Elementary Education Online, 2017; 16(3): 917-934
İlköğretim Online, 16(3), 917-934, 2017. [Online]:http://ilkogretim-online.org.tr
DOI: 10.17051/ilkonline.2017.330232

A Closer Examination of TPACK-Self-efficacy Construct: Modeling Elementary Pre-service Science Teachers' TPACK-Self efficacy[1]

Teknolojik Pedagojik Alan Bilgisi (TPAB)- Öz yeterlik Kavramının Yakından İncelenmesi: İlköğretim Fen Bilgisi Öğretmen Adaylarının TPAB-Öz yeterliğinin Modellemesi

Sevgi Aydın-Günbatar, *Yuzuncu Yil University*, sevgi.aydin45@hotmail.com
Yezdan Boz, *Middle East Technical University*, yezdan@metu.edu.tr
Sevda Yerdelen-Damar, *Yuzuncu Yil University*, syerdelen@gmail.com

ABSTRACT. TPACK (Technological pedagogical content knowledge) is a useful framework for integrating technology into teaching for meaningful understanding. Since its introduction by Mishra and Kohler in 2006, there is no consensus in the results of the studies examining structure of TPACK. Recently, some studies have focused on TPACK self-efficacy (TPACK-SE) beliefs. We aimed to validate factor structure of TPACK-SE and reveal the relations among the components. A structural equation model (SEM) formed in light of TPACK- SE literature was tested with LISREL 8.8. The participants were 665 senior elementary pre-service science teachers (467 Females, 198 Males) from 7 colleges in Turkey. The model had acceptable fit. In the model, in light of the literature, direct relations of core components (e.g., PK, CK, and TK) to TPACK-SE were not proposed. Instead, indirect relations through interaction components (e.g., PCK) were hypothesized. All hypothesized relations got significant path coefficients. Second, indirect relations of CK, TK, and PK were also significant. Regarding the amount of explained variances on all dependent constructs (R2), CK, PK, TK, PCK, TCK and TPK explained 87% of the variance of TPACK-SE. Implications for technology integration in science teacher education were proposed.
Keywords: TPACK- SE, Structural Equational Modeling, Pre-service Science Teachers

ÖZ. Teknolojik pedagojik alan bilgisi (TPAB) anlamlı öğrenmenin gerçekleşmesi için teknolojinin öğretime entegrasyonunu sağlamada kullanılan yararlı bir teorik çerçevedir. Mishra ve Kohler'in 2006 yılında TPAB kavramını alan yazına tanıtmasından bu yana TPAB'ın yapısını konu alan çalışmalar yapılmıştır. Diğer taraftan, bu çalışmalarda, TPAB'ın yapısı ile ilgili ortak görüşe tam olarak varılmamıştır. Son dönemde TPAB- öz yeterliği (TPAB-Ö) alan yazında incelenmektedir. Bu çalışma TPAB-Ö' nün faktör yapısının geçerliliğini araştırmak ve bileşenlerinin birbirleriyle olan ilişkilerini ortaya koymak amacıyla yapılmıştır. Çalışmada, LISREL 8.8. paket programı ile, TPAB alan yazına bağlı olarak oluşturulan Yapısal Eşitlik Modeli (YEM) test edilmiştir. Yedi farklı üniversitenin Eğitim Fakülteleri'nde öğrenim görmekte olan 665 son sınıf Fen Bilgisi öğretmen adayı (467 bayan, 198 bay) çalışmaya katılmıştır. Önerilen model, YEM sonuçlarına göre verilere iyi bir uyum göstermiştir. TPAB alan yazını ışığında oluşturulan modelde, temel bileşenlerin (pedagoji bilgisi (PB), teknoloji bilgisi (TB), vb.) TPAB-Ö'a doğrudan katkısına yer verilmemiştir. Aksine, modelde bu bileşenlerin TPAB-Ö' ye dolaylı katkılarının, ikincil bileşenler (örneğin pedagojik alan bilgisi (PAB), vb.) üzerinden olduğu ortaya konulmuştur. Modellemede ortaya atılan tüm ilişki hipotezleri istatistiksel olarak anlamlı bulunmuştur. İkinci olarak; TB, PB, ve alan bilgisinin (AB) dolaylı katkılarının da anlamlı olduğu görülmüştür. Tüm bağımlı değişkenlerin TPAB öz yeterliğinde açıklayabildiği varyans (R2)(PB, AB, TB, PAB, vb.) %87'dir. Fen öğretmen eğitimine teknolojinin nasıl entegre edilmesi noktasında öneriler sunulmuştur.
Anahtar Kelimeler: TPAB Öz yeterlik İnancı, Yapısal Eşitlik Modeli, Fen Öğretmen Adayları

[1] An earlier version of this paper was presented at the NARST-2015 held in Chicago, IL, US.

Geliş tarihi: 29/06/2016, Kabul tarihi: 23/03/2017, Yayımlanma tarihi: 01/07/2017

INTRODUCTION

We live in the technological age; therefore, technology has become essential part of our life. This also influenced the role of technology in education. Technology has been integrated in the curriculum and instruction (e.g., National Research Council, 2012; National Ministry of Education, 2012). Since teachers have a crucial role in the implementation of technology in classrooms, they need to be given necessary skills and knowledge required for the effective integration of technology by teacher educators (Niess, 2011). Additionally, their self-efficacy beliefs about technology integration into their teaching play crucial role in their integration (Abbitt, 2011) . TPACK (Technological pedagogical content knowledge) framework has been suggested by Mishra and Koehler (2006) for the effective integration of technology into instruction. According to this framework, effective teaching with technology requires content knowledge, pedagogical knowledge, technology knowledge as well as the interplay between and among these three knowledge types (Mishra & Koehler, 2006; Koehler & Mishra, 2009). However, both the factor structure of TPACK and the relationships among these knowledge types have not fully been confirmed by research studies (Chai, Koh, & Tsai, 2013a). Moreover, self-efficacy beliefs, described as one's perceptions of their own competence, are another important concept. Since pre-service teachers' self-efficacy beliefs of TPACK influence their technology integration and considering the fact that TPACK being suggested as a potentially worthwhile framework for teacher education programs, it is important to validate the factor structure and understand the interrelationships among knowledge types of TPACK self-efficacy (TPACK-SE), which constitute TPACK-SE. Therefore, research questions guiding this study are:

1. What is the factorial structure of TPACK-SE?
2. What are the interrelationships among knowledge types of TPACK-SE?

In the present study, we aimed to find answers to these questions whose answers will be useful for teacher education programs regarding how to design technology-integrated courses.

Theoretical Framework

In this part, literature review on characteristics of the TPACK framework, factorial structure of TPACK, interrelationships among knowledge types of TPACK, and self-efficacy beliefs will be described, respectively.

