologies, and teaching approaches to support student learning.

Items with First Revision/Initial Items	Items with Second Revision/Revised Items.
1.2. I can choose technologies that enhance the teaching approaches for a lesson in my content area.	2.2. I can use curriculum-based technologies that enhance the teaching approaches in my curriculum area(s) to support student learning.
1.3. I can choose technologies that enhance students' learning for a lesson in my content area.	2.3. I can use curriculum-based technologies that support student understanding, thinking and learning in my curriculum area(s).
1.4. I can adapt the use of technologies to different teaching activities in my content area.	2.4. I can adapt the uses of particular technologies to different teaching activities in my curriculum area(s).
1.5. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.	2.5. I can use curriculum-based technologies that enhance what I teach, how I teach and what students learn.
1.6. I can provide leadership in helping my colleagues combine content, technology and teaching approaches at my school and/or district.	2.6. I can adapt the content curriculum to take advantage of technology features for learning the key content objectives.
	2.7. I can implement content topics where technologies can support students' learning.

Context of this Study

Teacher Education Program

Data were collected from pre-service teachers enrolled in the Elementary Teacher Education (ETE) program at a Mid-Atlantic University. The ETE program is a four-year undergraduate program accredited by the National Council for the Accreditation of Teacher Education (NCATE). Participants who complete the program receive elementary (K-5) and middle school (6-8) teacher certification. The program consists of a series of courses including general studies, professional studies [methods], and concentration courses. The ETE program also provides pre-service teachers with a variety of field experiences: early field experiences, methods field experiences, and student teaching.

The general studies courses offered in the program support the development of pre-service teachers' content knowledge. The professional studies courses prepare pre-service teachers for their future classrooms. The concentration courses aim to help pre-service teachers acquire proficiency in one of the concentration areas (middle-school courses of English, mathematics, science, social studies, and special education).

The ETE program offers a variety of methods courses including literacy, social studies, mathematics, and science. These courses are offered in three blocks; elementary block, middle school block, and special education block. These method courses concentrate on the curriculum and appropriate instruction methods for teaching subject matter concepts to elementary or middle school students. Pre-service teachers have the opportunity to review, develop and evaluate the curriculum materials, as well as pedagogical approaches that use technology and research assessment on student learning. Faculty who teach method courses also present a good model for using technology with a specific content and appropriate pedagogical strategies.

The ETE program curriculum also provides pre-service teachers with a range of field experiences including early field experiences, methods field experiences, and student teaching in a variety of classroom settings beginning in the freshman year. Efforts are made to place pre-service teachers in classrooms that show effective use of technology. Pre-service teachers have opportunities to observe experienced teachers and classroom environments and learn how to interact with children. Methods field experiences are taken together with methods courses to provide pre-service teachers the opportunity to teach lessons to an entire class. During methods field experience, pre-service teachers spend three full weeks each semester in a classroom setting. They observe classroom teachers in a daily routine including their use of technology, progress in student learning, and establish strong relationships with cooperating teachers. Early field experiences and methods field experiences help prepare pre-service teachers for student teaching where they gradually take over responsibilities for a period of one semester.

Educational Technology Course

The educational technology course, entitled *Integrating Technology in Education*, runs for 15 weeks every semester and is required for all pre-service teachers within the ETE program. The purpose of the educational technology course is to introduce prospective teachers to technologies available for use in classroom content areas (e.g., concept mapping software, interactive manipulatives, Internet resources, and Web 2.0 tools), pedagogical approaches with these technologies, and teaching and learning practices that effectively combine these technologies with content and pedagogy. Course instructors also model a variety of ways in which these technologies can be used to support student learning.

Table 10 summarizes important course content and activities (see Mouza & Karchmer-Klein, 2015). The instructors' pedagogical approach to helping pre-service teachers acquire a deeper understanding of the interactions among technology, content and pedagogy involved simultaneous participation in the educational technology course, methods courses and field experience. When designed carefully, this model is consistent with key markers of effective teacher preparation in the use of technology recently described in the literature (Tondeur, Van Braak, Sang, Voogt, Fisser & Ottenbreit-Leftwich, 2012). These markers include: (a) theory to practice connections, (b) opportunities for instructional design, (c) modeling, (d) authentic experiences, and (e) opportunities for enactment and reflection. Table 10 indicates how the integration of educational technology coursework, methods courses, and field experience addresses these key markers of effective teacher preparation.

