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Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers

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Abstract

*Based in Shulman's idea of Pedagogical Content Knowledge, Technological Pedagogical Content Knowledge (TPACK) has emerged as a useful frame for describing and understanding the goals for technology use in preservice teacher education. This paper addresses the need for a survey instrument designed to assess TPACK for preservice teachers. The paper describes survey development process and results from a pilot study on 124 preservice teachers. Data analysis procedures included Cronbach's alpha statistics on the TPACK knowledge domains and factor analysis for each domain. Results suggest that, with the modification and/or deletion of 18 of the survey items, the survey is a reliable and valid instrument that will help educators design longitudinal studies to assess preservice teachers' development of TPACK. (*Keywords**:** *TPACK, instrument development, preservice teachers)*

The purpose of this study was to develop and validate an instrument designed to measure preservice teachers' self-assessment of their Technological Pedagogical Content Knowledge (TPACK) and related knowledge domains included in the framework. TPACK is a term used increasingly to describe what teachers need to know to effectively integrate technology into their teaching practices. In this article, we detail the steps used to develop and validate an instrument to measure preservice teachers' development of TPACK.

THEORETICAL FRAMEWORK

Technological Pedagogical Content Knowledge (TPCK) was introduced to the educational research field as a theoretical framework for understanding teacher knowledge required for effective technology integration (Mishra & Koehler, 2006). The TPCK framework acronym was renamed TPACK (pronounced "tee-pack") for the purpose of making it easier to remember and to form a more integrated whole for the three kinds of knowledge addressed: technology, pedagogy, and content (Thompson & Mishra, 2007–2008). The TPACK framework builds on Shulman's construct of Pedagogical Content Knowledge (PCK) to

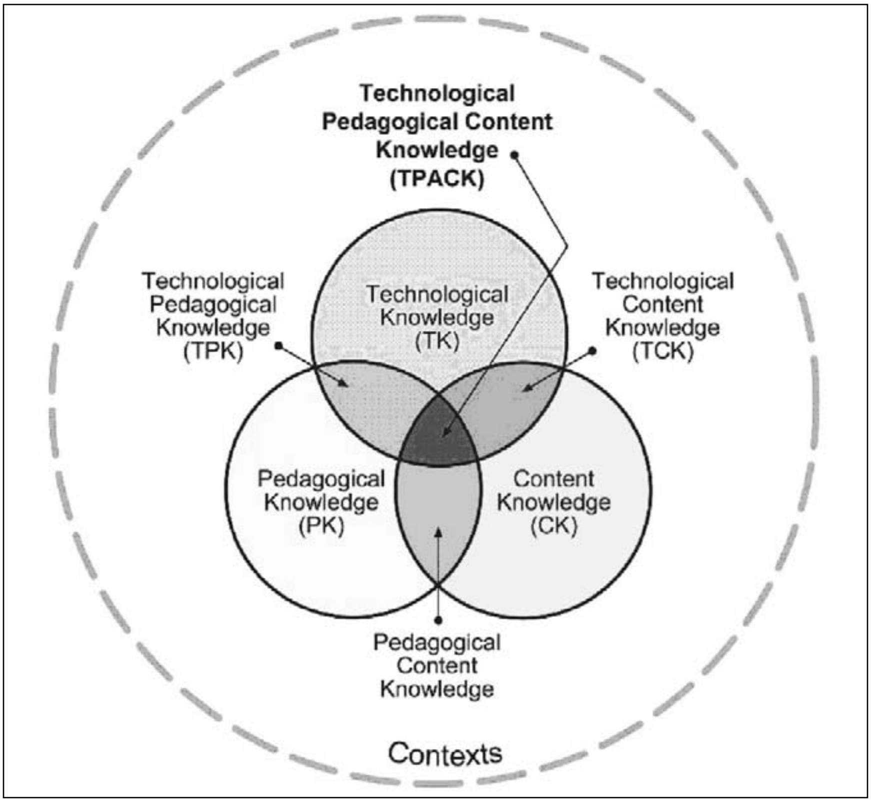

Figure 1: The components of the TPACK framework (graphic from http://tpack.org).

include technology knowledge as situated within content and pedagogical knowledge.

Although the term is new, the idea of TPACK has been around for a while. A precursor to the TPCK idea was a brief mention of the triad of content, theory (as opposed to pedagogy), and technology in Mishra (1998), though within the context of educational software design. Pierson (1999, 2001), Keating and Evans (2001), and Zhao (2003) similarly describe the relationships between technology, content, and pedagogy. Other researchers have addressed similar ideas, though often under different labeling schemes, including integration literacy (Gunter & Bumbach, 2004); information and communication (ICT)-related PCK (e.g., Angeli & Valanides, 2005); Technological Content Knowledge (Slough & Connell, 2006); and electronic PCK or e-PCK (e.g., Franklin, 2004; Irving, 2006). Others who have demonstrated a sensitivity to the relationships between content, pedagogy, and technology include Hughes (2004); McCrory (2004); Margerum-Leys and Marx (2002); Niess (2005); and Slough & Connell (2006).

TPACK is a framework that introduces the relationships and the complexities between all three basic components of knowledge (technology, pedagogy, and content) (Koehler & Mishra, 2008; Mishra & Koehler, 2006). At the intersection of these three knowledge types is an intuitive understanding of teaching content with appropriate pedagogical methods and technologies. Seven components (see Figure 1) are included in the TPACK framework. They are defined as:

1. ***Technology knowledge (TK):*** Technology knowledge refers to the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs.
2. ***Content knowledge (CK):*** Content knowledge is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p. 1026). Teachers must know about the content they are going to teach and how the nature of knowledge is different for various content areas.
3. ***Pedagogical knowledge (PK):*** Pedagogical knowledge refers to the methods and processes of teaching and includes knowledge in classroom management, assessment, lesson plan development, and student learning.
4. ***Pedagogical content knowledge (PCK):*** Pedagogical content knowledge refers to the content knowledge that deals with the teaching process (Shulman, 1986). Pedagogical content knowledge is different for various content areas, as it blends both content and pedagogy with the goal being to develop better teaching practices in the content areas.
5. ***Technological content knowledge (TCK):*** Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that, by using a specific technology, they can change the way learners practice and understand concepts in a specific content area.
6. ***Technological pedagogical knowledge (TPK):*** Technological pedagogical knowledge refers to the knowledge of how various technologies can be used in teaching, and to understanding that using technology may change the way teachers teach.
7. ***Technological pedagogical content knowledge (TPACK):*** Technological pedagogical content knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies.