TPACK Framework

Technological pedagogical content knowledge (TPACK) framework, based on Shulman's (1986) pedagogical content knowledge, was suggested by Mishra and Koehler (2006) for effective use of technology in instruction. TPACK framework has gained much attention in recent years, and many teacher education and professional development programs have considered this framework to enhance teachers' knowledge about technology integration (Chai, Koh & Tsai, 2010; Niess, 2005; Niess, Suharwoto, Lee & Sadri, 2006).

TPACK framework involves technology, pedagogy, and content knowledge as well as the interaction between/among these three components (Koehler & Mishra, 2009; Mishra & Koehler, 2006) (Figure 1).

Koehler and Mishra (2009) stated that "at the heart of good teaching with technology are three core components: content, pedagogy, and technology, plus the relationships among and between them." (p.62). Seven knowledge types; technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK) are included in the model. Table 1 summarizes the necessary details about the seven components.

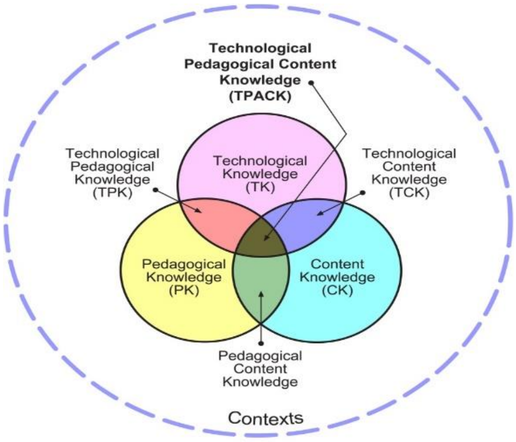

Figure 1. *TPACK model proposed by Koehler & Mishra (2009) (p.63)*

Table 1. *Seven knowledge types in the TPACK literature*

Component	Description	Example
Technology knowledge (TK)	Knowledge about both low technological tools (e.g., blackboard, pencil etc.) and advanced technology (e.g., Internet, spreadsheets) (Mishra & Koehler, 2006)	Having the skills and knowledge necessary for installing and uninstalling programs, using word processors, Internet can be given as examples of TK
Content knowledge (CK)	Knowledge of concepts, facts, theories required for a specific field as well as methods necessary to develop this knowledge are involved in the CK	Knowing about the behavior of the particles' collisions and the relations among pressure, mole, volume, and temperature of the gases
Pedagogical knowledge (PK)	General knowledge about how students learn, teaching methods and strategies that can be applied in the instruction, classroom management, and assessment and evaluation strategies	Knowing that teachers should wait for a while after asking questions to let students think about the questions asked
Pedagogical content knowledge (PCK)	"[T]he special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (Shulman, 1987, p.8)	Using high hill analogy to teach the activation energy topic in reaction rate unit that has an abstract nature is an example of PCK
Technological content knowledge (TCK)	"Teachers need to understand which specific technologies are best suited for addressing subject-matter learning in their domains and how the content dictates or perhaps even changes the technology—or vice versa." (Koehler & Mishra, 2009, p.65)	Knowing the existence of simulations and animations for visualizing and examining the particulate nature of matter and knowing how to use them (i.e., independent from pedagogy and/or teaching)
Technological pedagogical knowledge (TPK)	Knowledge about the use of various technological tools in instruction without considering the specific content	The use of smart boards in instruction and use of Excel to keep attendance of students can be considered as TPK (i.e., independent from content area) (Koehler & Mishra, 2009)
Technological pedagogical content knowledge (TPACK)	"an understanding that emerges from interactions among content, pedagogy, and technology knowledge" (Koehler & Mishra, 2009, p. 66)	Using online timeline called *Dipity* to help students to learn history of Atomic Models and the contribution of the different scholars (e.g., Dalton, Thomson, Rutherford, Bohr, etc.)

Self-efficacy beliefs

Another important construct in the educational research is the self-efficacy beliefs. Self-efficacy is described as 'people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances' (Bandura 1986, p.391). Tschannen-Moren, Hoy, and Hoy (1998) state the importance of teacher efficacy beliefs on their behavior and choice. Teachers with high self-efficacy beliefs are more enthusiastic to teach and they put more effort into their teaching and they are more willing to experiment new teaching methods. On the other hand, teachers with low self-efficacy beliefs tend be more anxious about their instruction and they do not put much effort and easily give up when they encounter with obstacles (Schunk, 1981; Schunk, Hanson, & Cox, 1987).

Similarly, research studies showed that teachers' self-efficacy beliefs regarding technology will have an influence on their technology integration (Albion, 1999; Compeau & Higgins, 1995; Teo, 2009). If teachers have more self-efficacy beliefs about technology, they are more willing to integrate technology into their instruction and they can integrate technology into their instruction effectively (Compeau & Higgins, 1995).

With regard to the relationship between TPACK-SE beliefs and their technology integration, Lee and Tsai (2010 stated that if teachers have more self-efficacy beliefs with respect to their TPACK, they tend to integrate technology into their instruction effectively. Therefore, it is important to reveal pre-service/in-service teachers' self-efficacy beliefs about TPACK. As mentioned above, many research studies were conducted about the factorial structure of TPACK (see Table 2) and interrelationships among knowledge types of TPACK (please see the "Interrelationships among knowledge types of TPACK" section), and these studies reported different findings regarding both the factorial structure of TPACK as well as the interrelationships among knowledge types of TPACK. Therefore, no consensus was reached with respect to these issues. Technological pedagogical content knowledge self-efficacy questionnaire is relatively new; it was developed by Canbazoğlu-Bilici, Yamak, Kavak, and Guzey (2013). Canbazoğlu-Bilici et al (2013) validated the seven factorial structure of TPACK-SE. Similarly, Kiray (2016) developed another TPACK-SE scale for pre-service science teachers. Kiray (2016) also validated the seven factorial structures. However, there are not many research studies exploring the factorial structure and interrelationships among knowledge types of TPACK-SE. Since there has not been any consensus about the knowledge types and the interrelationships among these knowledge types constituting the TPACK framework, and similarly, since TPACK-SE is based on TPACK framework, similar issues as knowledge types and the interrelationships among these knowledge making up TPACK-SE would be unclear as well. Hence, we adopted the same strategy as Bilici Canbazoğlu-Bilici and her colleagues (2013) did. We also used a hybrid TPACK-SE model in which TPACK-SE was the only component of the model with a different name from the original TPACK model. The aims of our study are to explore the factorial structure of TPACK-SE and interrelationships among knowledge types of TPACK-SE.