Table 10. Description of Course Assignments (Mouza and Karchmer-Klein, 2015)

Marker	Activities/Assignments	Description
Instructional Design	Integrated Lesson Review	Participants identify a technology integrated lesson in a content area of their choice from a lesson-plan portal called Thinkfinity. Subsequently, they prepare a critique which discusses the instructional objectives of the lesson, the strengths and weaknesses of the learning activities presented in the lesson, the content and technology standards addressed, and the role of technology in relation to the lesson's objective.
Instructional Design	Concept Mapping	Participants practice using concept mapping software, reflect on their experiences, and generate one lesson idea that integrates concept mapping in a content area of their interest.
Authentic Experiences	Technology Inventory	Participants construct an inventory of technological resources available in their assigned school and classroom during the first week in their field experience. The inventory needs to identify both hardware and software resources. This assignment helps participants understand the kinds of technologies typically

Marker	Activities/Assignments	Description
		available in K-12 settings and where they are located (e.g., computer lab, classroom, library, etc.)
Instructional Design	Inquiry-based Activity	Participants learn how to design inquiry based activities around web-based resources (akin to a WebQuest) in order to reinforce or teach a literacy, social studies, mathematics or science concept. First, participants decide the content area and specific learning goals they want students to practice (e.g., what should students know, understand or be able to do). Second, they search for web-based resources that support students as they learn/practice these skills. Third, they design inquiry oriented activities that engage students with the web resources as they learn content specific concepts. Finally, they describe the mechanisms in which student work will be assessed.
Instructional Design	Collaboration Tools	Participants learn about web 2.0 tools (e.g., blogs, wikis, podcasts, Glogster or Voicethread). They use these tools to complete course assignment and generate lesson ideas that focus on the integration of the selected tool in a classroom setting.
Reflection	Reflective Essay	In the final course assignment, participants implement one of the activities designed earlier in the course in their field placement. They can choose to implement their lesson with a whole class but are often advised to try their activity with a smaller group of students. This assignment seeks to strengthen the connection between theory and practice. Upon completing the implementation of their lesson, participants write a reflective case that discusses their experience following specific writing and reflection prompts.

Marker	Activities/Assignments	Description
Theory to Practice		Educational technology course integrated with methods courses and field experience to facilitate learning and implementation of technology with content and pedagogy.
Role Models		Educational technology faculty, methods faculty, and cooperating teachers in the field model uses of technology.

Participants

The newly developed survey was administered to all pre-service teachers enrolled in an undergraduate technology integration course during the Fall 2013, Spring 2014, and Fall 2014 semesters. A total of 140 pre-service teachers responded to the survey; of those, only 124 respondents completed the survey in its entirety. The majority of respondents were female (91%). Nearly all were in the last two years of their program; 57% of the respondents were juniors, 39% of the respondents were seniors, and 5% selected the other option. All respondents were between the ages of 18 to 22 with the exception of one student who was in the 23-26 age-range. During their participation in the course, all pre-service teachers were enrolled or had completed a field experience in a K-12 classroom.

Data Collection Procedures

The survey was built within Qualtrics, a web-based survey software tool available at the University. The survey link was emailed to pre-service teachers who enrolled in the technology integration course. Informed consent was obtained from the pre-service teachers upon opening the online survey; the first page of the survey included a brief statement describing the purpose of the study as well as the informed consent statement. The statement informed pre-service teachers that participation was voluntary and all information would remain confidential. All appropriate institutional review board procedures through the University were completed before collecting any data.

Data Analysis Procedures

Survey data were downloaded from Qualtrics and imported into Excel. The data were reviewed and all data from sixteen participants who did not respond to an entire question set were eliminated. Subsequently, the data were imported into the Statistical Package for the Social Sciences (SPSS) software to run the factor analyses. Factor analysis was used in order to examine the construct validity and reliability of the current survey. In addition, descriptive statistics were conducted. Descriptive statistics were used to summarize and categorize all data. In order to measure the internal-consistency of the new survey, a Cronbach's alpha was calculated using SPSS.

Limitations of the Study

One of the limitations of this study is that the survey is a self-report measure which is subject to bias that may be difficult to control. To reduce potential bias, participants completed the survey using an online, digital survey platform. Additionally, they completed the survey outside of class time. In all, 124 pre-service teachers responded to the survey, which is a small but acceptable sample size for a quantitative study of this kind (Tabachnick & Fidell, 2007). Another limitation of this study is that there was no supporting qualitative data collected. For example, collecting qualitative data in the beginning of the study may have guided the development of reliable survey items to capture TPACK development of pre-service teachers.

