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Development, Validity and Reliability Study of Technological Pedagogical Content Knowledge (TPACK) Efficiency Scale for Mathematics Teacher Candidates

İbrahim Çetin^{1*}, Ahmet Erdoğ an¹

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Abstract

The aim of this study is to develop a valid and reliable measurement tool that can be used to determine the technological pedagogical content knowledge efficiency of mathematics teacher candidates. The study is conducted with 453 elementary and secondary school preservice mathematics teachers. SPSS and AMOS programs are used for statistical analysis. Since the conceptual framework of TPACK is obvious, the scale items are written around this existing frame in TPACK sub-dimensions, and for that reason only Confirmatory Factor Analysis (CFA) is performed on the predetermined factors. Total correlations of the items in the scale range from .33 to .86. The results of the t-test between the item average points of the upper 27% and lower 27% groups show that the differences were significant for all items and factors. The internal consistency Cronbach Alpha coefficient calculated for the overall scale was .98, and for sub-dimensions it was between .81 and .97. These results indicate that the reliability of the scale is high. As a result of the confirmatory factor analysis, the criteria for the reconstructed model adaptation are examined considering the modification proposal, and the model adaptation is found sufficient. As a result, the use of measurement tool consisting of seven sub-dimensions with 79 items in five Likert type is made ready. The obtained TPACK efficiency scale proves to be a valid and reliable measurement tool that can be used in determining the self-efficiency of teacher candidates.

Key words: TPACK Scale, Mathematics Teacher Candidates

Introduction

Today, what is expected from education is to raise individuals who have qualified workforce, who are conscious about the effective use of capital, who can enter into competition with global economy, and who are able to use technology effectively in every field. Education system's fulfilling these services depends largely on the quality of teacher who has an important role in the operation of system. The quality of the teacher is the main contributing because that will make education system successful or unsuccessful. For this reason, it is of utmost importance that the teachers are trained with the necessary competences before the service.

The efficiency expected from the teachers differs according to the expectations of each era. For instance, when we were an agricultural society, the most important efficiency expected from teachers who were trained at village institutes was to educate the villagers about agriculture and improve the villages where they carried out their duties. In today's knowledge society, it is one of the most important efficiency that the teacher has good knowledge of the field and pedagogy as well as being able to use the technology effectively in learning environments.

According to National Council of Teachers of Mathematics (NCTM), the expectation from a teacher is not only using technology and bringing hardware and software to the class, but also providing an environment which is facilitative and supportive in students' learning using technology effectively with appropriate teaching strategies and techniques without ignoring the learning styles and individual differences of the students. Hereunder, technology is not the solution to everything. Technology can only be an effective tool for education if it enhances learning opportunities, and actualises actualizes significant learning. Therefore, it becomes more and more important that which, when and how technology will be used by teachers.

A great amount of budget and effort is spent on the use of technology in the education process (TED, 2009). It has been determined that despite the investments made in order to provide technological infrastructure to the

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schools through a major project called FATİH project in our country, there is a problem about the integration of educational technologies into the teaching process (Ciftci, Taskaya & Alemdar, 2013).

Technology integration defines teaching-learning environments as effective and efficient use of technology in all aspects of the teaching-learning process, including teaching and learning (Yalin et al., 2007). In other words, it is knowing how to integrate technology into the course at each stage from planning to evaluation. It is the effective use of technology in overcoming difficulties related to the subject, in the usage of different teaching methods, in the establishment of relations between conceptual knowledge, and in the evaluation processes. In order for teacher candidates to achieve the desired success in their professional lives, first of all, they should accept the role of technology in education, and have the ability to use it (Erdemir et al. 2009). Since the teacher candidates will come across with student groups who have fascination with technology. Teachers should be equipped with the skills and knowledge to use technology in university years in order to use technology effectively in their professions. Mishra and Koehler (2006) show the lack of a model and theory for the integration of technology as a reason for the inconvenience. For this reason, they recommend Technological Pedagogical Content Knowledge (TPACK) in order to determine teachers' competences in this field and to provide a theoretical framework.