Factorial structure of TPACK

Based on the TPACK framework, instruments have been developed to measure teachers' perceptions of their TPACK. One of the instruments used by researchers is developed by Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009). Schmidt and her colleagues applied this instrument to pre-service elementary and early childhood teachers in the USA. The CK covered in the instrument was math, science, social studies, and literacy. Reliability analysis showed that the instrument was reliable. They also validated the factor structure as distinct seven knowledge types as hypothesized in the TPACK framework (See Table 2). Seven-factor structure of TPACK framework has been validated in some other studies (e.g., Lin, Tsai, Chai & Lee, 2013; Chai, Ng, Li, Hong & Koh, 2013b), however, there were contradicting results regarding the factorial structure in the literature. For example, by using the adapted version of Schmidt et al.'s (2009) instrument, Koh, Chai and Tsai (2010) portrayed TPACK of Singaporean pre-service chemistry teachers. Instead of hypothesized seven distinct knowledge types, they received five factors, which were named as "technological knowledge, content knowledge, knowledge of pedagogy, knowledge of teaching with technology and knowledge from critical reflection" (p. 563). TK and CK appeared as two distinct knowledge types. PK and PCK made up the third factor, named as "knowledge of pedagogy." The fourth factor, "knowledge of teaching with technology" involved both TPK, TCK and TPACK while two of the TPK items formed the fifth factor that is "knowledge from critical reflection".

As seen from Table 2, by using the instrument developed by Archambault and Crippen (2009), Archambault and Barnett (2010) surveyed teachers' TPACK regarding online teaching in the USA. Instead of the hypothesized seven-factor structure, they found three factors that they named as "pedagogical content knowledge", "technological-curricular content knowledge", and "technological knowledge" (p. 1658). For the "pedagogical content knowledge" factor, items related to content, pedagogy and pedagogical content knowledge items loaded together. TCK, TPK and TPACK items made up the second factor "technological-curricular content knowledge". Only technological items loaded as distinct knowledge type making the technological knowledge factor.

In another study, Chai, Koh, Tsai, and Tan (2011) made adaptations of Schmidt et al.'s (2009) instrument. For example, instead of the PK items proposed by Schmidt and her colleagues, Chai et al. (2011) put items related to "pedagogical knowledge for meaningful learning". They distributed the instrument to measure TPACK of primary school pre-service teachers in Singapore. Factor analysis showed the five-factorial structure; PK, CK, TK, TPK, and TPACK (see Table 2). TPACK factor included five TPACK items and one TCK item. However, TCK and PCK did not load as two distinct knowledge types in the study of Chai et al. (2011). Similarly, Ovez and Akyüz (2013) reported the problems in validating the seven-factor structure of the Schmidt et al (2009) instrument, and received four-factor structure. CK and TK appeared as two distinct knowledge types, whereas items related to PK and PCK loaded together as one factor and TPK, TCK, and TPACK items made up the fourth factor. Based on the research studies explained above, despite TPACK being suggested as a fruitful framework for integration of technology into instruction (Mishra & Koehler, 2006), still factor structure of TPACK has not been explained (Chai, et al., 2011; Koh, et al., 2010; Archambault & Barnett, 2010; Ovez & Akyüz, 2013). Unclear boundaries among knowledge types within the TPACK framework as Cox and Graham (2009) mentioned, may have an influence on not being able to validate the seven distinct knowledge types as hypothesized in the framework. Another issue that is not clear in the literature is the contribution of knowledge components, CK, TK, PK, PCK, TCK, and TPK to TPACK.

All of the studies and their results summarized above were presented in the summary Table 2.

Interrelationships among knowledge types of TPACK

Koehler, Mishra, and Yahya (2007) stated, "good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context-specific, strategies and representations" (p. 741). However, in the related literature, few studies investigated the interrelationships among knowledge types and there are contradicting results about how six knowledge types, CK, TK, PK, PCK, TCK and TPK contribute to TPACK.

Table 2. *Research studies focusing on modeling teachers' TPACK*

Study	Participants	Instrument used	Factors identified
Schmidt,, Baran, Thompson, Mishra, Koehler & Shin (2009)	124 Pre-service teachers in the USA	Developed a new questionnaire with 47 items; Survey of Preservice Teachers' Knowledge of Teaching and Technology	Identified 7 factors (the content related items are for science, math, and literacy)
Koh, Chai, & Tsai, (2010)	Pre-service teachers in Singapore	Adapted version of Schmidt et al. (2009)	5 factors: • CK, TK, • TPK, TCK, and TPACK loaded as one factor • PK and PCK loaded together • Factor related to teacher reflection (2 items)
Archambault & Barnett (2010)	K-12 teachers in the USA	Web-based survey developed by Archambault and Crippen (2009)	3 factors: • TK, • PCK (CK, PK, and PCK items loaded as one factor labeled as PCK • TPK, TCK, and TPACK was named as 'technological curricular content knowledge'
Lee & Tsai (2010)	558 Taiwanese elementary and high school teachers	30-item TPCK-Web Survey	• Received 5 factors: TK, TCK, TPK, TPACK, and attitudes toward web-based instruction • TPK and TCK loaded as one factor
Chai, Koh, Tsai, & Tan (2011)	834 Pre-service teachers from Singapore	Modified version of Schmidt et al. (2009)	• Identified 5 factors, namely, TK, PK, CK, TPK, and TPACK
Chai, Ng, Li, Hong, & Koh (2013)	Pre-service teachers from China, Hong Kong, Singapore, and Taiwan	Adapted version of the instruments used in Chai et al. (2011)	• Identified 7 factors
Ovez & Akyuz (2013)	473 Elementary mathematics pre-service teachers in Turkey	Adapted version of Schmidt et al. (2009)	Identified 4 factors: • CK for Mathematics, • TK, • PK and PCK loaded together and named as Teaching Mathematics knowledge • TCK, TPK and TPACK loaded in one factor named as TPACK for mathematics teaching

Koehler et al. (2007), who investigated the development of master's students TPACK during the design seminar where faculty members and master students worked together to design online courses, stated that students firstly developed CK, PK and TK before making connections between/among them. Chai, et al., (2010) assessed pre-service teachers' perceptions of their TK, CK, PK and TPACK before and after ICT course. Regression analysis revealed that all three knowledge components, TK, CK and PK contributed to TPACK, PK having the largest contribution both before and after the course. Similarly, Canbazoğlu-Bilici, Bulut, Guzey, Demirelli, and Kavak (2013) stated that TK, PK, and CK were related to TPACK, and PK and CK were strongly related with TPACK compared to the relationship of TK and TPACK. TPK was found to be highly correlated with TPACK while TCK had the non-significant weakest correlation with TPACK. High correlation between TPK and TPACK was also reported by Schmidt et al. (2009).