Chapter 3

RESULTS AND CONCLUSIONS

The purpose of this EPP was two-fold; first to develop a new survey to measure pre-service teachers' self-assessment of their Technology, Pedagogy and Content Knowledge considering the transformative perspective of the TPACK framework; and second, to examine the validity and reliability of the survey. The survey was developed based on previous research (e.g., Shinas et al., 2013) and feedback from experts in the field. Following the development of the survey, it was distributed to pre-service teachers who were enrolled in an educational technology course at a Mid-Atlantic University. Data were used to test the validity and reliability of the survey using factor analysis.

The previous chapter presented the survey development steps, the context of the teacher education program, the educational technology course, the participants, data collection, and data analysis procedures. In this chapter, the results of the factor analysis, reliability analysis, discussion, and conclusions are presented.

Factor Analysis

In the current study, EFA was used to analyze the data. EFA was used rather than confirmatory factor analysis (CFA) because it is better able to identify integral constructs underlying the items on the survey (see Appendix A). Empirical work provides evidence that CFA may be a less desirable technique for determining the number of factors measured by a data set. For instance, MacCallum and colleagues found that specification searches in correlation matrices often do not uncover the correct population model (MacCallum, 1986; MacCallum, Roznowski & Nowrwitz, 1992). Likewise, Gorsuch (2003) reported that whereas EFA results nearly always replicate during first-order CFAs the reverse is not true when CFA is employed to uncover first-order factors and then used to replicate results with a second sample. Therefore, EFA was employed because of the potential for stronger structural evidence to emerge during later CFA replications (Goldberg & Velicer, 2006).

Principal axis factor analysis was employed given its relative tolerance of multivariate non-normality and its superior recovery of weak factors (Briggs & MacCallum, 2003; Cudeck, 2000; Fabrigar, Wegener, MacCallum, & Strahan, 1999). Communalities were estimated through squared multiple correlations and were iterated to produce final communality estimates (Gorsuch, 2003). For both theoretical and empirical reasons, it was assumed that retained factors would be correlated. Consequently, a Promax rotation was employed with $k = 4$ (Tataryn, Wood, & Gorsuch, 1999).

One of the more critical decisions in an EFA is to determine the correct number of factors to retain and rotate (Fabrigar et al., 1999; Tabachnick & Fidell, 1996). The most common rule is to retain factors when eigenvalues are ≥ 1.0. This solitary criterion is the default procedure in most statistical packages. The shortcoming is that implementation of solitary criteria tends to under or overestimate the number of true latent dimensions (Gorsuch, 1983; Velicer, Eaton, & Fava, 2000; Zwick & Velicer, 1986). Accordingly, each model was evaluated against the following five rules: (a) eigenvalues greater than 1.0 (Kaiser, 1960), (b) scree (Cattell, 1966), (c) Glorfeld's (1995) extension of parallel analysis (PA; Horn, 1965), (d) minimum average parcels (MAP; Velicer, 1976), and (e) interpretability (Fabrigar et al., 1999; Gorsuch, 1983). Results from several investigations demonstrated that MAP and PA are the two best methods for determining the correct number of factors to accept and that the scree test is a useful adjunct (Buja & Eyuboglu, 1992; Glorfeld, 1995; Velicer et al, 2000, Zwick & Velicer, 1986).

Results of Factor Analysis

Means (*M*s) and standard deviations (*SD*s) for the 28 variables submitted to the EFAs are presented in Table 11. Results from Bartlett's Test of Sphericity (Bartlett, 1954) indicated that the correlation matrix was not random (χ^2 = 3,149.7; *df* = 378; *p* = .001). The Kaiser-Meyer-Olkin (KMO; Kaiser, 1974) statistic was .923, well above the .60 minimum suggested by Kline (1994). A two-factor and a four-factor solution were rotated. PA and scree pointed to two factors that should be retained while MAP and Kaiser's criterion pointed to four factors.

