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Technological Pedagogical Content Knowledge Self-Efficacy Scale (TPACK-SeS) for Pre-Service Science Teachers: Construction, Validation, and Reliability

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Abstract

Problem Statement: Based on developments in the 21st century technology has become a large part of the classroom experience. Teachers need to have an understanding of how technology can be coordinated with pedagogy and content knowledge in order to integrate technology effectively into classroom instruction. Self-efficacy beliefs toward technology also play a key role in technology integration. It has been shown that the beliefs of a teacher are closely linked to the technologies that they use and the way in which they use them. More specifically, the beliefs of a teacher with regards to their technological pedagogical content knowledge (TPACK) are pivotal in terms of using technology in the classroom because belief about their capability to use technology is a powerful predictor of their potential technology use. Hence, it is critical to measure pre-service teachers' self-efficacy beliefs toward TPACK in order to identify the factors that contribute to a teacher's use of technology in classroom instruction.

Purpose of This Study: The purpose of this study is to develop a comprehensive instrument to determine pre-service science teacher's self-efficacy beliefs towards TPACK

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Methods: The participants in the study consisted of 808 senior pre-service science teachers in 17 colleges for teacher education. In this study, the data was split into two random subsamples to perform factor analysis. Exploratory Factor Analysis (EFA) was conducted using one subsample (n = 420) to determine the factorial structure of the scale, and Confirmatory Factor Analysis (CFA) was conducted on the second subsample (n = 388) in order to confirm the structure model obtained from the EFA analysis in cross-validation the Technological Pedagogical Content Knowledge Self-Efficacy Scale (TPACK-SeS) for a different sample. Item total correlations and Cronbach’s alpha internal reliability coefficient were utilized in determining the reliability of the whole scale and its subscales for both samples.

Findings and Results: Based on the EFA results, the final version of the scale consists of an eight-factor structure with 52 items. Following EFA, CFA supported this eight-factor structure and showed a good fit with high indices. Cronbach's alpha coefficient, demonstrating the internal consistency reliability of the subscales and whole scale, were found to be high, and item total correlation coefficients were valid for the different samples.

Conclusions and Recommendations: The results show that TPACK-SeS can serve as a valuable tool for teachers, educators, and researchers in evaluating pre-service science teacher’s self-efficacy beliefs towards TPACK.

Keywords: Pre-service science teachers, technological pedagogical content knowledge, scale development

In this technology driven 21st century, technology has become a huge part of the education process. Despite the increased level of access to technology in classrooms, relatively few teachers have fully integrated technology into their teaching methods (Kahyaoglu, 2011). As various researchers have pointed out, while the value of knowing a variety of educational technology tools is important in terms of technology integration, knowing what technology to use and how to use it in the teaching context is more critical for effective technology integration. A growing number of researchers have argued that in order to use appropriate technology tools in teaching, teachers need to have a well-developed technological pedagogical content knowledge (TPACK) (Cox & Graham, 2009; McCrory, 2008; Mishra & Koehler, 2006; Niess, 2005). TPACK is a blend of pedagogical knowledge (PK), content knowledge (CK), and technology knowledge (TK), and has been addressed in many research studies as an indicator of successful technology use (Mishra & Koehler, 2006).

Technology integration is clearly related to a teacher’s TK and self-efficacy beliefs regarding technology use (Abbitt, 2011; Ertmer & Ottenbreit-Leftwich, 2010; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). Thus, it is important that educational reforms that involve technology integration should carefully consider how to provide effective opportunities for teachers to enhance their technology knowledge and establish self-efficacy beliefs with the aim of improving technology integration. More specifically, a teacher's beliefs about their TPACK are pivotal in terms of using technology in the classroom because a teacher's beliefs about their capability to use technology is a powerful predictor how effectively they will actually use technology (Lee & Tsai, 2010).

It is critical to measure pre-service science teacher's self-efficacy beliefs toward TPACK in order to identify the factors that contribute to a teacher's use of technology in classroom instruction and to develop a valid and reliable instrument that can be used to assess these factors. Creating the tools is critical in developing more effective science teacher education programs, and as such, pre-service science teacher's interests, confidence, and competence in technology use must be increased. The focus of this study was to develop a comprehensive self-efficacy scale to assess pre-service science teacher's beliefs about their TPACK.

Literature Review

The Nature of the TPACK Framework

In this widely accepted model of pedagogical content knowledge (PCK), Lee Shulman (1986) defines PCK as an amalgam of PK and CK. According to Shulman, PCK includes,

> *"the most useful forms of representation of...the most regularly taught topics in one's subject area..., the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others"* (p. 9).

While Shulman explicitly discusses various representations necessary to make learning more meaningful for students, he did not include educational technology in his conceptualization of PCK. However, in the last two decades, technology has become heavily involved in schools, and more and more teachers have integrated technology into their teaching. Recent advances in educational technology have allowed teachers to use a variety of technology tools (e.g., simulations, animations, and probeware). Hence, researchers have shown a growing interest in studying how teachers incorporate technology into their teaching and suggest that teachers need to have an understanding of how technology can be coordinated with PK and CK in order to integrate technology effectively into classroom instruction (Hughes, 2005; Keating & Evans, 2001; Margerum- Leys & Marx, 2002; Niess, 2005; Zhao, 2003). To fully understand teacher's knowledge about technology tools and their use of those tools in classroom instruction, Mishra and Koehler (2006) developed the TPACK framework, which builds on Shulman's PCK model. According to Koehler and Mishra (2008), TPACK is an integration of TK, CK, and PK, and it is necessary for teachers to fully familiar with all aspects of this in order to use technology effectively in their teaching (see Figure 1). More specifically,

> *"TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones"* (Koehler & Mishra, 2009, p.66).