TPACK is a type of knowledge that has emerged from Mishra and Koehler's incorporation of technology knowledge in 2006 to the definition of pedagogical content knowledge brought into field by Shulman (1986). TPACK is a model that highlight the coexistence and interaction of three disciplines; technology, pedagogy and content (content knowledge), which make up the framework of this model. It is important that the teacher has technological knowledge of how to use the technological programs, or it is important that the teacher has knowledge of any topic in the field, however it is the only basic. If a teacher knows something, but cannot explain it with appropriate methods and techniques, or if he cannot present it to the students with appropriate presentation, it is not important how well the teacher knows the topic. Since interaction of content knowledge with other components, technology and pedagogy, must be considered. TPACK, an interaction of the technology, pedagogy and knowledge dimensions, is a concept beyond these three components and is a kind of knowledge that emerges from the interaction of these three.

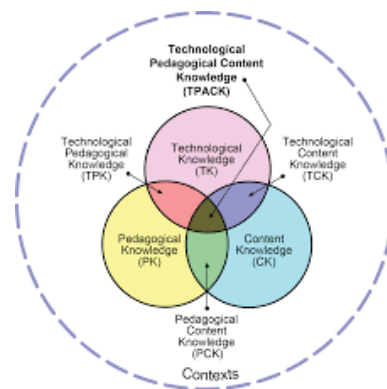


Figure 1: TPACK model

As it is seen in figure, TPACK model consists of three knowledge types: (i) Technology Knowledge (TK), (ii) Pedagogical Knowledge (PK), (iii) Content Knowledge (CK). The three sub-types of knowledge composed with the interaction of these three types of knowledge are (iv) Technological Pedagogical Knowledge (TPK), (v) Technological Content Knowledge (TCK) (vi) Pedagogical Content Knowledge (PCK), and at the junction point of the three types of knowledge, Technological Pedagogical Content Knowledge (TPACK) takes place. As it is seen TPACK consists of seven sub-dimensions.

Technology Knowledge: It is a knowledge that consists of information and usage of book, chalk, blackboard also modern technologies such as internet, smart board, tablet, e-mail. In sum, technology knowledge is the information and skills that teachers should have in using technology.

Content Knowledge: It refers to the subjects in the field and the related knowledge (Mishra-Koehler, 2006). Content knowledge is an information about learning and teaching the subject. Knowledge is the thing given in

courses There are different subjects, and basic principles, hypothesis, theories, proofs and algorithms based on these subjects.

Pedagogical Knowledge: It includes knowledge such as teaching methods, strategies and techniques used in the classroom, how the learning takes place, classroom management, and evaluation of the students. The teacher with this knowledge knows how to learn the student and how to measure and evaluate the learning outcome and knows effective classroom communication techniques.

Pedagogical Content Knowledge: It is a type of knowledge that includes effective teaching methods and techniques that can be used in teaching any topic and appropriate assessment-evaluation approaches. What is important here is to integrate pedagogy with the field. It is not knowing the subject or teaching method but it is being able to blend and integrate these two appropriately. In addition, pedagogical content knowledge includes knowledge about the learning disabilities and difficulties, and the use of pedagogical methods to overcome these disabilities and difficulties.

Technological Content Knowledge: It is the knowledge of selecting and using the most appropriate technology for the subject area, in a word, content. It can also be defined as the ability to know and evaluate which technology is the most appropriate technology for any subject. Considering that there are many applications today, it is not important to have knowledge about a large number of technologies, but it is important to choose the most appropriate and economical ones among these technologies.

Technological Pedagogical Knowledge: It covers what the technologies used in teaching are and what pedagogical knowledge is needed when using these technologies. Not every technology matches every learning method. According to the technology used, assessment-evaluation methods and classroom management can change and technology and pedagogy influence each other.

Technological Pedagogical Content Knowledge: It covers what kind of technologies used in teaching and what pedagogical knowledge is needed when using these technologies. Not every technology matches every learning method. According to the technology used, assessment-evaluation methods and classroom management can differ, and technology and pedagogy influence each other.

TPACK, which is the basis of teaching and learning process, requires having knowledge of what facilitates and challenges students in learning the concepts, how technology helps solving problems that students face, how technology structures and strengthens the foreknowledge of students (Canbazoglu Bilici et al., 2013). The training of mathematics teacher candidates during the undergraduate education and the determination of the TPACK competencies and the changes in these efficiency are an influential factor in the use of technology in the educational environment. For this reason, it is necessary to carry out researches on how teachers and teacher candidates can improve their competencies in the integration of technology.