Table 11. Means and Standard Deviations for Survey Items

Variable	*M*	*SD*
KT1	4.00	.70
KT2	3.97	.73
KT3	3.35	1.00
KT4	3.64	.91
KT5	3.97	.84
KT6	3.27	1.08
KT7	3.90	.80
KCT1	4.10	.65
KCT2	4.12	.68
KCT3	4.01	.72
KCT4	3.78	.96
KCT5	4.12	.67
KCT6	4.08	.73
KCT7	3.90	.84
KTT1	4.24	.62
KTT2	4.19	.66
KTT3	3.81	.89
KTT4	3.97	.83
KTT5	3.81	.84
KTT6	3.78	.81
KTT7	3.85	.85
KTCT1	4.07	.65
KTCT2	4.04	.70
KTCT3	4.04	.66
KTCT4	4.10	.61
KTCT5	4.10	.66
KTCT6	3.98	.75
KTCT7	4.12	.63

Note: *M* = mean, *SD* = standard deviation, *N* = 124. All values are rounded to the second decimal position for convenient presentation.

The two-factor solution satisfied requirements for simple structure in that most variables showed appreciable factor loadings and each variable loaded on only one factor (Field, 2005; Tabachnick & Fidell, 2007). Both the two-factor and four-factor solutions were analyzed. The two-factor solution revealed more interpretable structure than the four-factor solution. Therefore the two-factor solution was accepted. The rotated pattern matrix for the two-factor solution is presented in Table 12. The two-factor solution was interpreted according to the magnitude and meaning of their salient pattern coefficients. All coefficients greater than or equal to .50 were considered appreciable (Tabachnick & Fidell, 2007).

Table 12. Rotated Pattern Matrix from the new survey

Variable	Factor I	Factor II
KT1		.50
KT2		.52
KT3		.87
KT4		.80
KT5		.76
KT6		.89
KT7		.73
KCT1	.81	
KCT2	.74	
KCT3	.61	
KCT4		
KCT5	.86	
KCT6	.78	
KCT7	.53	
KTT1	.83	
KTT2	.76	
KTT3	.50	
KTT4	.76	
KTT5		.57
KTT6		
KTT7		.50
KTCT1	.75	
KTCT2	.86	
KTCT3	.92	
KTCT4	.75	
KTCT5	.88	
KTCT6	.53	
KTCT7	.74	
Eigenvalue	15.34	1.98
% of var.	54.78%	7.06%
cum. % of var.	54.78%	61.84%

Note: *N* = 124. Pattern coefficients greater than or equal to .50 are considered salient. Interpretation was simplified through the presentation of only salient coefficients. All coefficients are rounded to the second decimal position for convenient presentation.

The first factor was portrayed by variables specific to all but one KCT items, the first four KTT items, and all KTCT items. This factor was named *Knowledge of*

Teaching with Curriculum Based Technology. The second factor was defined by all KT items and three KTT items. These KTT items relate to technology knowledge, thus the second factor was named *Knowledge of Technology*. One KCT item on the survey, "I can design lessons, projects and unit plans that include curriculum-specific technologies (GPS unit, Google Sketchup, etc.)" and one KTT item "I know how to envision potential student problems with particular technologies and plan relevant activities to address those problems" did not load on any factor and should perhaps be removed from the survey. Table 13 presents the factors and items.

Table 13. Two Factors of the Revised Survey

Component	**Factor**	**Abbreviation**	**Survey Items**
I	Knowledge of Teaching with Curriculum-Based Technology	KTCT	KCT 1,2,3,5,6,7 KTT 1,2,3,4 KTCT 1-7
II	Knowledge of Technology	KT	KT 1-7 KTT 5, 7

Note: Survey Item KCT 4 and KTT 6 did not load on any factor.

The final survey was named "Survey of Knowledge of Teaching with Curriculum-Based Technology" (see Appendix B). Survey items associated with both factors are presented in Table 14.