The framework focuses on designing and evaluating teacher knowledge that is concentrated on effective student learning in various content areas (AACTE Committee on Innovation and Technology, 2008). Thus, TPACK is a useful frame for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge. Using TPACK as a framework for measuring teaching knowledge could potentially have an impact on the type of training and professional development experiences that are designed for both preservice and inservice teachers. Hence, there

Table 1: Scientifically Based Instruments Used to Evaluate Teachers' Use of Technology and Related Factors (Davis & Thompson, 2005)

Instrument	Factors Evaluated	Reference
Technology Proficiency Self-Assessment	Teachers' use of e-mail, Web, integrated applications, and technology integration	Knezek & Christiansen (2004), created in 1999
Concerns-Based Adoption Model Stages of Concern (CBAM SoC)	Teachers' CBAM stage of concern with technology integration as an innovation	Knezek & Christiansen (2004), created in 1999
Concerns-Based Adoption Model Levels of Use (CBAM LoU)	Teacher's CBAM Level of Use of Technology	Knezek & Christiansen (2004), created in 1999
Level of Technology Implementation (LoTi) Questionnaire * (http://www.lotilounge.com)	Teachers' technology skills, technology integration, stage of instructional development, strategies for technology-related professional development, access to technology	Keller, Bonk, & Hew (2005) adapted Moersch's (1995) LoTi (both pre-/post- and intervention/control groups)
Integrated Studies of Educational Technology (ISET) national survey of U.S. teachers, technology coordinators, principals	Teachers' technology integration, related professional development implementation and outcomes	SRI International (2002) created survey, complemented with case studies
Teaching, Learning, and Computing Survey (TLC)	Teachers' technology integration, in broader context with approach to teaching, professional engagement, and school-based access to technology	Becker & Riel (2000) created in 1998, complemented with case studies
National survey in England of teachers and technology-related professional development providers	Teachers' technology integration, quality of professional development model and its implementation, school's engagement with professional development, teacher access to technology	Preston (2004), complemented with case studies

is a continual need to rethink our preparation practices in the teacher education field and propose new strategies that better prepare teachers to effectively integrate technology into their teaching.

Although educators have expressed enthusiasm for the TPACK frame for teacher knowledge (Angeli & Valanides, 2009; Special Interest Group for Teacher Education [SIGTE] Leadership and National Technology Leadership Summit (NTLS) Program Committee, 2008; Wetzel, Foulger & Williams, 2008–2009), work is just beginning on assessing teachers' understanding of TPACK. Researchers have noted the need to develop reliable assessment approaches for measuring TPACK and its components to better understand which professional development approaches do (or do not) change teachers' knowledge, as well as deepening the collective sensitivity to the contexts in which these approaches work (or do not work) (Koehler & Mishra, 2005; Mishra & Koehler, 2006).

Building on a history of using survey methods to assess teachers' levels of technology integration, researchers have started work on creating survey instruments that assess preservice teachers' and teachers' levels of TPACK. Existing surveys tend to focus on teachers' self-assessment of their levels of technology use (e.g., Keller, Bonk, & Hew, 2005; Knezek & Christiansen, 2004), and Table 1 provides a summary of the most widely used of these surveys. Following the development of the TPACK framework, researchers began to work on the problem of assessing both preservice and inservice teachers' levels of TPACK. These surveys emphasize teachers' self-assessed levels of knowledge in each of the TPACK domains.

Previous attempts to measure TPACK include Koehler and Mishra (2005), who used a survey to track changes in teachers' perception of their understanding of content, pedagogy, and technology over the course of an instructional sequence emphasizing design of educational technology. Although they were able to establish and document changes in teachers' perception about their understanding, this approach relied on a survey specific to those unique course experiences, and thus is not generalizable to other contexts, content areas, or approaches to professional development. Koehler, Mishra, and Yahya (2007) also have used an approach based on discourse analysis to track the development of TPACK. Analyzing the conversations of teachers working in design teams, they have tracked the development of each of the seven components of TPACK over the course of a semester. This approach, however, is especially time consuming and is methodologically specific to the unique context in which it was used (i.e., semester-long design experiences).

Angeli and Valanides (2009) have explored the use of design-based performance assessments embedded into course sequences. The researchers used self-assessment, peer assessment, and expert assessment of these design-based performances as formative and summative assessments of teachers' understanding. Specifically, the expert assessment has raters judge the extent to which teachers do each of the following during their design activity: (a) identify suitable topics to be taught with technology, (b) identify appropriate representations to transform content, (c) identify teaching strategies that are difficult to implement by traditional means, (d) select appropriate tools and pedagogical uses, and (e) identify appropriate integration strategies. These ratings are combined to produce an overall rating of each teacher's "ICT-TPCK" competency. Again, this approach is time consuming and context specific to the extent that the design activities fit a particular content area and course content.

Archambault and Crippen (2009) have developed a survey-based approach to measuring TPACK based upon a sample of 596 K–12 online teachers. They used 24 survey questions asking teachers to rate their own understanding of various instructional and conceptual issues. Using prior research, definitions of the conceptual terms, and correlational analyses, the authors group questions to measure each of the seven components of TPACK. The present study proceeds in the same vein as the Koehler and Mishra (2005) study and the Archambault and Crippen (2009) study in that its purpose is to develop a fast, reliable, teacher-rated survey that measures teachers' understanding of each component of the TPACK framework. It extends the work of the Koehler and Mishra (2005) effort by developing a more robust survey that extends to general contexts, multiple content areas, and multiple approaches of professional development. It extends the work of Archambault and Crippen (2009) by offering triangulation on survey approaches that work, based upon a different methodological approach (factor-analysis), developed with a different population (preservice teachers), and premised upon an approach that measures teachers' understanding within several different content areas.