Many scale development and adaptation studies have been carried out in order to determine the efficiency and attitudes of teacher candidates and teachers about technology integration. Various TPACK scales are used in 22 of 30 study subjects reviewed in the field literature. Six of these scales are developed in Turkey. The scale developed by Schmidt et al. (2009) is the most adapted one. (Canbazoglu Bilici, 2013)

Dikkartin, Ovez and Akyuz (2013) has adapted the Technological Pedagogical Content Knowledge (TPACK) scale developed by Schmidt et al. (2009) into Turkish. The scale obtained after the linguistic equivalence test has been applied to 473 undergraduate elementary mathematics teaching students. Explanatory and confirmatory factor analysis has been carried out to examine the structure validity and factor structure. In addition, a model of structural equality has been developed in order to examine the relationship between the dimensions of the scale. Reliability and significance of differences between the upper and lower 27% groups have been examined by the Cronbach Alpha coefficient. Findings have revealed that the scale had a four-factor structure, and that the compliance indexes have been within the acceptance limit, also the reliability of Cronbach's alpha have been 0.91 and the reliability of all subscales have been found 0.70 and have been found that all differences between the item averages of the upper and lower 27% groups are significant.

The first scale developed for TPACK was conducted by Koehler and Mishra in 2005. The 13-item scale was developed for teacher candidates, and had a total of 33 items. It aimed to evaluate the TPACK development, online course designs and learning environment of teacher candidates.

The other scale developed by Schmidt et al. in 2009 to measure the development and implementation of TPACKs of 124 classroom teacher candidates during courses is "Teaching and Technology Knowledge Survey of Teacher Candidates". Seven sub-dimensions of EFA and TPACK models were obtained, and Cronbach's alpha coefficient for each dimension was calculated. According to this, Cronbach alpha reliability coefficient of seven factors, CK, PK, PACK, TK, TCK, TPK and TPACK, was between .79 and .93. Exploratory factor analysis (EFA) was used for construct validity. In the first EFA result applied to the scale consisting of the first 75 items, a second EFA was created by subtracting some items (28 items) that adversely affected the validity from the scale and a final 5-Likert scale consisting of 47 items was created.

The TPACK scale developed by Archambault and Crippen (2009), another study in the literature, was applied to 596 teachers, and it had 24 scale items. It was aimed to determine the perceptions of teachers about the 7 subscale dimensions related to TPACK using the scale which was investigated for validity and reliability. Pedagogical knowledge, pedagogical content knowledge and content knowledge points were the highest, teachers were very confident in this field, but they were less confident when these fields were combined with technology. There was a low relationship between technology and pedagogy, technology and the field, and a high correlation between pedagogy and the field (Timur, 2011).

It is aimed to measure the self-confidence of teachers in four subscales, TK, TCK, TPK and TPACK, in the TPACK scale developed for science teachers by Graham et al. (2009). There were 31 items in the scale applied to 15 teachers and the Cronbach alpha reliability coefficient was 0.90. At the beginning of the research, teachers' self-confidence towards TK was found to be highest. At the end of the research, it was found that the increase of self-confidence levels of teachers in TCK was higher than other information.

Chai, Koh and Tsai (2010) investigated the profiles of 1185 teacher candidates for TPACK in Singapore using the scale developed by Schmidt et al. (2009). It was determined that the TK, PK, CK and TPACK development of teacher candidates developed a large effect size in the last test when compared to preliminary test. Although they found some differences in TPACK perceptions according to gender, they did not find any difference in terms of teaching level.

When the national field was considered, various data collection tools and TPACK questionnaires were developed towards both teachers and teacher candidates. When the studies were examined, it was seen that some studies were on developing original scales while some were adaptation of developed scales into Turkish and their usage.