Table 14. Survey items loaded in two factors

Section	Item
Knowledge of Teaching with Curriculum-Based Technology (KTCT)	KCT1. I know about technologies that I can use for student learning in my curriculum area(s). KCT2. I can choose technologies that fit with learning goals in my curriculum area(s). KCT3. I can use technologies that are specific to my curriculum area(s). KCT5. I can use technologies to support student learning in my curriculum area(s). KCT6. I can identify specific topics in my curriculum area(s) where technologies support learning of the topics. KCT7. I can envision how students reason when using technology in my curriculum area(s). KTT1. I know how to design classroom activities that integrate technologies as learning tools. KTT2. I know how to design technology- based classroom activities that motivate students. KTT3. I know how to use technologies to differentiate instruction. KTT4. I know how to design technology-based classroom activities to support student collaboration. KTCT1. I can use instructional strategies that combine curriculum, technologies and teaching approaches to support student learning. KTCT2. I can use curriculum-based technologies that enhance the teaching approaches in my curriculum area(s) to support student learning. KTCT3. I can use curriculum-based technologies that support student understanding, thinking and learning in my curriculum area(s) KTCT4. I can adapt the uses of particular technologies to different teaching activities in my curriculum areas. KTCT5. I can use curriculum-based technologies that enhance what I teach, how I teach and what students learn. KTCT6. I can adapt the content curriculum to take advantage of technology features for learning the key content objectives KTCT7. I can implement content topics where technologies can support students' learning.

Section	Item
Knowledge of Technology (KT)	KT1. I know about a lot of different technologies. KT2. I have the technical skills needed to use different technologies. KT3. I know how to solve my own technical problems. KT4. My knowledge of new technologies is up-to-date. KT5. I learn to use new technologies easily. KT6. I explore new technologies frequently. KT7. I have confidence in my ability to work with different technologies. KTT5. I know how to use technology to assess student work. KTT7. I know how to explain the specifics of using different technologies to students.

Reliability of the Survey

The relative independence of scores among the scales was evaluated by comparing correlations among the rotated factors. Correlations between the rotated factors were .725 (r^2 = .53), suggesting that the variables share 53% of common variance (see Table 15). These two dimensions, then, are essentially oblique. In addition, Cronbach's (1951) coefficient alpha was used to estimate internal-consistency reliability for the two factors. The Cronbach's Alpha for the first factor was .96 and for the second factor was .91. Reliabilities greater than .70 are recommended by leading measurement textbooks (e.g., Allen & Yen, 1979; Thorndike, 1982).

Table 15. Factor Correlation Matrix

	Component	
Factor	I	II
I	1.00	.725
II	.725	1.00

Note: N=124. Extraction Method: Principal Axis Factoring; Rotation Method: Promax with Kaiser Normalization

Discussion and Conclusion

Discussion

Since its inception, TPACK has been widely studied, yet questions regarding how to measure TPACK among pre-service teachers persist (Shinas et al., 2013). Importantly, it has been suggested that this may be related to pre-service teachers' difficulty differentiating between the seven TPACK constructs (Archaumbault & Crippen, 2009, Cox & Graham, 2009, Shinas et.al. 2013). Given the challenges associated with measuring TPACK from an integrative approach, the transformative approach to the TPACK framework emerged (Graham, 2011; Angeli & Valanides, 2009). From the transformative perspective TPACK is defined as a unique and distinct form of knowledge rather than a combination of related domains (Angeli & Valanides, 2009). However, only few instruments have been designed to measure pre-service teachers' TPACK within the transformative view. The purpose of this EPP was to develop and validate a survey framed by the transformative perspective.

Findings from this study are consistent with the transformative view that treats TPACK as a unique knowledge base. Specifically, factor analysis revealed that the majority of the items loaded to a single factor, suggesting that TPACK is a single, unique body of knowledge. Namely, the participants indicated connections among KCT, KTT and KTCT items. This factor, which was named *Knowledge of Teaching with Curriculum Based Technology*, included items related to content, pedagogy, and the integration of technology within instruction. All remaining items designed to measure technology knowledge loaded to a single factor along with two KTT items, which was named *Knowledge of Technology*. These two KTT items, when analyzed in detail, are more about technology knowledge so it is not surprising that these items loaded together with KT items. In support of this finding, Archaumbault and Barnett (2010) and others (e.g., Chai et.al., 2011; Lee & Tsai, 2010; Shinas et.al., 2013) have found that survey items designed to measure TK tend to load as one factor.

Then, returning to the first factor that includes the majority of the items and evaluating underlying reasons for combining the three TPACK domains revealed supporting results towards the transformative perspective. First, KCT items were examined to seek the reasons that pre-service teachers did not perceive KCT as a discrete construct. Items in the KCT construct are related to pre-service teachers' knowledge about curriculum-based technology. The underlying reason might be that these items could not be associated with content-specific examples of technology integration as Koh et al. (2010) argued. Another reason might be the context of the items. For example, one KCT item "I know about technologies that I can use for student learning in my curriculum area(s)" might include pedagogy components in addition to curriculum and technology knowledge. Similarly, KTT items may include more than technology and pedagogy knowledge. One of the KTT items "I know how to design technology-based classroom activities that motivate students." reflects technology and pedagogy knowledge, however, stating "classroom activities" might reflect curriculum knowledge. As a result, pre-service teachers perceive KCT, KTT and KTCT items in the same category.