The belief that effective technology integration depends on content and pedagogy suggests that teachers' experiences with technology must be specific to different content areas. Using the TPACK framework to guide our research design, we conducted a study to develop an instrument with the purpose of measuring preservice teachers' self-assessment of the seven knowledge domains included within TPACK.

METHODOLOGY

This research team is interested in examining how preservice teachers develop and apply technological pedagogical content knowledge (TPACK) throughout their teacher preparation program and in PK–6 classrooms during practicum and student teaching experiences. As part of this research plan, we constructed the Survey of Preservice Teachers' Knowledge of Teaching and Technology to collect data on preservice teachers' self-assessment of the seven knowledge domains within the TPACK framework. These knowledge domains include: technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and finally, technological pedagogical content knowledge (TPACK). The researchers specifically designed the instrument for preservice teachers majoring in elementary or early childhood education, and it focused on the content areas (i.e., literacy, mathematics, science, social studies) that these preservice teachers would be preparing to teach.

Instrument Development

The first step in developing the TPACK survey involved reviewing relevant literature that cited numerous instruments that were already being used for assessing technology use in educational settings. Most of these instruments focused on the constructs of technology skills and proficiencies, teachers' beliefs and attitudes, technology support given, and barriers encountered. While developing this instrument, the purpose remained clear that the items included would measure preservice teachers' self-assessments of the TPACK domains, not their attitudes toward TPACK. Existing surveys provided information on the survey style and approach as we generated items designed to measure preservice teachers' self-assessed development of TPACK (Christensen & Knezek, 1996; Knezek & Christensen, 1998; Knezek, Christensen, Miyashita, & Ropp, 2000; Koehler & Mishra, 2005). The research group revised all items in an iterative process and then sent them out for expert content validity analysis.

Three nationally known researchers with expertise in TPACK were given the initial pool of 44 items to evaluate for content validity (Lawshe, 1975). Each expert was asked to rate to what extent each question measured one of the seven TPACK knowledge domains using a 10-point scale (with 1 being to the least extent and 10 being to the greatest extent). The experts were also encouraged to provide comments and suggestions for each question and, in some cases, offered their own lists of possible questions for each domain. The mean ratings for items in the seven knowledge domains were 5.14 (TK), 3.67 (PK), 8.50 (CK), 8.33 (TPK), 9.00 (PCK), and 7.88 (TPACK). The research team then collaborated to review the ratings and suggestions, and made revisions to several items. For example, the content-validity experts offered recommendations to revise survey items that ranged from changing the location of a word in a question to turning one question into several related questions. Areas with low mean ratings, such as TK, were determined to include items that did not adequately measure preservice teachers' knowledge about that particular construct. The research team then worked closely with two of the experts to rewrite items for all seven TPACK subscales.

Consequently, the instrument constructed contained 75 items for measuring preservice teachers' self-assessments of the seven TPACK domains: 8 TK items, 17 CK items, 10 PK items, 8 PCK items, 8 TCK items, 15 TPK items, and 9 TPACK items. For these 75 items, participants answered each question using the following five-level Likert scale:

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

The instrument also included items addressing demographic information and faculty and PK–6 teacher models of TPACK. The Survey of Preservice Teachers' Knowledge of Teaching and Technology was then administered online after students completed a required 3-credit introductory technology course designed specifically for PK–6 preservice teachers.

Research Context and Participants

The research team collected data for this survey development project from 124 students who were enrolled in a 3-credit introduction to instructional technology course at a large Midwestern university. This 15-week course focused on using technology in PK–6 classrooms and learning environments with an emphasis on integrating technology into all content areas. The preservice teachers were required to attend two 1-hour lectures and one 2-hour laboratory session per week. One member of this research group manages the course and teaches the two lectures offered each week. Typically, graduate teaching assistants teach the hands-on, laboratory sections that meet for 2 hours every week.

One researcher recently redesigned this introductory instructional technology course using TPACK as an organizing framework for course content and activities. Although developing preservice teachers' technology knowledge was still a primary focus of the course, there was an increased emphasis placed on developing their content knowledge and pedagogical knowledge as well. The design of course projects and assignments required preservice teachers to constantly make connections between content, pedagogy, and technology in relationship to the instructional goals. For example, one project required each preservice teacher to design a comprehensive lesson plan that integrated technology. In addition to selecting the technology, preservice teachers were also required to list specific content area standards addressed and to describe the pedagogical methods used for the lesson.

The researchers created the TPACK survey using an online survey development tool and posted it on the course WebCT site for participants to access. When the preservice teachers accessed the survey online the first time, they were presented with an informed consent document that described the study's purpose and were told that their participation in the study was voluntary. All participants completed the survey in their laboratory session during the last week of the semester. The survey took approximately 15–20 minutes for participants to complete.

The majority of responses (79.0%) were from students majoring in elementary education, whereas 14.5% of the responses were from early childhood education majors and 6.5% of the respondents were enrolled in another major. Of the 124 students who completed the survey, 116 (93.5%) were female and 8 (6.5%) were male. Just over half (50.8%) of the respondents were freshmen, 29.8% were sophomores, 16.1% were juniors, and 3.2% were seniors. At the time the survey was administered, the majority of the respondents (85.5%) had not yet completed a practicum or student teaching experience in a PK–6 classroom.

Data Analysis

The research team used quantitative research methods to establish the extent of the validity and reliability of the instrument. Researchers assessed each TPACK knowledge domain subscale for internal consistency using Cronbach's alpha reliability technique. We then investigated construct validity for each knowledge domain subscale using principal components factor analysis with varimax rotation within each knowledge domain and Kaiser normalization. Given that the instrument included 75 items when it was administered for the first time, it was clear that our sample size was too small to perform a factor analysis on the entire instrument.