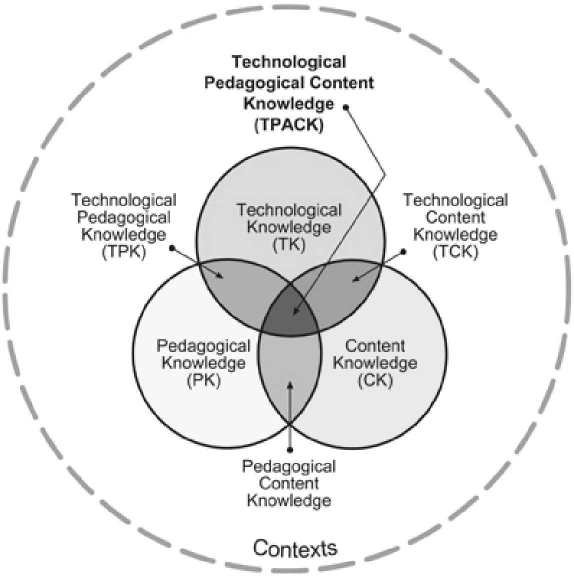

Figure 1. TPACK framework (Koehler & Mishra, 2009, p. 63)

As shown in Figure 1, the interactions among teacher's knowledge of content, pedagogy, and technology results in other knowledge bases in addition to TPACK and PCK: technological pedagogical knowledge (TPK) and technological content knowledge (TCK). These constructs of TPACK were defined by Mishra and Koehler and many other educational researchers after Mishra and Koehler introduced their TPACK framework (Chai, Koh, & Tsai, 2010; Chai, Koh, Tsai, & Tan, 2011; Cox, 2008; Jaipal & Figg, 2010; Koehler & Mishra, 2008; Koehler, Mishra, & Yahya, 2007). However, as Cox and Graham (2009) argue, the TPACK framework is not yet fully built, as the constructs (e.g., TCK, TPK) are not explicitly defined and the boundaries among those constructs are still fuzzy. In their conceptual analysis of the TPACK framework, Cox and Graham provide clear definitions of TPACK constructs and propose an elaborated TPACK model which builds on Mishra and Koehler's TPACK framework and Magnusson, Krajcik and Borko's (1999) PCK model. Cox and Graham (2009) argue that TPACK is a combination of CK, PK, and TK, and it also includes knowledge of subject-specific instructional strategies and topic-specific instructional strategies, which consist of topic-specific activities and topic-specific representations.

While Cox and Graham's (2009) TPACK framework provides definitions and distinctions of the TPACK constructs, there is still the need for a more clear definition of TPACK in the TPACK framework. The provided definitions are helpful for researchers who study each TPACK construct individually and then attempt to make a conclusion about a teacher's TPACK through combining the findings. This approach refers to the integrative model in Gess-Newsome's (1999) continuum model for PCK. According to Gess-Newsome, there are two ends of the continuum. There is the integrative model at one end, which suggests that PCK is a combination of CK and PK and these two knowledge bases remain distinct constructs even when they form PCK. At the other end of PCK is the transformative model in which CK and PK form PCK; however, they do not remain distinct knowledge bases when they uniquely form PCK. Thus, for the researchers who study TPACK using Gess-Newsome's transformative approach, the transformative model of TPACK, which suggests that TK, CK, and PK cannot be separated when they form TPACK, Cox and Graham's definition of TPACK in the TPACK framework is limited.

Building upon Gess- Newsome's (1999) transformative approach and Magnusson et al.'s (1999) model of PCK, we can further develop the TPACK construct in Cox and Graham's elaborated TPACK framework. According to Magnusson et al., there are five components of PCK: (a) orientation toward science teaching; (b) knowledge and beliefs about science curriculum; (c) knowledge and beliefs about student's understanding of specific science topics; (d) knowledge and beliefs about assessment in science; and (e) knowledge and beliefs about instructional strategies for teaching science. These PCK components can be used to fully define TPACK because PCK transforms into TPACK through the use of appropriate technologies:

Orientations (e.g., discovery, inquiry, didactic) Toward Science Teaching with Technology: Knowledge and beliefs about the purposes of teaching science with technology.

Knowledge of Science Curricula: Knowledge with regards to the goals and objectives for teaching a specific subject and knowledge about the programs and materials, including the educational technology tools to teach a specific subject.

Knowledge of Student's Understanding of Science: Knowledge about variations in student learning, prior knowledge, misconceptions, and topics that are difficult for students to learn, and technology tools that may represent those.

Knowledge of Assessment: Knowledge about student learning that needs to be assessed and methods to assess specific aspects of student learning using technologies.

K*nowledge of Instructional Strategies*: Knowledge of subject-specific and topic-specific strategies (activities and representations) that include educational technologies.

It is important to note that all types of teacher knowledge, including TPACK, are influenced by contextual factors, such as culture, socioeconomic status, and school organizational structures (Harris & Hofer, 2011). While studying a teacher's TPACK trajectory, researchers should consider school philosophy and expectations, demographic characteristics of students and teachers. Moreover, there are other components of contextual factors need to be considered which are cognitive, experimental, physical, psychological, and social characteristics of students and teachers, and physical features of the classroom (Kelly, 2008).

Method

Research Design

A mixed-methods exploratory sequential design was used to develop and test the reliability and validity of Technological Pedagogical Content Knowledge Self-Efficacy Scale (TPACK-SeS) (Creswell, 2012). Based upon this strategy, qualitative methods (open-ended interviews and expert views) were first used to generate an item pool. Then, subsequently quantitative methods (factor analysis, reliability, and item analysis) were used to evaluate the construct validity and reliability of TPACK-SeS.