In support of this outcome, Koh et al. (2010) found that prospective teachers viewed items of TPK, TCK and TPACK as conceptually similar. Koh and his colleagues (2010) argued that the reason might be that the pre-service teachers are inexperienced and the survey items were not contextualized to a specific subject. Also, Archaumbault and Barnett (2010) discovered that online teachers reported a connection between technological content, technological pedagogy, and technological pedagogical content items. Findings of this study indicate that experience is not a dominant factor for teachers to differentiate between knowledge domains. Furthermore findings of the study conducted by Lee and Tsai (2010) also emphasized that experience did not improve teacher candidates' knowledge of technology integration. In-service teachers' inability to differentiate between TPACK constructs calls into question whether the individual TPACK components exist (Archaumbault & Barnett, 2010).

Based on results, it appears that pre-service teachers demonstrate TPACK as a distinct body of knowledge that brings together their understanding of curriculum, technology and pedagogy. Researchers who examine TPACK using a transformative view (e.g., Angelis & Valanides, 2009) argue that pre-service teachers' TPACK is best understood as a single, discrete type of knowledge that can be developed and assessed. This work also supports the notion that TPACK is a unique body of knowledge independent from other TPACK components.

Implications and Recommendations for Future Research

Findings of this study provide insight for future research. First, the survey is a promising instrument that may be used to measure pre-service teachers' self-assessment of TPACK. As pointed by Shinas et al. (2013) there is a need for valid and reliable instruments. It is important to note, however, that this study must be considered exploratory in nature. Although the survey was found to be valid and reliable, future research must conduct CFA with a larger sample size to provide further refinement of the instrument. This future research will further validate the findings presented here and inform research that examines TPACK from the transformative view.

TPACK is currently the most robust framework described in the literature and holds promise as a tool for designing educational technology coursework within teacher preparation programs. However, there are weaknesses related to clarity of TPACK domain descriptions and the interrelations of these domains. The transformative perspective addresses these theoretical issues and provides more reliable results in terms of measuring TPACK (Graham, 2011). The results of this study also indicate that the relationship between the TPACK constructs are transformative. Specifically, TPACK is a synthesized form of knowledge that can be measured on its own and cannot be explained by the sum of its sub-domains. Therefore, this study points out that assessing and developing TPACK domains from the transformative perspective is crucial to designing efficient technology integration courses within teacher preparation programs.

Teacher education programs can benefit from the findings of this study. Teacher educators may use the survey to assess pre-service teachers' TPACK development, which may then be used to inform the design and development of technology integration courses along with methods courses and field experiences. Integrating these educational settings is important for obtaining the substantial teacher education environment that pre-service teachers need to develop positive attitudes toward teaching with technology (Shinas, Karchmer-Klein, Mouza, Yilmaz Ozden & Glutting, 2015). Participation in a technology integration course along with methods courses and field experience appears to better support pre-service teachers' development of TPACK than educational technology courses alone (Mouza & Karchmer-Klein, 2015) for meeting new accreditation standards for teacher education articulated by the Council for the Accreditation of Educator Preparation (CAEP).

> Educator preparation providers (EPP) should keep up with research, and those preparing educators should model best practices in digital learning and technology applications that the EPP expects candidates to acquire (CAEP, 2015, p. 22).

The survey developed in this study will be used to obtain data from pre-service teachers to assess their TPACK development over time. Based on the survey data results, weaknesses of the technology integration training within the teacher education program may be noted. Afterward, the program can be strengthened by addressing these weaknesses. Furthermore, future research can investigate the extents to which the survey discussed here may be used to support program development and evaluation.