In another research, Chai, et al. (2011) tested the relationships among knowledge components of pre-service primary school teachers for both pre and post Information and Communication Technologies (ICT) course. For the pre-course, there was not a significant link between CK and TPACK, however there was a direct relationship between TK and TPACK as well as an indirect relationship between TK and TPACK (through TPK) existed. Similarly, there was a direct and indirect relationship (through TPK) between PK and TPACK. After the course the relationship between CK and TPACK turned to be significant. The direct link between PK and TPACK became insignificant, however, there was an indirect relationship between PK and TPACK where TPK acted as the mediator. As in the pre-course, there was a direct relationship between TK and TPACK and an indirect relationship between TK and TPACK (through TPK) after ICT course. Both before and after the course, the strongest relationships existed between PK-TPK and TPK-TPACK.

Yet another research conducted with pre-service teachers, Chai, et al., (2013b) found that TK, CK, and PK did not have direct relationships with TPACK while there was an indirect relationship between TK and TPACK (through both TCK and TPK). TCK served as the mediator for the relationship between CK and TPACK. CK was not significantly related to PCK. The indirect relationship between PK and TPACK occurred through TPK and PCK. Between the second layer knowledge types, TCK and TPK contributed more to TPACK compared to PCK. On the other hand, Koh, et al., (2013) reported direct relationships of TK and PK with TPACK of practicing teachers. CK contributed to TPACK indirectly through TCK. Moreover, TCK and TPK were directly related to TPACK. TCK had more contribution, while PCK did not contribute to TPACK. However, PCK as the "backbone of [TPACK]" was put forward by Angeli and Valanides (2008, p.15).

Significance of the Study

As stated in the literature review part, the factorial structure of the TPACK-SE and how both basic knowledge types (i.e., CK, PK, and TK), and second layer knowledge types (i.e., TPK, TCK, and PCK) contribute to TPACK-SE are not clear yet. As Hechter, Phyfe and Vermette (2012) state, future research should involve how pre-service teachers develop an understanding of the nature of interconnected relations among discrete knowledge bases. . Considering the importance of teachers' self-efficacy beliefs on their instructional decisions, the present study aims to contribute to the literature by both validating the factor structure of TPACK-SE?, and revealing the interrelationships among components of TPACK-SE? To conclude, "the relationships among the knowledge factors according to the framework has not been fully tested with structural equation modeling for all the seven factors among preservice teachers" (Chai, et al., 2013a, p.44). The validation of the construct is vital because it is a fruitful framework for enlightening the teacher education programs and teacher educators about how to integrate technology into teacher education to train better teachers who are more able to use technology to teach science. Literature has clearly shown that integrating technology into teaching is a demanding task (Kramarski & Michalsky, 2010). Since TPACK-SE is an essential factor determining teachers' integration of technology into their science teaching, we think that this study would be the useful one for clearing the TPACK-SE construct and its factor structure. Rather than focusing only on knowledge, paying attention to beliefs would promise valuable results for teachers' technology integration literature. In light of all those points, we think that this study will contribute to the literature regarding the structure of TPACK-SE that has a potential to be a north star about developing technology related and integrated courses in teacher education programs, and use of technology for science teaching (Polly, Mims, Shepherd, & Inan, 2010). With the better understanding of the TPACK-SE construct, teacher education programs will have a better visualization of TPACK-SE and how to use it in designing technology integrated courses.

METHODOLOGY

Type of the Study

This study is quantitative in nature. In this research, a structural equation model (SEM) constructed based on TPACK-SE literature was tested with LISREL 8.8. SEM is a multivariate regression model through which researchers are able to show the causal relations among the variables focused on (Kline, 1998). It is mainly based on examining covariance among observed variables to get inference about latent variables (Schreiber, Nora, Stage, Barlow, & King, 2006). In the present study, maximum likelihood (ML) estimation method was used for SEM relied on the covariance matrix.

Participants

The study included 665 senior elementary pre-service science teachers (467 Female, 198 Male) from 7 colleges in Turkey. Data were collected through the convenience-sampling technique that may cause biases in the sample studied with. To minimize the biases, we paid specific attention to collect data from different colleges with different characteristics (i.e., regarding the geographical area- east-west, etc., types of the cities- large and small cities, and the accessibility to ICT) (Fraenkel & Wallen, 2006).

The participants of the study were enrolled in a four year-elementary science teacher education program (i.e., eight semesters, each semester including about 14 weeks). All programs have content courses (e.g., chemistry, biology, physics, etc.), pedagogical courses (e.g., educational psychology, classroom management), content-specific pedagogical courses (e.g., elementary science teaching methods course), ICT courses (e.g. Computer I, computer II, instructional technology and material development), and practicum courses. All of the participants were at the eighth semester (i.e., the last semester) of the elementary science teacher education programs. They completed most of the content and pedagogical courses and all the ICT courses.

Data Collection

To collect data, we used the technological pedagogical content knowledge self-efficacy scale (TPACK-SeS) developed by Canbazoğlu-Bilici, Yamak, Kavak, and Guzey (2013). Canbazoğlu-Bilici et al. (2013) validated the instrument by collecting data from 808 pre-service teachers enrolled to 17 universities in Turkey. The reliability coefficients were between .84 and .94 for the factors. The item total correlation coefficients were between .59 and .83. CFA and EFA showed that TPACK-SeS is a valid and reliable instrument to measure TPACK-SE. In the present study, the researchers also checked the construct validity and reliability of scores on the scale. The findings supported the validity (see the result section) and reliability of the scale used in this study. Cronbach's alphas of the sub-scales ranged between .83 and .94. Cronbach's alpha of the whole instrument with 47 items was estimated as .98. Cronbach's alpha values are acceptable because it should be at least .70 (Pallant, 2007). The instrument has 5-point Likert type items, the score of which ranges from 1 (Cannot do at all) to 5 (Highly certain can do). The instrument has 52 items loaded under eight subscales. However, based on the literature review, we realized that in TPACK framework proposed Mishra and Koehler (2006) and others considered 7-factor TPACK construct. Therefore, we did not include context knowledge (CxK) items probing teachers' beliefs of how contextual factors (e.g., culture, demographic characteristics of learners, learning environments in schools etc.) influence integration of technology to teaching, (Canbazoğlu-Bilici et al., 2013) in our study. Due to the fact that pre-service teachers do not have detailed knowledge of CxK of the context in which they are going to teach, we excluded CxK that is more suitable for in-service teachers who has an idea about the characteristics of learners, learning environments in schools. The instrument used in this study has 47 items under seven subscales (Table 3).

Table 3. *Details about the TPACK-SE scale used in the present study*

Subscales	Number of items	Alphas	Example items
CK	6	.87	I can explain various chemistry concepts.
PK	8	.91	I can use a variety of instructional methods effectively.
TK	6	.91	I can install software.
PCK	10	.94	I can address students' learning difficulties for specific science topics.
TPK	7	.83	I can explain how to manage a classroom that is equipped with technologies.
TCK	4	.93	I can prepare models that are used in science education with technological tools (animation and graphics software and etc.).
TPACK-SE	6	.91	I can use technological tools to assess students' prior knowledge about science topics.