Scale Development

To develop a reliable and valid instrument, DeVellis's (2003) eight-step guidelines for scale development were followed. These steps are (1) determine clearly what it is you want to measure, (2) generate an item pool, (3) determine the format for measurement, (4) have a completed initial item pool reviewed by experts, (5) consider the inclusion of validation items, (6) administer items to a development sample, (7) evaluate the items, and (8) optimize scale length (DeVellis, 2003, p.60).

Step 1: Determine the Construct Focused for Measurement. According to DeVellis's (2003) standard scale development procedures, the first step is to identify the construct to be measured and then to establish definitions of the construct. Furthermore, this phase includes defining the target group for which the instrument is being developed. In TPACK-SeS development, this phase includes a comprehensive literature review on PCK and TPACK. As noted earlier, Magnusson et al.'s (1999) conceptualization of PCK and Mishra and Koehler's (2006) TPACK model were adapted as a theoretical framework. The definitions were developed based on the selected frameworks (definitions can be found in the literature review section of the paper.). The review of the previous instruments (Archambault & Crippen, 2009; Graham et al., 2009; Kabakci- Yurdakul et al., 2012; Koehler & Mishra, 2005; Koh et al., 2010; Kuşkaya-Mumucu & Koçak-Usluel, 2010; MaKinster, Boone & Trautmann, 2010; Sahin, 2011; Schmidt et al., 2009) that were developed to assess science teacher's TPACK showed the need to develop a scale for pre-service science teachers. Thus, the target group for the scale was determined to be pre-service science teachers.

Step 2: Generate an Item Pool. Writing items is often the most difficult part of the scale development process (DeVellis, 2003). An initial pool of 84 items was generated based on the theoretical framework of TPACK and 32 open-ended interviews of pre-service science teachers. Furthermore, in this phase, five to fourteen items in each subscale of TPACK-SeS were identified, and four control items that have similar meanings as the real items were created.

Step 3: Determine the Format for Measurement. Selecting a response format is another critical step of the scale development (DeVellis, 2003). A 0-100 response format was used because it is a generally accepted format for evaluating self-efficacy since it increases the sensitivity and reliability of the instrument (Bandura, 2006). Bandura suggests using a 100-point rating scale ranging from 0 (can not do at all) to 100 (highly certain can do) divide in 10 unit intervals. Furthermore, Kan (2009) and Pajares, Hartley and Valiante (2001) emphasize that scales with a 0-100 response format were psychometrically stronger than a traditional likert format.

Step 4: Seek the Opinions of Experts to Review the Initial Item Pool. Obtaining content validation is also an important part in the scale development process (DeVellis, 2003). The items in the initial TPACK-SeS pool were assessed for content validity by 14 experts. Experts reviewed the content validity of the scale and the clarity and conciseness of each item using a 3-point likert scale: (0: absolutely inappropriate, 1: slightly appropriate, 2: absolutely appropriate). Of the opinions of the 14 experts, three of them have expertise in learning technologies, four are specialists in measurement and evaluation, two are faculty in a Turkish language department, and five are experts in science education. Based on expert's comments and feedback, revisions were made.

Step 5: Consider the Inclusion of Validation Items. According to DeVellis (2003), it is necessary to determine the validity of the scale several additional items to be included in the instrument. Two types of items can be added. The first type of item aims to find if the study participant try to represent themselves in a way that "society regards as positive" (p. 87). The second type of item to consider adding to the instrument are relevant constructs. At this step of the TPACK-SeS development, in addition to including construct related items (e.g., PCK), four control items that have the same meanings as the real items are used to measure whether participants read and answer them properly.

Step 6: Administer Items to a Development Sample. After determining the items in the scale, the scale should be administered to a large sample of subjects (DeVellis, 2003). The final version of TPACK-SeS scale was administered to 808 pre-service science teachers (64.6% female; 35.4% male) during the fall semester of the 2010-2011 academic year. Participants were chosen from teacher education departments across 17 universities that were randomly chosen from the following six regions in Turkey: Aegean, Black Sea, Central Anatolia, Eastern Anatolia, Marmara, and Mediterranean. TPACK-SeS was sent to science methods course instructors via mail. Course instructors then asked pre-service science teachers to complete the survey in class.

Step 7 and Step 8: Evaluate the Items and Optimize Scale Length. After administering the scale to a large and representative sample, determining the nature of the latent variables, which underlies a set of items and measures internal consistency reliability, is an important step in the scale development process. The results of factor analysis and reliability coefficient analysis are used to determine the optimal length of the scale (DeVellis, 2003). In this study, in order to conduct factor analysis, the data was split into the two random subsamples. Exploratory Factor Analysis (EFA) was conducted using one subsample (n = 420). which is the minimum ratio recommended by Gorsuch (1983) of 5:1, and Confirmatory Factor Analysis (CFA) was conducted on the second subsample (*n* = 388). According to Worthington and Whittaker (2006), sample sizes of at least 300 are generally sufficient in most cases. Descriptive statistics, reliability analysis, and EFA were conducted using the Statistical Package for the Social Sciences (SPSS) 11.5, and CFA were performed using LISREL 8.71 for Windows (Jöreskog & Sörbom, 2004). The following tests were used to determine the validity and reliability of the test items:

- *Kaiser-Meyer Olkin* (KMO) measure of sampling and *Bartlett's test of sphericity* were used to determine the appropriateness of an EFA,
- EFA was conducted to determine the factorial structure of the scale and to obtain the factor loading of each item,
- CFA was used to confirm the structure model obtained from the EFA analysis and cross-validation the TPACK-SeS in a different sample,
- Cronbach's alpha reliability coefficient was calculated to assess the internal consistency with both EFA and CFA samples ,
- The item-total correlation coefficient was calculated to obtain evidence for item validity with both EFA and CFA samples.