Conclusions

The purpose of this EPP was to develop and test an instrument to measure pre-service teachers' TPACK using a transformative lens. This is an important area of research given the widespread application of the TPACK framework within teacher preparation programs and research (Koehler et al., 2014; Cavanaugh & Koehler, 2013). Harris et.al. (2009) state:

> TPACK is a framework for teacher knowledge, and as such, it may be helpful to those planning professional development for teachers by illuminating what teachers need to know about technology, pedagogy, and content and their interrelationships. The TPACK framework does not specify how this should be accomplished, recognizing that there are many possible approaches to knowledge development of this type. (p. 403)

Teachers play an important role in the effective integration of technology in classrooms; therefore, it is essential that pre-service teachers be prepared to integrate technology effectively as soon as they enter the classroom. Teacher educators will benefit from access to a valid and reliable instrument to measure their students' TPACK. Although the findings of this study are promising, further research is needed to validate the TPACK framework from a transformative perspective and to develop assessment instruments accordingly.

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Appendix A

INITIAL SURVEY USING A TRANSFORMATIVE PERSPECTIVE

Based on our initial effort to revise the Schmidt et al. (2009) survey followed by expert feedback and reviewers, the final survey is presented below.

Demographic Information

1. e-mail address
2. Gender
    a. Male
    b. Female
3. Age range
    a. 18-22
    b. 23-26
    c. 27-32
    d. 32+
4. Year in college?
    a. First
    b. Second
    c. Third
    d. Fourth

e. Graduate Level

f. Other

5. Are you currently enrolled or have you completed a practicum experience in a K-12 classroom?

   a. Yes

   b. No

"Technology" is a broad concept that can mean many different things. In this survey, "technology" refers to digital technology/technologies. That is, the digital tools we use such as computers, laptops, tablets, smartphones and all software programs including mobile apps. Please answer all of the questions and if you are uncertain of an answer or neutral about your response you may select "Neither Agree or Disagree"

Knowledge of Technology

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I know about a lot of different technologies.	☐	☐	☐	☐	☐
2. I have the technical skills needed to use different technologies.	☐	☐	☐	☐	☐
3. I know how to solve my own technical problems.	☐	☐	☐	☐	☐
4. My knowledge of new technologies is up-to-date.	☐	☐	☐	☐	☐

5. I learn to use new technologies easily.	☐	☐	☐	☐	☐
6. I explorenew technologies frequently.	☐	☐	☐	☐	☐
7. I have confidence in my ability to work with different technologies.	☐	☐	☐	☐	☐

Knowledge of Curriculum-Based Technology

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I know about technologies that I can use for student learning in my curriculum area(s).	☐	☐	☐	☐	☐
2. I can choose technologies that fit with learning goals in my curriculum area(s).	☐	☐	☐	☐	☐
3. I can use technologies that are specific to my curriculum area(s).	☐	☐	☐	☐	☐
4. I can design lesson, project and unit plans that include curriculum-specific technologies (GPS unit, Google Sketchup, etc.).	☐	☐	☐	☐	☐
5. I can use technologies to support student learning in my curriculum area(s).	☐	☐	☐	☐	☐
6. I can identify specific topics in my curriculum area(s) where technologies support learning of the topics.	☐	☐	☐	☐	☐
7. I can envision how	☐	☐	☐	☐	☐

students reason when using technology in my curriculum area(s).

Knowledge of Teaching with Technology

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I know how to design classroom activities that integrate technologies as learning tools.	☐	☐	☐	☐	☐
2. I know how to design technology-based classroom activities that motivate students.	☐	☐	☐	☐	☐
3. I know how to use technologies to differentiate instruction.	☐	☐	☐	☐	☐
4. I know how to design technology-based classroom activities to support student collaboration.	☐	☐	☐	☐	☐
5. I know how to use technology to assess student work.	☐	☐	☐	☐	☐
6. I know how to envision potential student problems with particular technologies and plan relevant activities to address those problems.	☐	☐	☐	☐	☐
7. I know how to explain the specifics of using different technologies to students.	☐	☐	☐	☐	☐

Knowledge of Teaching with Curriculum-Based Technology

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I can use instructional strategies that combine curriculum, technologies, and	☐	☐	☐	☐	☐

teaching approaches to support student learning					
2. I can use curriculum-based technologies that enhance the teaching approaches in my curriculum area(s) to support student learning	☐	☐	☐	☐	☐
3. I can use curriculum-based technologies that support student understanding, thinking and learning in my curriculum area(s)	☐	☐	☐	☐	☐
4. I can adapt the uses of particular technologies to different teaching activities in my curriculum area(s)	☐	☐	☐	☐	☐
5. I can use curriculum-based technologies that enhance what I teach, how I teach and what students learn	☐	☐	☐	☐	☐
6. I can adapt the content curriculum to take advantage of technology features for learning the key content objectives	☐	☐	☐	☐	☐
7. I can implement content topics where technologies can support students' learning.	☐	☐	☐	☐	☐

Appendix B

SURVEY OF KNOWLEDGE OF TEACHING WITH CURRICULUM-BASED TECHNOLOGY

Based on our initial effort to revise the Schmidt et al. (2009) survey followed by expert feedback and reviewers, the final survey is presented below.