RESULTS

Factor analysis involves a series of analyses used to develop a rigorous instrument. For this analysis, the first step involved running a factor analysis on the items within each subscale to ascertain the covariation among the items and

Table 2: Factor Matrix for Technology Knowledge (TK)

	Factor Loadings	Internal Consistency (alpha)
Technology Knowledge		.82
I know how to solve my own technical problems.	.76	
I can learn technology easily.	.75	
I keep up with important new technologies.	.73	
I frequently play around with the technology.	.70	
I know about a lot of different technologies.	.66	
I have the technical skills I need to use technology.	.66	
I have had sufficient opportunities to work with different technologies.	.65	

whether the patterns fit well into the TPACK constructs. The researchers used the Kaiser-Guttman rule (which states that factors with Eigen values greater than 1 should be accepted) to identify a number of factors and their constitution based on the data analysis. In addition, we calculated reliability statistics for items in each subscale to identify problematic items. We examined questionable items for each TPACK domain subscale and eliminated those that reduced the reliability coefficient for the subscales. We also eliminated those items because it seemed they were not measuring the preservice teachers' knowledge of the related construct. Thus, we dropped the individual items that affected the reliability and construct validity of each knowledge domain subscale. As a result, 28 items were deleted from the survey, including one TK item, 5 CK items, 3 PK items, 4 PCK items, 4 TCK items, 10 TPK items, and 1 TPACK item (see Appendix A, pages 142–143).

After eliminating problematic items, we ran a second factor analysis on the remaining survey items within each of the seven subscales, and those results are presented in this section. The resulting TPACK instrument exhibited strong internal consistency reliability and included 47 items (see Appendix B). Reliability statistics were then repeated on the remaining items within each knowledge domain. The internal consistency reliability (coefficient alpha) ranged from .75 to .92 for the seven TPACK subscales. According to George and Mallery (2001), this range is considered to be acceptable to excellent. The alpha reliability coefficients are reported in Tables 2–8 for each TPACK subscale presented. We report the final items for the TPACK subscales, along with their reliabilities, in the sections that follow.

Technology Knowledge (TK)

The first knowledge domain, technology knowledge (TK), refers to understanding how to use various technologies. One factor, accounting for 49.36% of the total variance, was present using the seven items that captured students' self-assessment of their technology knowledge (see Table 2). Cronbach's alpha for this set of items was .82.

Table 3: Factor Matrix for Content Knowledge (CK)

Content Knowledge	Factor Loadings	Internal Consistency (alpha)
Mathematics		.85
I have sufficient knowledge about mathematics.	.89	
I can use a mathematical way of thinking.	.89	
I have various ways and strategies of developing my understanding of mathematics.	.86	
Social Studies		.84
I have various ways and strategies of developing my understanding of social studies.	.92	
I have sufficient knowledge about social studies.	.87	
I can use a historical way of thinking.	.83	
Science		.82
I have various ways and strategies of developing my understanding of science.	.89	
I can use a scientific way of thinking.	.86	
I have sufficient knowledge about science.	.82	
Literacy		.75
I have various ways and strategies of developing my understanding of literacy.	.89	
I can use a literary way of thinking.	.79	
I have sufficient knowledge about literacy.	.79	

Content Knowledge (CK)

The second knowledge domain, content knowledge (CK), refers to the knowledge teachers must know about for the content they are going to teach and how the nature of that knowledge is different for various content areas. The factor analysis of the twelve items on this subscale extracted four factors (see Table 3). Each of the four factors extracted included items classified from the major subjects typically taught in an elementary classroom: mathematics with 77.32% variance, social studies with 77.06% variance, science with 73.25% variance, and literacy with 67.36% variance. Cronbach's alpha for mathematics was .85, social studies was .84, science was .82, and literacy was .75.

Pedagogical Knowledge (PK)

Pedagogical knowledge (PK), the third subdomain, refers to the methods and processes of teaching and would include fundamental knowledge in areas such as classroom management, assessment, lesson plan development, and student learning. After completing the factor analysis on the seven items representing PK, the results produced a single-factor structure having a 52.39% variance (see Table 4). Cronbach's alpha for this set of items was .84.

Table 4: Factor Matrix for Pedagogical Knowledge (PK)

	Factor Loadings	Internal Consistency (alpha)
Pedagogical Knowledge		.84
I know how to assess student performance in a classroom.	.79	
I can adapt my teaching based upon what students currently understand or do not understand.	.78	
I can adapt my teaching style to different learners.	.77	
I can assess student learning in multiple ways.	.77	
I can use a wide range of teaching approaches in a classroom setting.	.68	
I am familiar with common student understandings and misconceptions.	.68	
I know how to organize and maintain classroom management.	.59	

Table 5: Factor Matrix for Pedagogical Content Knowledge (PCK)

	Factor Loadings	Internal Consistency (alpha)
Pedagogical Content Knowledge		.85
I know how to select effective teaching approaches to guide student thinking and learning in literacy.	.87	
I know how to select effective teaching approaches to guide student thinking and learning in science.	.84	
I know how to select effective teaching approaches to guide student thinking and learning in mathematics.	.81	
I know how to select effective teaching approaches to guide student thinking and learning in social studies.	.79	

Pedagogical Content Knowledge (PCK)

The fourth knowledge domain, pedagogical content knowledge (PCK), refers to the content knowledge that deals with the teaching process. After completing the factor analysis on the seven items representing PCK, the results produced a single-factor structure having a 68.73% variance (see Table 5). Cronbach's alpha for this knowledge domain was .85.

Technological Content Knowledge (TCK)

The fifth knowledge domain, technological content knowledge (TCK), refers to teachers' understanding of how using a specific technology can change the way learners understand and practice concepts in a specific content area. The factor analysis produced one factor from the four items on the subscale and accounted for 64.95% of the item variance (see Table 6, page 134). For this set of items, the Cronbach's alpha was .80.