Results

Exploratory Factor Analysis (EFA) Results

EFA with an oblique rotation was used as a principal component method because relationships among factors were assumed (Worthington & Whittaker, 2006). The KMO measure of sampling was found to be .961 and Bartlett's test of sphericity was significant (χ^2 = 18628.597, df=1326, p<.000), and each indicates that the data used was appropriate for the EFA conducted. As Pallant (2001) and Buyukozturk (2007) suggest, in order to verify that the data is suitable for factor analysis, KMO should be larger than .60 and Bartlett's test should be significant.

To determine the scale items, items with a loading of less than .30 on all factors were deleted, and cross-loaded items with a factor loading difference of less than .15 from each other were eliminated and the analysis conducted again (Dilorio, 2005). Finally, a total of 52 items were retained for the eight-factor structure. The first factor (PCK) consists of 10 items, second factor (TK) includes 6 items, the third factor (CK) has 6 items, fourth factor (PK) consists of 8 items, the fifth factor (CxK) has 5 items, the sixth factor (TPK) includes 7 items, the seventh factor (TPACK) has 6 items, and the eighth factor (TCK) has 4 items. Table 1 below shows the factor loadings, cumulative percentages of variance, eigenvalues of the eight factors, and Cronbach's alpha coefficients. Furthermore, item total correlation coefficients ranged from .59 to .83.

Table 1

Final EFA Results (n=420)

		Factor Loadings							
	tem	PCK	TK	CK	PK	CxK	TPK	TPACK	TCK
Factor 1 PCK	37	.716							
	33	.676							
	34	.660							
	36	.658							
	35	.592							
	32	.529							
	31	.495							
	30	.463							
	38	.420							
	29	.385							
Factor 2 TK	46		.970						
	47		.900						
	45		.790						
	52		.769						
	43		.639						
	48		.613						
Factor 3 CK	18			.865					
	19			.862					
	17			.644					
	15			.557					
	16			.553					
	20			.507					
Factor 4 PK	2				.811				
	3				.754				
	8				.710				
	1				.709				
	10				.683				
	9				.663				
	7				.584				
	6				.368				
Factor 5 CxK	84					.906			
	82					.881			
	80					.778			
	81					.658			
	83					.597			

Table 1 continue

		Factor Loadings							
	tem	PCK	TK	CK	PK	CxK	TPK	TPACK	TCK
Factor 6 TPK	62						.584		
	67						.583		
	69						.529		
	63						.489		
	66						.461		
	61						.354		
	69						.328		
Factor 7 TPACK	75							.718	
	74							.615	
	76							.553	
	77							.396	
	72							.356	
	71							.328	
Factor 8 TCK	57								.742
	56								.657
	58								.595
	59								.514
Eigenvalues		24.512	3.387	1.875	1.544	1.462	1.220	1.157	1.097
%Variance		47.138	6.514	3.606	2.969	2.811	2.346	2.225	1.906
%Cumulative Variance		47.138	53.653	57.258	60.228	63.039	65.385	67.610	69.516
Cronbach's alpha coefficient (α)		.94	.92	.88	.91	.89	.93	.91	.84
Overall α= .98									

Confirmatory Factor Analysis (CFA) Results

EFA followed by a CFA was conducted on the 52 items of the TPACK-SeS, specifying the eight-factor structure derived through EFA. The maximum likelihood method was used to estimate the parameters of the model (Byrne, 1994). The model was tested in line with the results of fit statistics and modification indices. Modification indices provide an approximation of how much the Chi-square should decrease from the overall model when a fixed or constrained parameter is freely estimated (Brown, 2006). A high modification index between two items suggests the inclusion of a path between these two items should improve the overall fit of the model. Inclusion of the new path is reasonable not only statistically but also theoretically, following the premise that in order for a new path to be included in the model, it has to be meaningful within the theoretical framework (Pai et al., 2007).

Based on modification indices, an arrow was added between items 8 *(I can use a variety of instructional strategies effectively),* 9 *(I can use a variety of instructional methods effectively)*, 31 *(I can use a variety of instructional strategies to teach science),* 32 *(I can use a variety of instructional methods for specific science topics),* 33 *(I can address student's learning difficulties for specific science topics),* 34 *(I can address student's misconceptions about specific science topics)*, 37 *(I can determine what scientific concepts need to be assessed in a specific science topic)*, and 38 *(I can determine what skills need to be assessed for learning a specific science topic) the* on path diagram. The CFA was again performed and included these modifications in the model. According to the analysis, a set of goodness of fit indices were calculated to provide information on the adequacy of the fitted model (Sumer, 2000). These fit indices were Chi-square/Degrees of freedom (χ^2/df), Goodness of Fit Index (GFI), Comparative Fit Index (CFI), Non-Normed Fit Index (NNFI), Normed Fit Index, (NFI), Standardized Root Mean Square Residual (SRMR), and Root Mean Square Error of Approximation (RMSEA). The results (χ^2 =3781.07; p = .000, df=1242, χ^2/df=3.044), RMSEA=.073; SRMR=.055; CFI=.97; NNFI=.97; NFI=.96) show a good fit between the hypothesized model and the observed data. χ^2/df ratio of less than 2 shows a good fit (Kline, 1998, Segars & Grover, 1993), and values less than 5 show an acceptable level of fit (Sumer, 2000). According to Hoe (2008), RMSEA values less than .05 indicate good fit, values up to .08 indicate reasonable fit, and those between .08 and .10 indicate a mediocre fit. Bentler and Bonnett (1980) suggest that NFI and NNFI values greater than .90 are considered to reflect a good model fit. Bentler (1990) proposed that a CFI value is less affected by sample size and gives a more accurate estimate than NNFI (Hartwick & Barki, 1994). CFI also ranges from 0 to 1, with larger values indicating better fit. Again, CFI values higher than .95 indicate a better fit for the data and CFI values greater than .90 are agreed to be acceptable (Hu & Bentler, 1999; Schermelleh-Engel & Moosbrugger, 2003). As seen in Figure 2, the standardized path coefficients of eight factors ranging from .59 and .87 are all high and significant (p<.01).