Another study is by Kaya, Emre and Kaya (2010) who adapted the scale developed by Schmidt et al. (2009) into Turkish adding "I don't understand" option. The scale aimed to determine whether TPACK self-confidence levels of the classroom teachers had a significant difference in terms of their gender and class levels. In the scale in which t-test and one-way ANOVA analysis was used, it was determined that TPACK self-confidence levels did not have a significant difference in terms of gender, however it showed a significant difference in terms of teacher candidates' class levels at five dimensions of TPACK (TK, PK, CK, PACK, TCK). It was concluded that it could be used in Turkey. Savas (2011) who adapted the Teacher Candidates' Perception of TPACK Scale which was developed by Makinster, Boone and Trautman (2010) investigated the TPACK perceptions of science teacher candidates.

Sahin (2011) developed a 47-item questionnaire to measure TPACK perceptions of teacher candidates. The Cronbach Alpha coefficient for the subscales of the developed scale varied between 0.88 and 0.93, and high correlations were obtained especially in the sub-dimensions of technology, pedagogy and content knowledge.

As a result of factor and reliability analysis of his study conducted to investigate the attitudes of Turkish primary school mathematics teacher candidates towards computer and technology, Dogan (2010) found that the reliability coefficient was .94. The study group of scale consisted of 361 teacher candidates studying at elementary mathematics teaching at two different universities. 16 of the Likert type 39 questions were related to pedagogy, 13 of them were related to technology and 10 of them were related to content knowledge of TPACK. As a result of the research, it was determined that teacher candidates were generally positive about using computer and were able to use computers adequately. It was also determined that they were positive about computer and information technologies. Perception and attitudes were independent of gender.

Oksuz, Ak and Uca (2009) developed a measurement tool that could be used in determining the perceptions of teacher candidates / teachers about the use of technology in teaching primary mathematics. As a result of the item analysis of the scale applied to 348 people, a scale consisting of 73 items was obtained with a positive

point of 63 and a negative point of 10 items. The internal coefficient of consistence (Cronbach Alpha) of the scale was calculated as .96. The internal coefficient of consistence calculated for the sub-dimensions were .95, .96, .84 respectively. According to the results of the research, this scale which was called Perception Scale of Technology Use in Elementary School Mathematics Teaching (TUPS) was a valid and reliable tool that could be used in the field of education.

Although TPACK studies, during the recent years in Turkey, have become a fastest growing research field, the number of scales specific to the field of mathematics is little if any. Some of the field-specific scale development studies are either adaptations (Dikkartin-Ovez and Akyuz; 2013, Mandaci-Sahin et al., 2011) or can be used for all branches (Sahin, 2011, Sancar- Tokmak et al., 2012). In some scales developed specifically for the field, a discrimination of elementary and secondary school mathematics teacher candidates / teachers is seen (Oksuz et al., 2009). Moreover, many of the available scales in literature do not provide answers to the problems that are sought in this research. Thereby, it is aimed to develop a scale that will respectively have the ability to respond to sub problems of the research, include the appropriate assessment and evaluation approaches to program together with the skills indicated in the updated curriculum in 2013, measure the competence related to integration of DGY used in mathematics and BITs such as manipulative and interactive sites to education, be up-to-date and be used by both secondary school and high school teachers/teacher candidates.,

Method

Participants

In order to develop to TPACK scale which is used as data collection tool in the study, elementary and secondary school mathematics teaching students studying at state universities in Turkey, and the students of Mathematics Department at Faculty of Science training for pedagogical formation are included into the study. This study is conducted with 453 students, 327 females and 126 males, who are elementary and secondary school mathematics teaching teacher candidates studying at 4 different geographical regions, Central Anatolia, Aegean, Mediterranean and Southeastern Anatolia regions (Necmettin Erbakan University Pamukkale University Department of Elementary Mathematics Teaching, Akdeniz University, Gaziantep University) during 2014-2015 academic year.

Data collection

The data of this scale, prepared to determine the efficiency of technological pedagogical content knowledge of mathematics teacher candidates, has been collected by taking the following steps. These are i) Literature review and item pooling ii) Expert opinion iii) Item-total correlations iv) Confirmatory factor analysis v) Cronbach Alpha internal consistency reliability, vii) Examining the correlation between sub dimensions

While forming the items of this scale prepared to determine the sufficiency of technological pedagogical content knowledge of mathematics teacher candidates, local and foreign literature have reviewed, and the scales based on TPACK developed by Sahin (2011), Graham et al. (2009), Schmidt et al. (2009), Ropp (1999) have been used. In addition, a pool of items consisting of 93 items have been created by taking the curriculums of the secondary school and high school mathematics education, and the proposals of the qualifying program which can be the related scale item into consideration. After the revisions, the scale item numbers have been reduced to 84. Below is the question distribution of the TPACK scale item pool according to the dimensions and the items representing that dimension.