Table 6: Factor Matrix for Technological Content Knowledge (TCK)

	Factor Loadings	Internal Consistency (alpha)
Technological Content Knowledge		.80
I know about technologies that I can use for understanding and doing literacy.	.87	
I know about technologies that I can use for understanding and doing social studies.	.86	
I know about technologies that I can use for understanding and doing science.	.80	
I know about technologies that I can use for understanding and doing mathematics.	.69	

Table 7: Factor Matrix for Technological Pedagogical Knowledge (TPK)

	Factor Loadings	Internal Consistency (alpha)
Technological Pedagogical Knowledge		.86
I can choose technologies that enhance the teaching approaches for a lesson.	.91	
I can choose technologies that enhance students' learning for a lesson.	.89	
My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.	.78	
I am thinking critically about how to use technology in my classroom.	.75	
I can adapt the use of the technologies that I am learning about to different teaching activities.	.69	

Technological Pedagogical Knowledge (TPK)

Technological pedagogical knowledge (TPK) refers to teachers' knowledge of how various technologies can be used in teaching and understanding that using technology may change the way an individual teaches. For the sixth knowledge domain one factor emerged from the seven items included on the TPK subscale (see Table 7). The total variance reported for the TPK domain was 65.32%. The Cronbach's alpha for the TPK knowledge domain was .86.

Technological Pedagogical Content Knowledge (TPACK)

The seventh and final knowledge domain, technological pedagogical content knowledge (TPACK), refers to the knowledge teachers require for integrating technology into their teaching—the total package. Teachers must have

Table 8: Factor Matrix for Technological Pedagogical Content Knowledge (TPCK)

	Factor Loadings	Internal Consistency (alpha)
Technological Pedagogical Content Knowledge		.92
I can teach lessons that appropriately combine literacy, technologies, and teaching approaches.	.87	
I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.	.85	
I can choose technologies that enhance the content for a lesson.	.85	
I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	.82	
I can teach lessons that appropriately combine science, technologies, and teaching approaches.	.82	
I can teach lessons that appropriately combine social studies, technologies, and teaching approaches.	.80	
I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district.	.74	
I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches.	.67	

an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies. A factor analysis of the eight items representing TPACK included one factor accounting for 64.63% of the item variance. Cronbach's alpha for this set of items was .92 (see Table 8).

Correlations among TPACK Subscales

A final set of analyses examined the relationship between TPACK subscales using Pearson product-moment correlations. With respect to correlations between subscales, coefficients varied from .02 (social studies and math content knowledge) to .71 (TPK and TPACK). TPACK was significantly correlated with eight subscales at the .001 level and with social studies content knowledge (SSCK) at the .05 level. The highest correlations were between TPACK and TPK (r=.71), TPACK and TCK (r=.49), and TPACK and PCK (r=.49) (see Table 9, page 136).

DISCUSSION

These results indicate that this is a promising instrument for measuring preservice teachers' self-assessment of the TPACK knowledge domains. Although the sample size was small, we have good indications that the survey, as revised, is a reliable measure of TPACK and its related knowledge domains. Future work will include further refinement of the instrument through obtaining a

Table 9: Correlations between TPACK Subscales

TPACK Subscale	TK	SSCK	MCK	SCK	LCK	PK	PCK	TPK	TCK	TPACK
Technology Knowledge (TK)	—	.07	.41**	.37**	.19*	.21*	.17	.40**	.54**	.43**
Social Studies Content Knowledge (SSCK)		—	.02	.35**	.43**	.18*	.35**	.16	.22*	.18*
Math Content Knowledge (MCK)			—	.39**	.15	.14	.25**	.23*	.21*	.26**
Science Content Knowledge (SCK)				—	.33**	.30**	.33**	.26**	.36**	.37**
Literacy Content Knowledge (LCK)					—	.42**	.32**	.35**	.23**	.31**
Pedagogical Knowledge (PK)						—	.56**	.51**	.23**	.53**
Pedagogical Content Knowledge (PCK)							—	.32**	.20*	.49**
Technological Pedagogical Knowledge (TPK)								—	.46**	.71**
Technological Content Knowledge (TCK)									—	.49**
Technological Pedagogical Content Knowledge (TPACK)										—
Mean	3.67	3.80	3.70	3.65	4.03	3.97	3.63	4.15	3.84	3.97
Standard Deviation	.55	.70	.78	.73	.48	.45	.65	.44	.53	.52

larger sample size so a factor analysis can be performed on the entire instrument, and then further validation of the instrument using classroom observation procedures.

This survey instrument was designed with a specific purpose in mind: examining preservice teachers' development of TPACK. Over the years, several instruments have been developed for measuring constructs like teachers' technology skills, technology integration, access to technology, and teachers' attitudes about technology (Becker & Riel, 2000; Keller, Bonk, & Hew, 2005; Knezek & Christiansen, 2004). Although advances were made in developing valid and reliable instruments for these purposes, this instrument is different from others in that it measures preservice teachers' self-assessment of their development of TPACK rather than teachers' attitudes or teachers' technology use and integration. It extends the work of Mishra and Kohler (2005) and Archambault and Crippen (2009) with the creation of another robust survey that specifically targets preservice teachers and thoroughly examines their knowledge development in each of the seven TPACK domains.

Readers are reminded that this survey was specifically designed for preservice teachers who are preparing to become elementary (PK–6) or early childhood education teachers (PK–3). Thus, the content knowledge domain includes separate factors for the content areas of math, science, social studies, and literacy. Because PK–6 teachers generally teach all of these subjects in their classrooms, having separate factors for each content area seems most appropriate and supports the idea that the TPACK framework is content dependent (AACTE Committee on Innovation and Technology, 2008; Mishra & Kohler, 2006). Future work in this area will benefit from efforts that specifically address measuring secondary teachers' self-assessment in the content areas of mathematics, science, social studies, and English. Taking into account the results from this study, it seems realistic that there would be an instrument designed specifically for each secondary content area.

It should be noted that two of the subscales (PCK and TCK) included only four items, and each item in the subscale was connected to a content area. For example, a PCK item stated: I know how to select effective teaching approaches to guide student thinking and learning in mathematics. The remaining three items addressed literacy, science, and social studies respectively. Given the results on this instrument, writing additional items for these subscales might strengthen the instrument's reliability and validity in these areas. Research plans include continual revision and refinement of the instrument, including the addition of more items to some of the TPACK subscales.