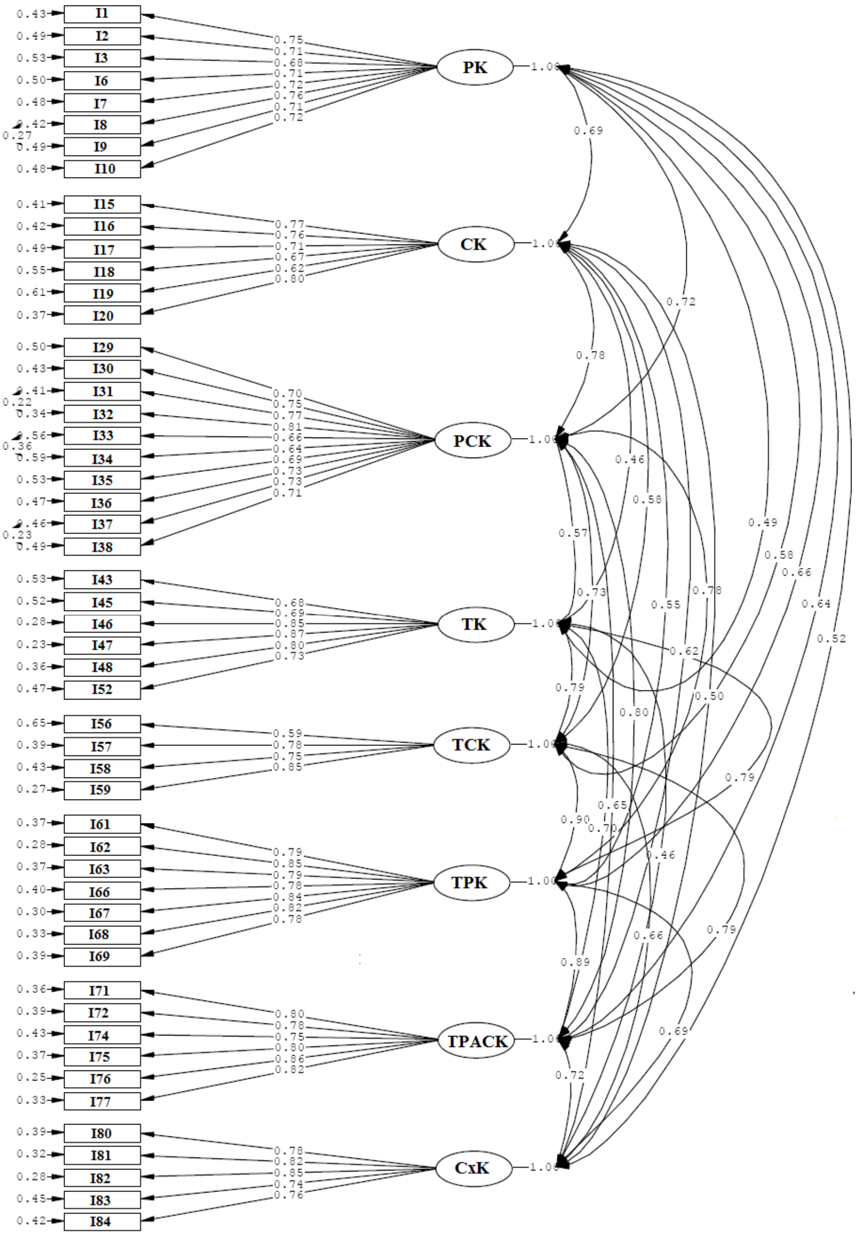

Figure 2. Results of the CFA: Structure coefficients for the TPACK-SeS (n=388)

The correlations among the eight subscales derived from the CFA model are positively significant. As seen in Table 2, the correlation between TPK -TCK (.90) was highest and TK-CK and CxK-TK were the lowest (.46).

Table 2

Correlation among the Eight Subscales

	PK	CK	PCK	TK	TCK	TPK	TPACK	CxK
PK	1.00							
CK	.69	1.00						
PCK	.72	.78	1.00					
TK	.49	.46	.57	1.00				
TCK	.58	.58	.73	.79	1.00			
TPK	.66	.55	.78	.79	.90	1.00		
TPACK	.64	.62	.80	.70	.79	.81	1.00	
CxK	.52	.50	.65	.46	.66	.69	.72	1.00

The correlation coefficients between .70 - 1.00 can be defined as having a strong relation, while those between .30 - .70 as having a moderate relation, and coefficients between .00 - .30 are defined as having a weak relation between the subscales (Buyukozturk, 2007). The Cronbach's alpha coefficient for internal consistency reliability for the whole scale was computed to be .98. The Cronbach's alpha coefficients computed for each subscale are .92, .90, .86, .89, .89, .93, .92, and .82, respectively. Furthermore, item total correlation coefficients ranged from .50 to .83. Pearson's correlation coefficient was calculated to determine correlation between the control and real items. As seen in Table 3, four pairs of items had a significant moderate correlation in two different samples.