After taking necessary permissions from Institution Review Board (IRB), the instrument was administered to the volunteer participants from different colleges all around the country.

RESULTS

Descriptive Results

Before conducting confirmatory factor analysis and SEM analysis, all assumptions required were checked and met.

Table 4 shows descriptive statistics and correlations among the components.

Table 4. *Descriptive statistics*

Factors	n	M	SD	Skewness	Kurtosis	CK	PK	TK	PCK	TCK	TPK	TPACK-SE
CK	665	3.31	.67	.03	.38	-						
PK	665	3.52	.69	.01	.21	.60	-					
TK	665	3.09	.91	.01	-.33	.53	.50	-				
PCK	665	3.47	.67	-.02	.18	.72	.77	.56	-			
TCK	665	3.37	.78	-.07	-.20	.64	.64	.74	.72	-		
TPK	665	3.52	.69	-.07	.14	.65	.69	.64	.80	.79	-	
TPACK-SE	665	16.66	3.75	-.07	.14	.66	.65	.61	.79	.75	.82	-

The correlations among the factors were between .50 (i.e., between TK and PK) that is moderate and .82 (i.e., between TPK and TPACK-SE) that is strong correlation (Pallant, 2007).

The measurement model

Confirmatory factor analysis (CFA) was carried out to test seven-factor structure of TPACK proposed by Mishra and Koehler (2006). As normality assumption was met, maximum likelihood (ML) estimation method was used for CFA relied on the covariance matrix. Table 5 summarized the fit values and results obtained from the CFA run in this research.

Table 5. *Fit values for CFA and results received in this study*

Fit indexes	Fit values (criteria)	Acceptable fit values	Fit values received in the study
χ^2/df	$.00 < \chi^2/df < 3$	$3.01 < \chi^2/df < 5.00$	2.68
RMSEA	.00 < RMSEA < .05	.05 < RMSEA < .10	.05
SRMR	.00 < SRMR < .05	.05 < SRMR < .10	.04
NFI	.95 < NFI < 1.00	.90 < NFI < .95	.99
CFI	.95 < CFI < 1.00	.90 < CFI < .95	.99

The fit indexes of CFA analysis were acceptable level, according to cutoff values for goodness of fit indexes proposed by Schreiber et al., (2006), except for χ^2/df which was greater than 3 ($\chi^2(881, N = 665) = 3669.27$, *NFI* = .98, *CFI* = .98, RMSEA = .07 (90 % *CI* = .06, .07), SRMR = .05). Thus, suggested modifications were carried out by letting error terms of a few items in the same scales. Since those items measure the same construct it was reasonable that they were correlated each other. After those modifications, the TPACK-SE model with seven components moderately fit the data ($\chi^2(869, N = 665) = 2325.57$, χ^2/df = 2.68, *NFI* = .99, *CFI* = .99, RMSEA = .05 (90 % *CI* = .047, .052), SRMR = .04). All items were significantly loaded to hypothesized constructs. In other words, seven components underlying TPACK-SE framework were confirmed on the data of the present study. These results supported the construct validity of the instrument used in this study.

The first proposed model

To fill the gap regarding the factorial structure of TPACK-SE framework, we examined the indirect and direct relations among TPACK-SE components (Figure 2).

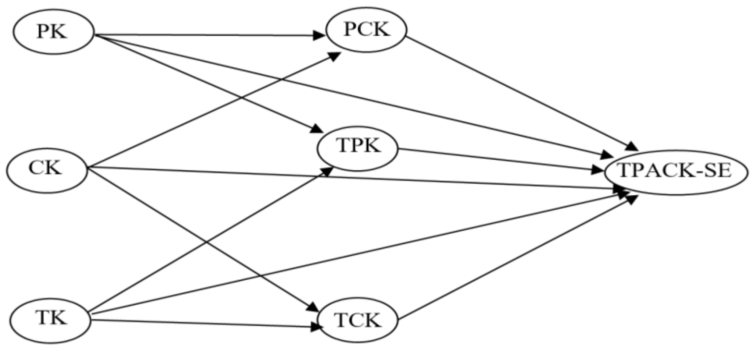

Figure 2. *The proposed structural model*

We built the proposed structural model on the measurement model tested with CFA. After running SEM, we saw that the model did not fit the data. Although some of fit indices are within the acceptable range (e.g., $\chi^2(887, N = 665) = 3917.85$, *NFI* = .98, *CFI* = .98, RMSEA

= .07, SRMR = .06), direct paths of basic components (i.e., TK, PK, and CK) on TPACK-SE were not significant. Although Koh et al., (2013) stated that PK, CK, and TK had direct influence on TPACK of practicing teachers, Chai et al. (2013a) found that they did not have direct effect on TPACK-SE of pre-service teachers, which could be related to lack of experience and inability in seeing the influence of those knowledge types on TPACK. Hence, in light of the related literature, we tested a new model that did not include direct effects of basic knowledge components on TPACK-SE in this study (Figure 3). Rather; we examined their indirect effect that is the effect of an independent variable on a dependent variable via mediating variables (Schreiber, et al., 2006).

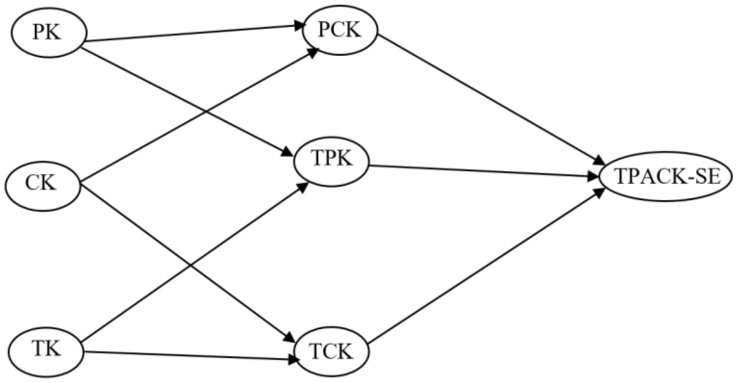

Figure3. *The modified structural model of TPACK*-SE

Testing the modified structural equation model

The results regarding the modified model are summarized in Figure 4.