CONCLUSIONS

The instrument developed for this study provides a promising starting point for work designed to examine and support preservice teachers' development of TPACK. The authors plan on conducting a longitudinal study with the preservice teachers who participated in this study to examine the development of TPACK after completing content area methodology courses and student teaching. Research plans also involve following these preservice teachers during their induction years of teaching. Perhaps most important, we plan to conduct classroom observations of student teachers and induction year teachers to evaluate the level of TPACK demonstrated in their classrooms and then investigate how scores on the TPACK instrument predict classroom behaviors. In addition, the authors plan studies designed to further validate and revise the instrument.

We are also in the process of completing a study of pre- and posttest scores using the instrument with preservice teachers currently enrolled in the same introductory instructional course to determine what effect the class has on the early development of TPACK (Schmidt, et al., 2009). We have also used the instrument to investigate how inservice teachers' beliefs about teaching and technology changed during a set of educational courses offered both face to face and online (Shin et al., 2009). Use and modification of this instrument should encourage a line of research on measuring the development of TPACK in preservice teachers and ultimately help preservice teacher education programs design and implement approaches that will encourage this development. We plan to administer the survey periodically throughout teacher education programs, using the results to inform researchers of specific times or events when each knowledge domain is developed. This information will provide valuable insight into the development of TPACK and provide program feedback on effective approaches in encouraging this development.

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References

American Association of Colleges of Teacher Education (AACTE) Committee on Innovation and Technology. (2008). *Handbook of technological pedagogical content knowledge (TPCK) for educators.* New York: Routledge/Taylor & Francis Group.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*(1), 154–168.

Angeli, C., & Valanides, N. (2005). Preservice elementary teachers as information and communication technology designers: An instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning, 21*(4), 292–302.

Archambault, L., & Crippen, K. (2009). Examining TPACK among K–12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*(1). Retrieved August 28, 2009, from http://www.citejournal.org/vol9/iss1/general/article2.cfm

Becker, H. J., & Riel, M. M. (2000). *Teacher professional engagement and constructive-compatible computer usage* (Report no. 7). Irvine, CA: Teaching, Learning, and Computing. Retrieved May 1, 2009, from http://www.crito.uci.edu/tlc/findings/report_7/

Christensen, R., & Knezek, G. (1996). *Constructing the teachers' attitudes toward computers (TAC) questionnaire.* Paper presented to the Southwest Educational Research Association Annual Conference, New Orleans, Louisiana, January, 1996.

Davis, N., & Thompson, A. (2005). The evaluation of technology-related professional development, Part 2. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2005* (pp. 825–830). Chesapeake, VA: AACE.

Franklin, C. (2004). Teacher preparation as a critical factor in elementary teachers: Use of computers. In R. Carlsen, N. Davis, J. Price, R. Weber, & D. Willis (Eds.), *Society for Information Technology and Teacher Education Annual, 2004* (pp. 4994–4999). Norfolk, VA: Association for the Advancement of Computing in Education.

George, D., & Mallery, P. (2001). SPSS for Windows. Needham Heights, MA: Allyn & Bacon.

Hughes, J. (2004). Technology learning principles for preservice and in-service teacher education. *Contemporary Issues in Technology and Teacher Education, 4*(3), 345–362.

Irving, K. E. (2006). The impact of technology on the 21st-century classroom. In J. Rhoton & P. Shane (Eds.), *Teaching science in the 21st century* (pp. 3–20). Arlington, VA: National Science Teachers Association Press.

Keating, T., & Evans, E. (2001). Three computers in the back of the classroom: Pre-service teachers' conceptions of technology integration. In R. Carlsen, N. Davis, J. Price, R. Weber, & D. Willis (Eds.), *Society for Information Technology and Teacher Education Annual, 2001* (pp. 1671–1676). Norfolk, VA: Association for the Advancement of Computing in Education.

Keller, J. B., Bonk, C. J., & Hew, K. (2005). The TICKIT to teacher learning: Designing professional development according to situative principles. *Journal of Educational Computing Research, 32*(4), 329–340.

Knezek, G., & Christensen, R. (2004). *Summary of KIDS project findings for 1999–2004 research and project evaluation.* (U.S. Department of Education, Grant #R303A99030). Denton, TX: Institute for the Integration of Technology into Teaching and Learning (IITTL). Retrieved May 1, 2009, from http://www.iittl.unt.edu/KIDS5YearSummary2.pdf

Knezek, G., & Christensen, R. (1998). Internal consistency reliability for the teachers' attitudes toward information technology (TAT) questionnaire. In S. McNeil, J. D. Price, S. Boger-Mehall, B. Robin, & J. Willis (Eds.), *Technology and Teacher Education Annual 1998, Vol. 2* (pp. 831–832). Charlottesville: Association for the Advancement of Computing in Education.

Knezek, G. A., Christensen, R. W., Miyashita, K. T., & Ropp, M. M. (2000). *Instruments for assessing educator progress in technology integration.* Denton, TX: Institute for the Integration of Technology into Teaching and Learning. Retrieved from http://iittl.unt.edu/pt3II/downloadpubs.htm

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. AACTE Committee on Innovation and Technology (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3–29). Mahwah, NJ: Lawrence Erlbaum Associates.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131–152.

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy, and technology. *Computers and Education, 49*(3), 740–762.

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology, 28*(4), 563–575.

Margerum-Leys, J., & Marx, R. (2002). Teacher knowledge of educational technology: A study of student teacher/mentor teacher pairs. *Journal of Educational Computing Research, 26*(4), 427–462.

McCrory, R. (2004). A framework for understanding teaching with the Internet. *American Educational Research Journal, 41*(2), 447–488.

Mishra, P. (1998). Flexible learning in the periodic system with multiple representations: The design of a hypertext for learning complex concepts in chemistry. (Doctoral dissertation, University of Illinois at Urbana—Champaign). *Dissertation Abstracts International, 59*(11), 4057. (AAT 9912322).