Table 3

Pearson Correlation Coefficients between Control and Real Items

Items	r (n=420)	r (n=388)	p
Item 1 (I recognize individual differences in students) Item10 (I identify students' learning differences)	.643	.629	.000
Item 43 (I can explain the differences between hardware and software) Item 52 (I can explain the similarities between hardware and software)	.704	.701	.000
Item 71 (I can use technological tools to determine students' misconceptions about science) Item 77 (I can use technological tools to address students' misconceptions about science topics)	.634	.657	.000
Item 82 (I consider the community around the school in my teaching) Item 84 (I consider students' home environment in my teaching)	.750	.701	.000

Correlation is significant at the .01 level

Discussion and Conclusion

In this study, TPACK-SeS was developed and validated with 808 pre-service science teachers from teacher education programs across 17 different universities in Turkey. EFA and CFA were conducted in two different samples for cross-validation of the scale. EFA results indicated an eight-factor structure. Following EFA, CFA supported this eight factor structure and showed a good fit with high indices. The final version of the scale consists of 52 items and eight subscales: PCK (10 items), TK (6 items), CK (6 items), PK (8 items), CxK (5 items), TPK (7 items), TPACK (6 items), and TCK (4 items). Cronbach's alpha coefficient for internal consistency reliability of the subscales and whole scale were found to be high in both samples (Alpar, 2003). Item total correlation coefficients, which range from .50 to .83 in EFA and CFA samples, were found to be valid (Kan, 2009). Pearson's correlation coefficients were also significant between the control and real items (Buyukozturk, 2007).

The results of our study show that there is a high correlation between TPACK, TK, TCK, TPK, and PCK (see Table 2). Also, in several previous studies of TPACK, a strong correlation between TPACK and TCK, TPK, and PCK has been shown (Archambault & Crippin, 2009; Burgoyne, Graham & Sudweeks, 2010; Sahin, 2011). However, Schmidt et al. (2009) found a weak correlation between TPACK and TCK while showing a high correlation between TPACK and TPK. These mixed results are closely related to the TPACK models (transformative vs. integrative) used by the researchers to develop the existing surveys. While the integrative approach suggests that TPACK is a combination of different knowledge bases, the transformative model suggests that TPACK is formed uniquely by the constructs, which cannot be separated from it (Graham, 2011). In this study, we followed the transformative approach to construct the TPACK-SeS items. The reliability and validity analyses showed high correlations between TPACK and its constructs, which support TPACK as a distinct form of knowledge-transformative model. In addition, the high correlation between PCK and TPACK indicates that PCK is the backbone of TPACK, a finding that was supported by previous studies (Angeli &Valanides, 2008;Mishra & Koehler, 2006).

TPACK is identified as an ill-structured, complex, and messy concept (Koehler & Mishra, 2008; Mishra & Koehler, 2006; Wilson & Wright, 2010). There has not been a consensus among researchers regarding the constructs of the TPACK framework (Graham, 2011). We adapted Gess-Newsome's (1999) transformative approach and Magnusson et al.'s (1999) PCK model to explicitly define the elements of TPACK in our TPACK framework. The findings of this study also support the transformative TPACK framework,

TPACK-SeS is different from other previous TPACK instruments in several ways. First, as previously noted, the items were written following the transformative approach. Second, unlike many previous instruments (e.g. Mishra & Koehler, 2005), TPACK-SeS includes items to measure a teacher's CxK. According to Koehler and Mishra (2009), TPACK and its components are highly influenced by CxK. The high correlation between CxK and TPACK showed that the pre-service science teacher's beliefs about contextual factors, such as culture, demographic characteristics of students, and physical features of the classroom, affect how technology is integrating into the teaching and learning process (Jimoyiannis, 2010; Wilson & Wright, 2010). Finally, TPACK-SeS was developed to measure only pre-service science teacher's TPACK whereas a majority of the previous surveys target both pre-service and in-service teachers (e.g., Graham et al, 2009).

In conclusion, the findings of this study show that TPACK-SeS is a reliable and valid tool to measure pre-service science teacher's TPACK. The study sheds new light on the literature for TPACK, as well as technology integration. A well-developed TPACK is required for effective technology integration (Mishra & Koehler, 2006), and thus measuring teacher's TPACK is essential. Teachers and educators can use TPACK-SeS to measure pre-service teacher's TPACK and then design courses using the TPACK framework. Successful education reforms can take place if we can provide a variety of experiences for teachers to enhance their TPACK and establish self-efficacy beliefs in technology integration.

TPACK-SeS in this study was validated in a large group of pre-service science teachers. However, it is important to note that future research is necessary to investigate whether this instrument can be successfully used to measure science teacher's self efficacy towards TPACK. For the next step, we plan to administer the instrument to a large group of in-service science teachers in Turkey.

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Appendix:

TPACK-SeS

Please rate how certain you are that you can do each of the things described below by writing appropriate number. Rate your degree of confidence by recording a number from 0 to 100 using the scale given below.

0 10 20 30 40 50 60 70 80 90 100

Can not do at all ——— Moderately certain can do ——— Highly certain can do

		(0-100)
PK (8)	1. I recognize individual differences in students.	
PK	2. I can take steps to reduce the likelihood of disruptive student behavior in the classroom.	
PK	3. I can manage my classroom effectively.	
PK	4. I can prepare assessment tools for specific purposes.	
PK	5. I can score assessment tools for specific purposes.	
PK	6. I can use a variety of instructional strategies effectively.	
PK	7. I can use a variety of instructional methods effectively.	
PK (1)	8. I identify students’ learning differences.	
CK	9. I can explain various chemistry concepts.	
CK	10. I can explain various physics concepts.	
CK	11. I can explain various biology concepts.	
CK	12. I can explain various geology concepts.	
CK	13. I can explain various astronomy concepts.	
CK	14. When I teach a content area (e.g. biology, chemistry, physics), I can make appropriate connections to other content areas.	
PCK	15. I can teach science and technology courses according to theoretical framework of national curriculum.	
PCK	16. I can identify instructional objectives for each topic in science and technology curriculum at each grade level.	
PCK	17. I can use a variety of instructional strategies to teach science.	
PCK	18. I can use a variety of instructional methods for specific science topics.	
PCK	19. I can address students’ learning difficulties for specific science topics.	
PCK	20. I can address students’ misconceptions about specific science topics.	
PCK	21. I can provide opportunities for students to conduct research on science topics.	
PCK	22. I can choose appropriate assessment tools to evaluate students’ learning of science topics.	
PCK	23. I can determine what scientific concepts need to be assessed in a specific science topic.	
PCK	24. I can determine what skills need to be assessed for learning a specific science topic.	
TK (30)	25. I can explain the differences between hardware and software.	
TK	26. I can fix hardware problems.	
TK	27. I can install software.	
TK	28. I can use software.	
TK	29. I can choose appropriate technological tools.	
TK (25)	30. I can explain the similarities between hardware and software.	
TCK	31. I can prepare models that are used in science education with technological tools (animation and graphics software and etc.).	