Table 1: The distribution of TPACK scale item pool according to dimensions

Sub-Dimension	Number of Items	Items that Represent Sub-dimension
Technology	16	I1: I know how to solve a technical problem in my computer.
Knowledge		I2: I can keep up with the latest technology.
		I5: I have technical knowledge related to the technology I will use.
		I10: I know how to use my smartphone
		I13: I can use cloud storage technology (like Google Drive, Dropbox)
		I15: I can download videos via video sharing sites (like YouTube, Vimeo, Daily Motion).

Sub-Dimension	Number of Items	Items that Represent Sub-dimension
Content Knowledge	7	<p>I17: I have enough knowledge about algebra learning area.</p> <p>I20: I have enough information about the numbers and operations learning area.</p> <p>I21: I follow symposiums, panels and conferences related to mathematics.</p> <p>I22: I follow curriculum changes related to mathematics.</p> <p>I23: I know the historical development of mathematics.*</p>
Pedagogy Knowledge	8	<p>I25: I can prepare different activities according to the learning styles of the students.</p> <p>I29: I can choose class management strategies according to the method, technique and material used in the class.</p> <p>I30: I can apply different learning approaches (project-based learning, multiple intelligence, problem-based learning) in the classroom.</p> <p>I31: I know the necessary precautions against negative situations that can be faced in the class.</p>
Pedagogical Knowledge	19	<p>I32: I can choose appropriate teaching strategies for sub- learning fields (e.g. Algebra, geometry, numbers).</p> <p>I38: During the mathematics learning process, I can provide a democratic classroom environment to enhance my students' critical thinking skills.</p> <p>I41: During the mathematics learning process, I can organize activities to improve my students' problem-solving skills / strategies.</p> <p>I42: I can create learning environments that allow different mathematical concepts to be related within each other.</p> <p>I44: I can identify students' learning difficulties and conceptual misconceptions about a particular mathematics subject.</p> <p>I46: I can choose an appropriate assessment tool for a subject related to a math class.</p>
Technological Content Knowledge	19	<p>I52: I have enough knowledge to use math lesson related technologies in the classroom.</p> <p>I54: I consider the possibilities that the technology I use will have for the teaching of the subject concerned.</p> <p>I56: I can use Dynamic Mathematics / Geometry Software (such as Geogebra, Sketchpad, Desmos and Cabri II) effectively.</p> <p>I58: I can use calculators effectively and competently.</p> <p>I59: I can use Computer Algebra Systems (such as Derive, Mathematica and Maple) effectively. *</p> <p>I61: I can use internet effectively to access programs such as math video, application, MEB Vitamin.</p>
Technological Pedagogical Knowledge	11	<p>I62: I can use technologies that are appropriate for individual differences.</p> <p>I64: Depending on the level of the student group, I can determine at what stage of the class I will use the technology.</p> <p>I67: I can use the technological tool I used for teaching also for the assessment and evaluation process</p> <p>I70: I can use technology to give students the skills beyond cognition (such as analysis, synthesis, evaluation)</p>
Technological	13	<p>I75: I follow the applications and latest developments in mathematics.</p> <p>I77: I can organize different learning activities for different</p>

Sub-Dimension	Number of Items	Items that Represent Sub-dimension
Pedagogical		technologies to be used in mathematics education.
Content		I79: With dynamic geometry software, I can show multiple representations of geometric concepts.
Knowledge		I81: I can arrange electronic worksheets that improve mathematical reasoning skills. I82: I can identify misconceptions in any learning field using Computer Algebra Systems and appropriate Dynamic Geometry and Mathematical Software

* Represents the omitted items in the scale.