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teachers' knowledge. *Teachers College Record, 108*(6), 1017–1054.

Moersch, C. (1995). Levels of technology implementation (LoTi): A framework for measuring classroom technology use. *Learning and Leading with Technology, 23*(3), 40–42.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509–523.

Pierson, M. E. (1999). Technology integration practice as a function of pedagogical expertise (Doctoral dissertation, Arizona State University). *Dissertation Abstracts International, 60*(03), 711. (AAT 9924200).

Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education, 33*(4), 413–429.

Preston, C. (2004). *Learning to use ICT in classrooms: Teachers' and trainers' perspectives.* Evaluation of the English NOF ICT teacher training programme (1999–2003). London, MirandaNet and the Teacher Training Agency.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Examining preservice teachers' development of technological pedagogical content knowledge in an introductory instructional technology course. In I. Gibson, R. Weber, K. McFerrin, R. Carlsen, & D. A. Willis (Eds.), *Society for Information Technology and Teacher Education International Conference book, 2009* (pp. 4145–4151). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shin, T. S., Koehler, M. J., Mishra, P., Schmidt, D. A., Baran, E., & Thompson, A. D. (2009). Changing Technological Pedagogical Content Knowledge (TPACK) through course experiences. In I. Gibson, R. Weber, K. McFerrin, R. Carlsen, & D. A. Willis (Eds.), *Society for Information Technology and Teacher Education International Conference book, 2009* (pp. 4152–4156). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Special Interest Group for Teacher Education (SIGTE) Leadership and National Technollogy Leadership Summit (NTLS) Program Committee. (2008). Realizing technology potential through TPACK. *Learning & Leading with Technology, 36*(2), 23–26.

Slough, S., & Connell, M. (2006). Defining technology and its natural corollary, technological content knowledge (TCK). In C. Crawford, D. Willis, R. Carlsen, I. Gibson, K. McFerrin, J. Price, & R. Weber (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference, 2006* (pp. 1053–1059). Chesapeake, VA: AACE.

SRI International (2002). *Technology-related professional development in the context of educational reform: A literature review: Subtask 5: Professional development study*. Retrieved September 7, 2004, from http://www.sri.com/policy/cep/mst/SRI_PD_Lit_Review_2002.pdf

Thompson, A., & Mishra, P. (2007–2008). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education*, *24*(2), 38–64.

Wetzel, K., Foulger, T. S., & Williams, M. K. (2008–2009). The evolution of the required educational technology course. *Journal of Computing in Teacher Education*, *25*(2), 67–71.

Zhao, Y. (2003). *What teachers should know about technology: Perspectives and practices*. Greenwich, CT: Information Age Publishing.

APPENDIX A: SURVEY ITEMS DELETED

Technology Knowledge (TK)

- When I encounter a problem using technology, I seek outside help.

Content Knowledge (CK)

- I have a deep and wide understanding of the subjects I plan to teach.
- I know about various examples of how mathematics applies in the real world.
- I know about various examples of how literacy applies in the real world.
- I know about various examples of how science applies in the real world.
- I know about various examples of how social studies applies in the real world.

Pedagogical Knowledge (PK)

- I know when it is appropriate to use a variety of teaching approaches in a classroom setting (collaborative learning, direct instruction, inquiry learning, problem/project-based learning, etc.)
- I have an understanding of how students learn.
- I can structure a lesson to promote student learning.

Pedagogical Content Knowledge (PCK)

- I know that different mathematical concepts do not require different teaching approaches.
- I know that different literacy concepts do not require different teaching approaches.
- I know that different science concepts do not require different teaching approaches.
- I know that different social studies concepts do not require different teaching approaches.

Technological Content Knowledge (TCK)

- Using technology can fundamentally change the way people understand mathematics concepts.
- Using technology can fundamentally change the way people understand literacy concepts.
- Using tåechnology can fundamentally change the way people understand science concepts.
- Using technology can fundamentally change the way people understand social studies concepts.

Technological Pedagogical Knowledge (TPK)

- Different teaching approaches do not require different technologies.
- I have the technical skills I need to use technology appropriately in teaching.
- I have the classroom management skills I need to use technology appropriately in teaching.
- I know how to use technology in problem/project-based learning.
- I know how to use technology in inquiry learning.
- I know how to use technology in collaborative learning.
- I know how to use technology in direct instruction.
- My teaching approaches change when I use technologies in a classroom .
- Knowing how to use a certain technology means that I can use it for teaching.
- Different technologies require different teaching approaches.

Technological Pedagogical Content Knowledge (TPACK)

- Integrating technology in teaching content (i.e. mathematics, literacy, science, social studies) will be easy and straightforward for me.

APPENDIX B: SURVEY OF PRESERVICE TEACHERS' KNOWLEDGE OF TEACHING AND TECHNOLOGY

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. Your individual name or identification number will not at any time be associated with your responses. Your responses will be kept completely confidential and will not influence your course grade.

Demographic Information

1. Your e-mail address

2. Gender
    a. Female
    b. Male

3. Age range
    a. 18–22
    b. 23–26
    c. 27–32
    d. 32+

4. Major
    a. Early Childhood Education (ECE)
    b. Elementary Education (ELED)
    c. Other

5. Area of Specialization
    a. Art
    b. Early Childhood Education Unified with Special Education
    c. English and Language Arts
    d. Foreign Language
    e. Health
    f. History
    g. Instructional Strategist: Mild/Moderate (K8) Endorsement
    h. Mathematics
    i. Music
    j. Science—Basic
    k. Social Studies
    l. Speech/Theater
    m. Other

6. Year in College
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior

7. Are you completing an educational computing minor?
    a. Yes
    b. No
8. Are you currently enrolled or have you completed a practicum experience in a PK–6 classroom?
    a. Yes
    b. No

9. What semester and year (e.g., spring 2008) do you plan to take the following? If you are currently enrolled in or have already taken one of these literacy block, please list semester and year completed.