0	10	20	30	40	50	60	70	80	90	100
Can not do at all					Moderately certain can do					Highly certain can do

TCK	32. I can utilize technological tools (e.g., pH meter, ammeter) to gather scientific data.	
TCK	33. I can use technological tools (e.g., spreadsheets, computer) to analyze scientific data.	
TCK	34. I can explain advantages of using technology in science education.	
TPK	35. I can determine technologies that are appropriate for students' grade level.	
TPK	36. I can explain how to use technologies in my lesson plan.	
TPK	37. I can explain how to manage a classroom that is equipped with technologies	
TPK	38. I can answer students' questions about the technology use in my classroom.	
TPK	39. I can utilize technological tools to make teaching processes more productive.	
TPK	40. I can explain how technology affects student learning.	
TPK	41. I can assess student learning in a technology-rich lesson.	
TPACK (47)	42. I can use technological tools to determine students' misconceptions about science.	
TPACK	43. I can use technological tools to assess student learning of science.	
TPACK	44. I can apply my technological knowledge, content knowledge, and pedagogical knowledge all together to create an effective learning environment.	
TPACK	45. I can develop quality lesson plans using my technological knowledge, content knowledge, and pedagogical knowledge together.	
TPACK	46. I can use technological tools to assess students' prior knowledge about science topics.	
TPACK (42)	47. I can use technological tools to address students' misconceptions about science topics.	
CxK	48. I consider students' socio-economic background, culture, and ethnicity when I teach science.	
CxK	49. I take the physical characteristics of my classroom into account in my teaching.	
CxK (52)	50. I consider the community around the school in my teaching.	
CxK	51. I assist my colleagues in blending technological knowledge, pedagogical knowledge, and content knowledge.	
CxK (50)	52. I consider students' home environment in my teaching.	

Fen Bilgisi Öğretmen Adayları için Teknolojik Pedagojik Alan Bilgisi Özyeterlik Ölçeği (TPAB-ÖyÖ): Geliştirilmesi, Geçerlik ve Güvenirlik Çalışmaları

Atıf:

Canbazoğlu Bilici, S., Yamak, H., Kavak, N., & Guzey, S.S. (YYYY). Technological pedagogical content knowledge self-efficacy scale (TPACK-SeS) for pre-service science teachers: Construction, validation and reliability. *Egitim Arastirmalari-Eurasian Journal of Educational Research, 52*, 37-60.

Özet

Problem Durumu: Bilgi çağı olarak adlandırılan 21. yüzyılın ilk yıllarında görülen gelişmeler sonucunda toplumlar, bilim ve teknoloji alanında hızlı bir değişim süreci içerisine girmiş ve teknolojik ürünler hayatımızın her alanında olduğu gibi eğitim alanında da yaygınlaşmaya başlamıştır. Bu doğrultuda tüm dünyada olduğu gibi ülkemizde de Temel Eğitim Projesi, Eğitimde Fırsatları Arttırma ve Teknolojiyi İyileştirme Hareketi Projesi vb. çalışmalar ile okullar teknolojik ürünler ile donatılmaktadır. Bu çalışmalarla okullar teknolojik açıdan gerekli fiziki mekân, araç-gereç, donanım ve yazılımlara sahip olsada, bu teknolojilerin öğretim sürecinde etkili kullanılmasında anahtar rolü olan öğretmenlerin teknolojiyi öğretim sürecine entegre edebilme bilgileri ya da başka bir ifade ile teknolojik pedagojik alan bilgisi (TPAB)ne sahip olmaları önem taşımaktadır. Öğretim ve öğrenim sürecinde teknolojiyi etkili kullanmanın temeli olan TPAB; öğrencilerin kavramları öğrenmesini nelerin kolaylaştırdığı ve zorlaştırdığı, öğrencilerin karşılaştığı bir takım problemleri çözmeye teknolojinin nasıl yardım ettiği, öğrencilerin ön bilgilerini teknolojinin nasıl yapılandırdığı veya güçlendirdiği gibi konularda bilgi sahibi olmayı gerektirmektedir. Öğretmenlerin TPAB'a sahip olmakla birlikte TPAB'a yönelik özyeterlik inançlarının da yüksek olması öğretim sürecinde teknoloji kullanımını arttıran bir faktördür. Geleceğin öğretmenleri olan Fen bilgisi öğretmen adaylarının TPAB'a yönelik özyeterlik düzeylerinin ölçülmesi, lisans eğitimi boyunca verilen derslerin TPAB'a yönelik özyeterlik düzeyine etkisinin belirlenmesi ve öğretmen adaylarının teknolojiyi kullanımlarını etkileyen faktörlerin tespit edilmesi açısından önem taşımaktadır.

Araştırmanın Amacı: Etkili teknoloji entegresyonu için öğretmen adaylarının TPAB'a yönelik özyeterlik düzeylerinin ölçülmesi gereksiniminden yola çıkarak bu çalışmada fen bilgisi öğretmen adaylarının TPAB'a yönelik özyeterlik inaçlarını belirlemeye yönelik geçerli ve güvenilir bir ölçeğin geliştirilmesi amaçlanmıştır.