In order to ensure the content validity of the data, the opinions of 3 experts who have dealt with scale development previously and a Turkish language expert to evaluate the related items in terms of language and narration are considered. After making the necessary editing in the scale in the direction of experts' views, the test form consisting remaining 84 items have been applied to 513 teacher candidates. However, after taking out the 58 scale forms which are incomplete and filled out randomly, 453 scale forms are used for analysis. Prior to the application, a guideline has been prepared for the teacher candidates who would respond to scale items, and the application is conducted face-to-face and verbal explanations are made when necessary.

In the arranged scale, the data is prepared in 5-point Likert scale type and the options are organized and pointed as "1-Strongly Agree", "2-Slightly Agree", "3-Neither Agree nor Disagree", "4-Slightly Disagree", "5-Strongly Disagree" respectively. There has been no item with negative expression.

There are seven dimensions, Technological Knowledge (1.-16. items), Content Knowledge (CK) (17.-23. items), Pedagogical Knowledge (PK) (24.-31. items), Pedagogical Content Knowledge (PACK) (32.-50. items), Technologic Content Knowledge (TCK) (51.-61. items), Technological Pedagogical Knowledge (TPK) (62.-71. items), Technological Pedagogical Content Knowledge (TPACK) (72.-84. items).

Analysis of Data

The data set obtained after the survey have been analyzed using SPSS 20 (Statistical Package for Social Sciences) and Amos 20.0 package programs. Descriptive statistics, Cronbach's Alpha reliability analysis, Confirmatory Factor Analysis (CFA) and correlation analysis techniques have been used in the data set analysis. Factor analysis can be used to indicate the theoretical structures underlying the particular data set and the extent to which these structures reflect real values (Henson and Roberts, 2006, as cited by: Bulbul, 2012, p.162). In order to test how many of the scales developed in the scale development studies gathered around which factors, firstly the Exploratory Analysis Factor (EFA) was constructed and then the Confirmatory Factor Analysis (CFA) have been used to test this structure.

CFA is an analysis to assess how well the various established variables are supported by a theoretical basis (Sumer, 2000). In other words, the CFA is based on testing the predictions that certain variables will predominantly be on predetermined factors based on a theory (Secer, 2015). CFA is used to test the presence of these theoretical constructs. The variables in CFA are selected in a predetermined pattern and the ratio of these variables in the determined factors are examined (Cakir, 2011). The TPACK model is the basis for this research. In other words, since the conceptual framework of TPACK already exists in the literature, the scale items are written around this existing frame in TPACK sub-dimensions. The sub dimensions of TPACK theory are identified as 7 sub-factors, TK, CK, PK, TCK, TPK and TPACK. For this reason, only Confirmatory Factor Analysis (CFA) has been performed on these predetermined factors in this study.

Findings

The Kaiser-Meyer-Olkin sampling adequacy criterion and the Bartlett test have been applied to determine the suitability of the data set for factor analysis and sample adequacy. For the factor analysis of sampling consisting 455 people in terms of size, first of all the suitability of the data set is examined and it was found that Kaiser Meyer Olkin (KMO) value is 0,96 and Barlett value is 27858.88. As the KMO value is higher than .70 and Barlett test value is significant ($p < .05$), the data set is evaluated as appropriate for factor analysis.

Table 2: KMO values table

Kaiser-Meyer-Olkin	0,962
Bartlett X2	27858,88
P	0,000

The confirmatory factor analysis results of TPACK scale

When the literature is reviewed, it is seen that there is a large number of fit index that are used to determine the adequacy of model tested in Confirmatory Factor Analysis (CFA). These are χ^2/df , RMSEA, SRMR, GFI, NFI, NNFI, AGFI indexes (Karademir, 2013). There is no consensus about which fit index will be accepted as standard (Tanguma, 2001; Munro, 2005; Simsek, 2007). In this study, Chi-Square Fit Test (χ^2), Degrees of Freedom (df), χ^2 / df , Standardized Root-Mean-Square Error (SRMR) exact fit indexes The Root-Mean-Square Error (RMSEA) are calculated and reported.