Literacy Block-I (C I 377, 448, 468A, 468C)	
Literacy Block-II (C I 378, 449, 468B, 468D)	
Student teaching	

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies—that is, the digital tools we use such as computers, laptops, iPods, handhelds, interactive whiteboards, software programs, etc. Please answer all of the questions, and if you are uncertain of or neutral about your response, you may always select "Neither agree nor disagree."

Technology Knowledge (TK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

1. I know how to solve my own technical problems.	SD	D	N	A	SA
2. I can learn technology easily.	SD	D	N	A	SA
3. I keep up with important new technologies.	SD	D	N	A	SA
4. I frequently play around with the technology.	SD	D	N	A	SA
5. I know about a lot of different technologies.	SD	D	N	A	SA
6. I have the technical skills I need to use technology.	SD	D	N	A	SA
7. I have had sufficient opportunities to work with different technologies.	SD	D	N	A	SA

Content Knowledge (CK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

Mathematics					
8. I have sufficient knowledge about mathematics.	SD	D	N	A	SA
9. I can use a mathematical way of thinking.	SD	D	N	A	SA
10. I have various ways and strategies of developing my understanding of mathematics.	SD	D	N	A	SA
Social Studies					
11. I have sufficient knowledge about social studies.	SD	D	N	A	SA
12. I can use a historical way of thinking.	SD	D	N	A	SA
13. I have various ways and strategies of developing my understanding of social studies.	SD	D	N	A	SA
Science					
14. I have sufficient knowledge about science.	SD	D	N	A	SA
15. I can use a scientific way of thinking.	SD	D	N	A	SA
16. I have various ways and strategies of developing my understanding of science.	SD	D	N	A	SA
Literacy					
17. I have sufficient knowledge about literacy.	SD	D	N	A	SA
18. I can use a literary way of thinking.	SD	D	N	A	SA
19. I have various ways and strategies of developing my understanding of literacy.	SD	D	N	A	SA

Pedagogical Knowledge (PK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

20. I know how to assess student performance in a classroom.	SD	D	N	A	SA
21. I can adapt my teaching based upon what students currently understand or do not understand.	SD	D	N	A	SA
22. I can adapt my teaching style to different learners.	SD	D	N	A	SA
23. I can assess student learning in multiple ways.	SD	D	N	A	SA
24. I can use a wide range of teaching approaches in a classroom setting.	SD	D	N	A	SA
25. I am familiar with common student understandings and misconceptions.	SD	D	N	A	SA
26. I know how to organize and maintain classroom management.	SD	D	N	A	SA

Pedagogical Content Knowledge (PCK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

27. I can select effective teaching approaches to guide student thinking and learning in mathematics.	SD	D	N	A	SA
28. I can select effective teaching approaches to guide student thinking and learning in literacy.	SD	D	N	A	SA
29. I can select effective teaching approaches to guide student thinking and learning in science.	SD	D	N	A	SA
30. I can select effective teaching approaches to guide student thinking and learning in social studies.	SD	D	N	A	SA

Technological Content Knowledge (PCK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

31. I know about technologies that I can use for understanding and doing mathematics.	SD	D	N	A	SA
32. I know about technologies that I can use for understanding and doing literacy.	SD	D	N	A	SA
33. I know about technologies that I can use for understanding and doing science.	SD	D	N	A	SA
34. I know about technologies that I can use for understanding and doing social studies.	SD	D	N	A	SA

Technological Pedagogical Knowledge (TPK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

35. I can choose technologies that enhance the teaching approaches for a lesson.	SD	D	N	A	SA
36. I can choose technologies that enhance students' learning for a lesson.	SD	D	N	A	SA
37. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.	SD	D	N	A	SA
38. I am thinking critically about how to use technology in my classroom.	SD	D	N	A	SA
39. I can adapt the use of the technologies that I am learning about to different teaching activities.	SD	D	N	A	SA

Technological Pedagogical Content Knowledge (TPACK)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

40. I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches.	SD	D	N	A	SA
41. I can teach lessons that appropriately combine literacy, technologies, and teaching approaches.	SD	D	N	A	SA
42. I can teach lessons that appropriately combine science, technologies, and teaching approaches.	SD	D	N	A	SA
43. I can teach lessons that appropriately combine social studies, technologies, and teaching approaches.	SD	D	N	A	SA
44. I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	SD	D	N	A	SA
45. I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.	SD	D	N	A	SA
46. I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district.	SD	D	N	A	SA
47. I can choose technologies that enhance the content for a lesson.	SD	D	N	A	SA

Models of TPACK (Faculty, PK–6 Teachers)

Strongly Disagree = SD Disagree = D Neither Agree/Disagree = N Agree = A Strongly Agree = SA

1. My mathematics education professors appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA
2. My literacy education professors appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA
3. My science education professors appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA
4. My social studies education professors appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA
5. My instructional technology professors appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA

6. My educational foundation professors appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA
7. My professors outside of education appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA
8. My PK–6 cooperating teachers appropriately model combining content, technologies, and teaching approaches in their teaching.	SD	D	N	A	SA

	25% or less	26% –50%	51% – 75%	76% – 100%
9. In general, approximately what percentage of your teacher education professors have provided an effective model of combining content, technologies, and teaching approaches in their teaching?				
10. In general, approximately what percentage of your professors outside of teacher education have provided an effective model of combining content, technologies, and teaching approaches in their teaching?				
11. In general, approximately what percentage of the PK–6 cooperating teachers have provided an effective model of combining content, technologies, and teaching approaches in their teaching?				

Please complete this section by writing your responses.

1. Describe a specific episode where a professor or an instructor effectively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content was being taught, what technology was used, and what teaching approach(es) was implemented.

2. Describe a specific episode where one of your PK–6 cooperating teachers effectively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content was being taught, what technology was used, and what teaching approach(es) was implemented. If you have not observed a teacher modeling this, please indicate that you have not.

3. Describe a specific episode where you effectively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content you taught, what technology you used, and what teaching approach(es) you implemented. If you have not had the opportunity to teach a lesson, please indicate that you have not.