Demographic Information

6. e-mail address

   [ ]

7. Gender

   c. Male

   d. Female

8. Age range

   e. 18-22

   f. 23-26

   g. 27-32

   h. 32+

9. Year in college?

   g. First

   h. Second

   i. Third

   j. Fourth

k. Graduate Level

l. Other

10. Are you currently enrolled or have you completed a practicum experience in a K-12 classroom?

c. Yes

d. No

"Technology" is a broad concept that can mean many different things. In this survey, "technology" refers to digital technology/technologies. That is, the digital tools we use such as computers, laptops, tablets, smartphones and all software programs including mobile apps. Please answer all of the questions and if you are uncertain of an answer or neutral about your response you may select "Neither Agree or Disagree"

Knowledge of Technology

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I know about a lot of different technologies.	☐	☐	☐	☐	☐
2. I have the technical skills needed to use different technologies.	☐	☐	☐	☐	☐
3. I know how to solve my own technical problems.	☐	☐	☐	☐	☐
4. My knowledge of new technologies is up-to-date.	☐	☐	☐	☐	☐
5. I learn to use new technologies easily.	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

6. I explorenew technologies frequently.	☐	☐	☐	☐	☐
7. I have confidence in my ability to work with different technologies.					
8. I know how to use technology to assess student work.	☐	☐	☐	☐	☐
9. I know how to explain the specifics of using different technologies to students.	☐	☐	☐	☐	☐

Knowledge of Teaching with Curriculum-Based Technology

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I know about technologies that I can use for student learning in my curriculum area(s).	☐	☐	☐	☐	☐
2. I can choose technologies that fit with learning goals in my curriculum area(s).	☐	☐	☐	☐	☐
3. I can use technologies that are specific to my curriculum area(s).	☐	☐	☐	☐	☐
4. I can use technologies to support student learning in my curriculum area(s).	☐	☐	☐	☐	☐
5. I can identify specific topics in my curriculum area(s) where technologies support learning of the topics.	☐	☐	☐	☐	☐
6. I can envision how students reason when using technology in my curriculum area(s).	☐	☐	☐	☐	☐
7. I know how to design classroom activities that integrate technologies as learning tools.	☐	☐	☐	☐	☐

8. I know how to design technology-based classroom activities that motivate students.	☐	☐	☐	☐	☐
9. I know how to use technologies to differentiate instruction.	☐	☐	☐	☐	☐
10. I know how to design technology-based classroom activities to support student collaboration.	☐	☐	☐	☐	☐
11. I can use instructional strategies that combine curriculum, technologies, and teaching approaches to support student learning	☐	☐	☐	☐	☐
12. I can use curriculum-based technologies that enhance the teaching approaches in my curriculum area(s) to support student learning	☐	☐	☐	☐	☐
13. I can use curriculum-based technologies that support student understanding, thinking and learning in my curriculum area(s)	☐	☐	☐	☐	☐
14. I can adapt the uses of particular technologies to different teaching activities in my curriculum area(s)	☐	☐	☐	☐	☐
15. I can use curriculum-based technologies that enhance what I teach, how I teach and what students learn	☐	☐	☐	☐	☐
16. I can adapt the content curriculum to take advantage of technology features for learning the key content objectives	☐	☐	☐	☐	☐
17. I can implement content topics where technologies can support students' learning.	☐	☐	☐	☐	☐

Appendix C

IRB APPROVAL FORM

UNIVERSITY OF DELAWARE

RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	November 6, 2014
TO:	Sule Yilmaz Ozden
FROM:	University of Delaware IRB
STUDY TITLE:	[541669-3] Survey for Measuring Teachers' Technological Pedagogical Content Knowledge
SUBMISSION TYPE:	Continuing Review/Progress Report
ACTION:	APPROVED
APPROVAL DATE:	November 6, 2014
EXPIRATION DATE:	December 1, 2015
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # *(7)*

Thank you for your submission of Continuing Review/Progress Report materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.