Araştırmanın Yöntemi: Teknolojik pedagojik alan bilgisine yönelik öz-yeterlik ölçeği (TPAB-ÖyÖ)'nin geliştirilmesinde DeVellis (2003) tarafından önerilen ölçek geliştirme aşamaları takip edilmiştir. İlgili alanyazın ve 32 öğretmen adayının TPAB'ın alt boyutları ile ilişkili açık uçlu sorulara verdikleri yanıtlar doğrultusunda madde havuzu oluşturularak, uzman görüşü doğrultusunda ölçek maddelerine son hali verilmiştir. Araştırmada 84 maddeden oluşan 10'lu likert tipinde cevaplama formatındaki ölçeğin nihai formu, 2010 - 2011 eğitim-öğretim yılının güz döneminin başlangıcında altı coğrafi bölgede yer alan 17 farklı eğitim fakültesinin fen bilgisi öğretmenliği anabilim dalının son sınıfında öğrenim gören 808 öğretmen adayına

(%64.6 kız, % 35.4 erkek) uygulanmıştır. Ölçeğin yapı geçerliğine kanıt sağlamak amacıyla 420 öğretmen adayının yanıtlarından elde edilen veriler ile SPSS 11.5 paket programı kullanılarak Açımlayıcı Faktör Analizi (AFA), 388 öğretmen adayının yanıtlarından elde edilen veriler ile Lisrel 8.7 paket programı kullanılarak Doğrulayıcı Faktör Analizi (DFA) gerçekleştirilmiştir. Bu yolla AFA doğrultusunda ortaya çıkan madde-faktör bağıntılarının uygunluğu DFA yapılarak değerlendirilmiştir. Ölçek maddelerinin güvenirliğine kanıt sağlamak amacıyla madde test korelasyonları ve Cronbach alfa iç tutarlık katsayısı hesaplanmıştır.

Bulgular ve Sonuçlar: AFA yapılmadan önce verilerin faktör analizine uygunluğu Kaiser-Meyer-Olkin (KMO) ve Bartlett testiyle değerlendirilmiştir. 84 maddenin KMO değeri .961 ve Barlett testi anlamlı bulunmuştur (χ^2 = 18628.597, df=1326, p<.000). Ölçekteki maddelerden hangilerinin ölçekte kalacak nitelikte olduğunu belirlemek amacıyla temel bileşenler analizi ve oblimin döndürme tekniği kullanılmıştır. Analiz sonucunda, birinci faktörün (PAB) 10 maddeden, ikinci faktörün (TB) altı maddeden, üçüncü faktörün (AB) altı maddeden, dördüncü faktörün (PB) sekiz maddeden, beşinci faktörün (BB) beş maddeden, altıncı faktörün (TPB) yedi maddeden, yedinci faktörün (TPAB) altı maddeden ve sekizinci faktörün (TAB) dört maddeden oluştuğu belirlenmiştir. Belirlenen sekiz faktörlü yapının her birinin açıkladığı varyans değeri sırasıyla; %47.138, %6.514, %3.606, %2.969, %2.811, %2.346, %2.225 ve %1.906'dür. Bu sekiz faktörün açıkladığı toplam varyans değeri ise 69.516% olarak bulunmuştur. Faktörlerin her birinin özdeğeri sırasıyla 24.512, 3.387, 1.875, 1.544, 1.462, 1.220, 1.157 ve 1.097 olarak elde edilmiştir. TPABÖÖ'nün faktör yapısını belirlemek için yapılan AFA sonuçlarını DFA sonuçları desteklemiştir. DFA sonucunda ortaya çıkan uyum indeksi değerleri (χ^2/df=3.044; RMSEA=.073; SRMR=.055; CFI=.97; NNFI=.97; NFI=.96) ölçeğin geçerli bir yapıda olduğunu göstermektedir.

Ölçeğin güvenirlik çalışmaları AFA ve DFA'nın uygulandığı her iki örneklem grubu ile gerçekleştirilmiştir. Elde edilen puanlar incelendiğinde ölçeğin alt faktörlerinin ve tamamının güvenirlik katsayıları her iki örneklemde de yüksek bulunmuştur. Benzer şekilde madde toplam korelasyon katsayısı n=420 için .59-.83, n=388 için .50-.83 aralığında tespit edilmiştir. Güvenirlik analizlerinden elde edilen bu bulgular, TPAB-ÖyÖ'nün farklı örneklemler üzerinde de güvenilir bir veri toplama aracı olduğu göstermektedir. Ayrıca, ölçekte yer alan aynı özelliği ölçmeyi hedefleyen dört madde çiftinde maddeler arasındaki ilişkiyi belirlemek için Pearson korelâsyon katsayıları hesaplanmış ve maddeler arasında .634 ile .750 arasında değişen, yüksek düzeyde, pozitif ve anlamlı bir ilişki olduğu bulunmuştur

Öneriler: Bu çalışmada elde edilen analiz sonuçları doğrultusunda 10'lu likert türünde 52 maddeden oluşan TPAB-ÖyÖ'nün fen bilgisi öğretmen adaylarının TPAB'a yönelik özyeterlik inançlarını değerlendirmek için hem eğitimciler hem de araştırmacılar tarafından kullanılabilecek geçerli ve güvenilir bir araç olduğunu göstermektedir. Araştırmada TPAB-ÖyÖ'nün geçerlik ve güvenirlik çalışmaları fen bilgisi öğretmen adayları ile gerçekleştirilmiştir. Fen bilgisi öğretmenlerinin de TPAB'a yönelik öz-yeterlik düzeylerinin ölçülmesine duyulan ihtiyaçtan yola çıkarak, TPAB-ÖyÖ'nün geçerlik ve güvenirlik çalışmaları fen bilgisi öğretmenleri ile de gerçekleştirilebilir.

Anahtar Kelimeler: Öğretmen eğitimi, teknolojik pedagojik alan bilgisi, fen bilgisi öğretmen adayları, ölçek geliştirme