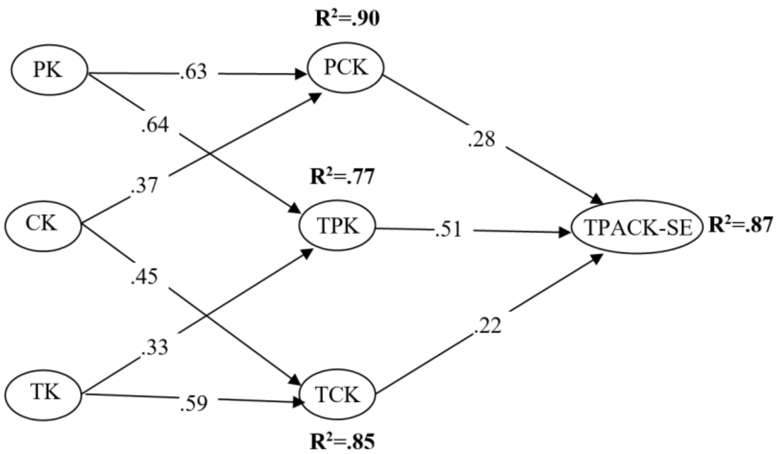

Figure 4. *Final model received with path coefficients and amounts of explained variances on all dependent constructs (R2)*

According to the fit indexes, the model had an acceptable fit (χ^2(878, N = 665) = 2546.55, χ^2/df = 2.90, *NFI* = .984, *CFI* = .99, RMSEA = .05 (90 % *CI* = .05, .06), SRMR = .05). Negative error variances or covariance and standardized estimates greater than one were not observed (Figure 4). All proposed paths are significant ($p < .05$).

The Relations of core components to interaction components

All proposed interactions got significant path coefficients. As can be seen from Figure 4, PK component has significant direct effect on the PCK (β = .63, $p < .05$) and TPK (β = .64, $p < .05$). According to Kline (1998), when the magnitude of standardized regression coefficients is less than .10, it is considered as small effect size, when it is around .30, it is considered as medium effect size and when it is larger than .50 it is considered as large effect size. Thus, the effect sizes of both relations are large since path coefficient is bigger than .50. The TK component is significantly associated with TPK (β = .33, p < .05) and TCK (β = .59, p < .05). The relation to TPK has medium effect size while that to TCK has large effect size. According to this result, it can be implied that contribution of TK to TCK is larger than contribution of TK to TPK. CK has significant path coefficients to PCK (β = .37, p < .05) and TCK (β = .45, p < .05). The effect sizes of those relations are medium.

The Relations to TPACK-SE

In the model, direct relations of core components to TPACK-SE were not proposed. Instead, indirect relations through interaction components (i.e., PCK, TCK, and TPK) were hypothesized (Figure 3 and 4). The indirect effects of the core components on TPACK-SE are presented in Table 6. All hypothesized relations got significant path coefficients. However, the relations have different effect sizes. According to sizes of path coefficients, TPK (β = .51, p < .05) is more related to TPACK-SE compared to PCK (β = .28, p < .05) and TCK (β = .22, p < .05). The relation of TPK has large effect size since path coefficient is bigger than .50 (Kline, 1998) whereas the associations of PCK and TCK have small to medium effect size.

Second, indirect relations of CK, TK, and PK were also significant (please see Table 6). When sizes of indirect effects are compared to each other, it is seen that the relation of PK to TPACK-SE through PCK and TPK (β = .51, p < .05) is greater than that of CK through PCK and TCK (β = .20, p < .05), and TK through TCK and TPK (β = .30, p < .05).

Finally, the amounts of explained variances on all dependent constructs (R^2) in the model are seen in Figure 4. According to the magnitude of R^2s, it can be said that most of the variances on the dependent variables were explained by the independent variables in the model. The explained variances of derived constructs changed between .77 (i.e., for TPK) and .90 (i.e., for PCK). CK, PK, TK, PCK, TCK and TPK explained 87% of the variance of TPACK-SE. The explained variances have also large effect size based on threshold values (R^2 = .01, small effect size; R^2 = .09, medium effect size; R^2 = .25; large effect size) proposed by Cohen and Cohen (1983).

Table 6. *Direct, indirect and total relations among TPACK-SE components*

Variables		PCK			TCK			TPK			TPACK-SE		
		Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
CK	***β***	.37	-	.37	.45		45	-	-	-	-	.20	.20
	SE	.04		.04	.04		.04					.02	.02
	t	8.57		8.57	11.58		11.58					8.70	8.70
PK	***β***	.63	-	63				.64		.64		.51	.51
	SE	.05		.05				.04		.04		.04	.04
	t	13.30		13.30				16.21		16.21		14.02	14.02
TK	***β***	-	-	-	.59		59	.33		.33		.30	.30
	SE				.04		.04	.03		.03		.03	.03
	t				13.97		13.97	9.56		9.56		10.22	10.22
PCK	***β***	-	-	-	-	-	-	-	-	-	.28	-	.28
	SE										.05		.05
	t										6.22		6.22
TCK	***β***		-	-	-	-	-	-	-	-	.22	-	.22
	SE										.04		.04
	t										5.39		5.39
TPK	***β***	-	-	-	-	-	-	-	-	-	.51	-	.51
	SE										.05		.05
	t										10.98		10.98

Elementary Education Online, Year; Vol (Issue): pp. XX-XX
İlköğretim Online, Yıl; Cilt (Sayı): s.XX-XX . [Online]: http://ilkogretim-online.org.tr
doi

DISCUSSION & CONCLUSION

In this study, to enlighten the related literature about the structure of TPACK and self-efficacy beliefs about TPACK, and the teacher education programs regarding how to teach pre-service teachers integrating technology use in teaching, we focused on the nature of TPACK-SE model regarding how knowledge components contribute to TPACK-SE. In the literature, different results regarding factor structure of TPACK have been presented. In the current study, we proposed seven-factor structure (please see Figure 3) and the study results (i.e., According to the fit indexes the model had acceptable fit (χ^2(878, N = 665) = 2546.55, χ^2/df = 2.90, *NFI* = .984, *CFI* = .99, RMSEA = .05 (90 % *CI* = .05, .06), SRMR = .05) confirmed the seven-factor structure of TPACK-SE framework (please see Figure 4) as suggested by Mishra and Koehler (2006). Additionally, TPACK-SE is a construct that is theoretically formed by basic (e.g., PK) and second layer knowledge factors (e.g., TPK). However, whether all those have direct influence on the TPACK-SE or not is unclear. Chai et al. (2013a) showed that PK, TK, and CK did not have direct influence on TPACK-SE. They contributed to TPACK-SE indirectly through the intermediary roles of TPK, TCK, and PCK. However, the structural equation model stated by Koh et al. (2013) showed direct relationship between TPACK, and PK, CK and TK of practicing teachers. In this study, based on the literature review, we proposed that PK, CK, and PK had indirect influence on TPACK-SE (please see Figure 3). Our model based on the data collected supported the indirect influences of basic knowledge components on TPACK-SE of preservice teachers (please see Figure 4 and Table 6). Our results are consistent with Chai et al.'s (2013a) model regarding the indirect influence of basic factors. When we put all those results together, we can state that preservice teachers may not be able see the direct connection between TPACK-SE, and TK, PK and CK. On the contrary, as in Koh et al. (2013) practicing teachers, who have more teaching experience, may be able to directly relate them (Chai et al., 2013a). Among the significant indirect relations, the relation of PK to TPACK-SE through PCK and TPK (β = .51, p < .05) is greater than that of CK and TK through PCK, TCK, and TPK. In other words, participants' indicated that PK is the most available basic knowledge components that contribute to participants' TPACK-SE development.

In their theoretical paper focusing on the interpretation of TPACK in teacher education, Hechter et al., (2012) proposed "a reductionist approach to deconstructing the TPACK model to best identify and illuminate TPACK's relationships and connections toward pragmatic applications for preservice and inservice teachers." (p. 142) In this approach, Hechter and his colleagues suggested that derivative construct that are TPK, TCK, and PCK play a pivotal role in understanding TPACK. Although TK, PK, and CK are separate entities from each other, intermediate knowledge types help teachers to develop an integrated understanding of discrete areas and to form a rich repertoire of TPACK (Hechter & Phyfe, 2010 as cited in Hechter et al. 2012). Parallel to Hechter et al.'s deconstruction idea (2012), in this study, participant preservice teachers realized the importance of intermediary steps in forming TPACK-SE. The comparison of path coefficients revealed that TPK is more related to TPACK-SE than PCK and TPK. TPK's effect size was found as large whereas PCK and TCK's were small and medium, respectively. Similar to PK' results discussed above, participants' of this study might think that integration technology into teaching and learning fosters TPACK-SE more than other paths (e.g., TCK or PCK). The basic factors' influence in developing TPACK-SE is indirect and is formed through intermediary steps. Development of TPACK-SE directly from basic components (e.g., TK, PK) "to a full integration of the knowledge types without passing through the intermediate dual-overlapping steps, we believe this is a complicated trajectory." (Hechter et al., 2012, p. 143)

Chai et al. (2011) also obtained 7-factor TPACK model in their study. They could support five out of seven hypothesis. Only intermediary factor contributing to TPACK was TPK in Chai et al.'s model. However, in the current study, we were able to detect to what extend TCK (β = .22, p < .05) and PCK (β = .28, p < .05) contributed to TPACK-SE Similar to Chai et al.'s results, according to sizes of path coefficients, as stated above, our results revealed that TPK is more related to TPACK-SE compared to PCK and TCK, which may show the critical role of TPK in development of

TPACK-SE. In teacher education programs this result should be paid more attention in designing the program courses and their sequence.

Implications for science teacher education

With help of the results, we can say that pre-service teacher educators should focus on developing derived constructs, namely, PCK, TCK, and TPK from PK, TK, and CK to support teachers develop rich TPACK-SE. Then, in the second step, the relation between derived knowledge types and TPACK-SE should be stressed in the science teacher education programs. As Hechter et al. (2012) suggested, the sequence should be reflected into the courses provided. The teacher education programs may put more emphasis on CK, TK, and PK at the very beginning. Then, courses focusing on "*the spaces between*" (Hechter et al., 2012, p. 142) that are derived factors (e.g., PCK, TCK, and TPK) should be offered to preservice teachers. In these courses, the relation between the domains should be highlighted. This step should be very clear and explicit to ensure full integrating of the domains. As the results of this study and the others (e.g., Chai et al., 2013b) TPK is more related to TPACK-SE, hence, more emphasis may be put on it. In the next step, content-specific highlights would be useful in developing TPACK-SE. Ultimately, through explicit introduction of the all components (i.e., deconstruction of TPACK-SE), focusing of all components, and providing planning and teaching experiences will be promising in developing rich TPACK-SE. Future research focusing on different paths of forming rich repertoires of TPACK-SE (e.g., focusing more on TPK at the beginning and then integrating content to the training or focusing more on TCK and integrating pedagogy in the next steps, etc.) should be designed and checked which way is better than the others.

Second, TPK is more related to TPACK-SE so teacher educators should pay more attention to it in the courses. Then, after graduation, in the induction year, professional development activities are more suitable context in which the relations between basic layer (e.g., PK) and TPACK-SE. Longitudinal studies are promising in examining how participants develop TPACK-SE regarding constructing relations between basic knowledge components and TPACK-SE, when they are able to see the connections among the factors, and how their use of knowledge layers evolve through their career are questions that future research should focus on.

Our results revealed that PK and TPK are more available for senior elementary science teachers to form TPACK-SE. In other words, they need more support to see the relevance of other basic components (e.g.CK and TK) and derivative components (e.g. TCK and PCK) to TPACK-SE, which is a clear implication for science teacher educators. To address this problem, technology should be integrated into science content courses, which is supposed to help pre-service teachers relate content and technology knowledge. At the beginning years of science teacher education programs, TK should be enrich through offering more effective ICT courses that include basic technology knowledge. Moreover, for the beginning years, use of technology in content courses by the instructors would be beneficial regarding victorious experience for preservice teachers. For instance, use of animations is very useful to make abstract particular interactions in dissolution process or in Voltaic cell reactions more concrete for preservice teachers. It will be helpful both for them in learning the topic (i.e., CK) and in seeing how technology is used for teaching content (i.e., TCK). Additionally, science teaching method course should include technology application parts to show hoe technology can be used to detect learners' alternative conceptions, teach science in a conceptual way, and how to assess learners' understanding by the use of technology. To conclude, in this technology-dominated century, use of technology should be part of teacher education programs. Finally, in the future research, researchers should study on how different technology integration models with different emphasis should be organized. One of the models, 'design- based learning' was suggested by Baran and Uygun (2016). Design- based learning is based on examining a lesson designed with technology in a group, and then designing a one with technology integration. After planning cooperatively, preservice teachers have a chance to enact them in micro teaching sessions. It is also highlighted that participants should reflect on their design experiences with technology. Reflection papers will be useful for teacher educators to understand their experiences. This model can be part of Science Teaching Method course and Teaching Practice course, which are the core courses for TPACK-SE development and enactment. Therefore, it is necessary to modify those courses both syllabus and structure in order to foster preservice teachers TPACK-SE development in light of the related literature support. In the future research, researchers should let participant teachers plan a lesson including effective use of technology, teach it, then reflect on its weak and strong parts, and finally, revise the plan. Longitudinal studies that shed lights on different pathways of supporting TPACK-SE will be valuable for both researchers trying to understand how TPACK-SE develops, and teacher educators struggling how to support pre-service and in-service teachers in effective use of technology for meaningful understanding.

Acknowledgement: This study was supported by Yuzuncu Yil University, Scientific Research Project Unit. The project number was BAP-2014-EF-B135.

REFERENCES

Abbitt, J. T. (2011). An investigation of the relationship between self-efficacy beliefs about technology integration and technological pedagogical content knowledge (TPACK) among pre-service teachers. *Journal of Digital Learning in Teacher Education, 27(4),* 134–143.

Angeli, C. & Valanides, N. (2008). *TPCK in pre-service teacher education: Preparing primary education students to teach with technology.* Paper presented at the annual meeting of the American Educational Research Association, New York City, NY.

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 October 25, 2014, from http://www.citejournal.org/vol9/iss1/general/article2.cfm

Archambault, L. M., & Barnett, J. H. (2010). Revisiting technological pedagogical content knowledge Exploring the TPACK framework. *Computers & Education, 55(4),* 1656–1662. Doi:10.1016/j.compedu.2010.07.009

Albion, P. (1999). *Self-efficacy beliefs as an indicator of teachers' preparedness for teaching with technology.* Association for the Advancement of Computing in Education (AACE)

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall.

Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach. *Australasian Journal of Educational Technology, 2016, 32(2),* 47-69. DOI: 10.14742/ajet.2551

Canbazoğlu Bilici, S., Yamak, H., Kavak, N., & Guzey, S.S. (2013). Technological pedagogical contet knowledge self-efficacy scale (TPACK-SeS) for preservice science teachers: Construction, validation and reliability. *Eurasian Journal of Educational Research, 52,* 37-60.

Canbazoğlu Bilici, S., Guzey, S., Bulut, O., Yamak, H. & Kavak, N., (2013). *Evaluation of the Technological Pedagogical Content Knowledge (TPACK) Framework Using Structural Equation Modeling*, AERA 2013 Annual Meeting San Francisco, ABD.

Chai, C.S., Koh, J.H.L., & Tsai, C.C. (2010). Faciliting preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society, 13(4),* 63-73.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013a). A review of technological pedagogical content knowledge. *Educational Technology & Society, 16(2),* 31-51.

Chai, C. S., Koh, J. H. L., Tsai, C. C. & Tan, L. (2011). Modeling primary school preservice teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education, 57,* 1184-1193. Doi:10.1016/j.compedu.2011.01.007

Chai, C.S., Ng, E.M.W., Li, W., Hong, H.Y. & Koh, J.H.L. (2013b). Validating and modelling technological pedagogical content knowledge framework among Asian preservice teachers. *Australasian Journal of Educational Technology, 29(1),* 41-53.

Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences* (2nd ed.). Hillside, NJ: Prentice Hall.

Compeau, D.R. and Higgins, C.A. (1995) Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly, 19 (2),* 189-212

Cox, S., & Graham, C. R. (2009). Diagramming TPACK in practice: Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *Tech Trends, 53(5),* 60–69. Doi. 10.1007/s11528-009-0327-1

Cuban, L., Kirkpatrick, H. & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal, 38(4),* 813-834.

Fraenkel, J.R. & Wallen, N.E. (2006). *How to design and evaluate research in education.* New York: McGraw-Hill.

Hechter, R. P., Phyfe, L. D., & Vermette, L. A. (2012). Integrating technology in education: Moving the TPCK framework towards practical applications. *Education Research and perspectives: An International Journal, 39,* 136-152.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6(1),* 1-55.

Kabakci-Yurdakul, I., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012).The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education, 58,* 964-977. Doi.10.1016/j.compedu.2011.10.012

Kiray, S.A. (2016). Development of a TPACK self-efficacy scale for preservice science teachers. *International Journal of Research in Education and Science (IJRES)*, 2(2), 527- 541.

Kline, R. B. (1998). *Principles and practice of structural equation modeling.* New York: The Guilford Press.

Kramarski, B. & Michalsky, T. (2010). Preparing preservice teachers for self-regulated learning in the context of technological pedagogical content knowledge. *Learning and Instruction, 20(5),* 434-447. Doi. 10.1016/j.learninstruc.2009.05.003

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy, and technology. *Computers & Education, 49,* 740–762. Doi:10.1016/j.compedu.2005.11.012

Koehler, M. & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge (TPCK)? *Contemporary Issues in Technology and Teacher Education, 9(1),* 60-70.

Koh, J.H.L., Chai, C.S., & Tsai, C.C. (2010). Examining the technological pedagogical content knowledge of Singapore preservice teachers with a large-scale survey. *Journal of Computer Assisted Learning, 26,* 563-573. Doi. 10.1111/j.1365-2729.2010.00372.x

Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2013). Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A structural equation modeling approach. *Instructional Science, 41,* 793–809. Doi: 10.1007/s11251-012-9249-y

Lee, C. & Kim, C. (2014). An implementation study of a TPACK-based instructional design model in a technology integration course. *Educational Technology Research Development, 62,* 437- 460. Doi. 10.1007/s11423-014-9335-8.

Lee, M., & Tsai, C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the world wide web. *Instructional Science: An International Journal of the Learning Sciences, 38(1),* 1-21. Doi. 10.1007/s11251-008-9075-4

Lin, T. C., Tsai, C., Chai, C. S., & Lee, M. H. (2013). Identifying Science Teachers' Perceptions of Technological Pedagogical and Content Knowledge (TPACK). *Journal of Science Education and Technology, 22(3),* 325-336. Doi. 10.1007/s10956-012-9396-6.

Mishra, P. & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108(6),* 1017-1054.

National Ministry of Education (NME) (2013). *Secondary Level Chemistry Curricula for 9th to 12th Grades*. NME: Ankara.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

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. Doi:10.1016/j.tate.2005.03.006

Niess M.L. (2011) Investigating TPACK: knowledge growth in teaching with technology. *Journal of Educational Computing Research, 44,* 299–317. Doi: 10.2190/EC.44.3.c

Niess, M. L., Suharwoto, G., Lee, K., & Sadri, P. (2006, April). *Guiding inservice mathematics teachers in developing TPCK.* Paper presented at the annual meeting of the American Education Research Association, San Francisco, CA.

Ovez, F. T. D. & Akyüz, G. (2013). Modelling technological pedagogical content knowledge constructs of preservice elementary mathematics teachers. *Education and Science 38(170),* 321-334. Doi. http://dx.doi.org/10.17943/etku.14356

Pallant, J. (2007). *SPSS survival manual: A step by step guide to data analysis using SPSS for Windows* (15th ed.) Buckingham: Open University Press.

Polly, D., Mims, C., Shepherd, C. E., & Inan, F. (2010). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. *Teaching and Teacher Education, 26,* 863-870. Doi.10.1016/j.tate.2009.10.024

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42(2),* 123-149.

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research, 99(6),* 323-338. Doi: 10.3200/JOER.99.6.323-338

Schunk, D. H. (1981). Modeling and attributional effects on children's achievement; A self-efficacy analysis. *Journal of Educational Psychology, 73*, 93-105.

Schunk, D. H., Hanson, A. R., & Cox, P. D. (1987). Peer-model attributes and children's achievement behaviors*. Journal of Educational Psychology, 79,* 54-61.

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

Shulman L.S. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review, 57,* 1–22.

Teo, T. (2009). Modelling technology acceptance in education: A study of pre- service teachers. *Computers & Education, 52(1),* 302-312.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68(2),* 202-248.