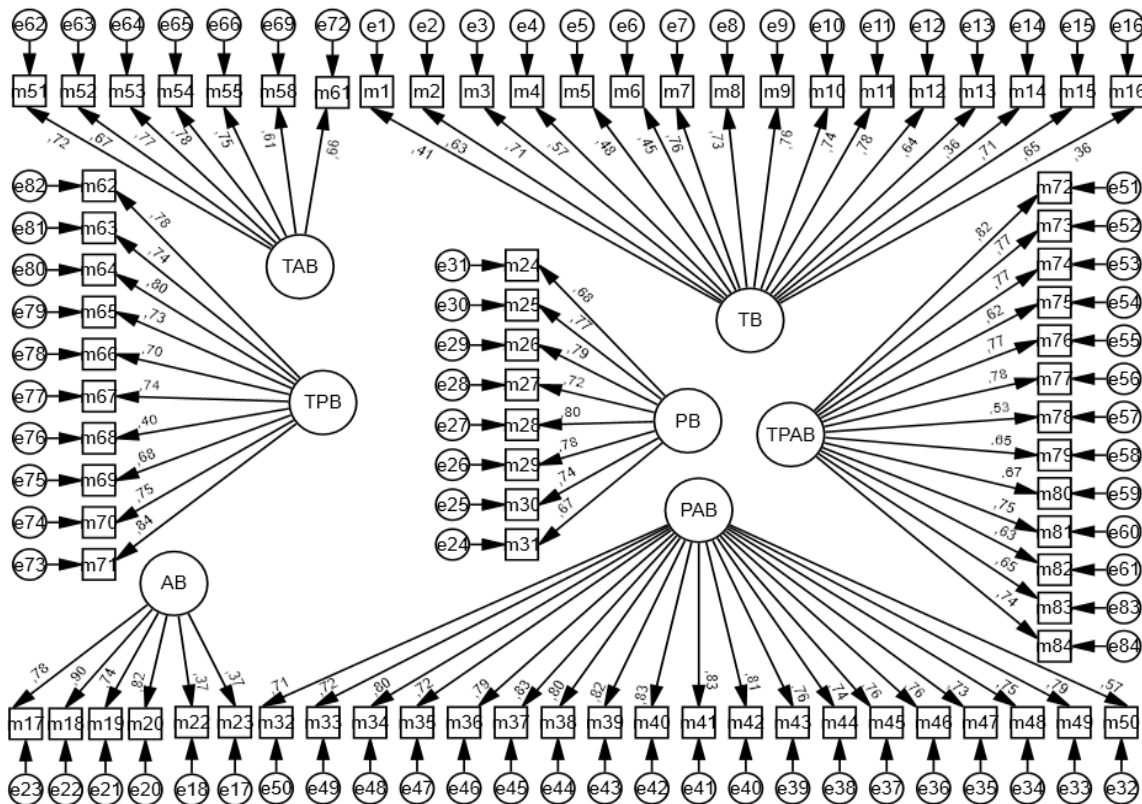


Figure 2: First CFA results of TPACK self-efficacy scale

The seven-factor structure of the scale, developed on the basis of the TPACK model, is tested with CFA. It is seen that the factor load of five items (m21, m23, m56, m57, m59) are below .30 in the CFA result and these items are removed from the data set. Then the CFA is performed again.

The fit value ($\chi^2 / Sd = 3.25$, RMSEA = .07, SRMR = .10) obtained with CFA indicates that the seven-factor model has been in accord with obtained data at acceptable levels (Browne & Cudeck, 1993; Carmines & McIver, 1981; Hooper, Caughlan and Mullen (2008). Less than 5 can be accepted for χ^2 / df value, and if $t\chi^2 / df$ value that it is less than 3 which, it means that the model has a perfect fit value (Kline, 2005, Tabachnick and Fidell, 2007). In addition, if the RMSEA value is less than 0,08, it means value has a good fit (Hoe, 2008), if SRMR value is a value between .05-.10, it means value is acceptable.

In order to obtain better fit values, the modification index values are examined and the correlations between the error values of the items under the same factor are released (Figure 3.2). Modification indexes show a decrease in the resulting Chi-square value shows that when a constant or a new parameter is added Chi square value decreases (Sumer, 2000). When the items are examined, semantic closeness is observed and it is reanalyzed after adding these modifications to the model. The fit values ($\chi^2 / Sd = 2.21$, RMSEA = .05, SRMR = .08) obtained after making the necessary modifications indicate that the collected data fit well with the seven-factor model (Browne and Cudeck, 1993; Carmines and McIver, 1981).

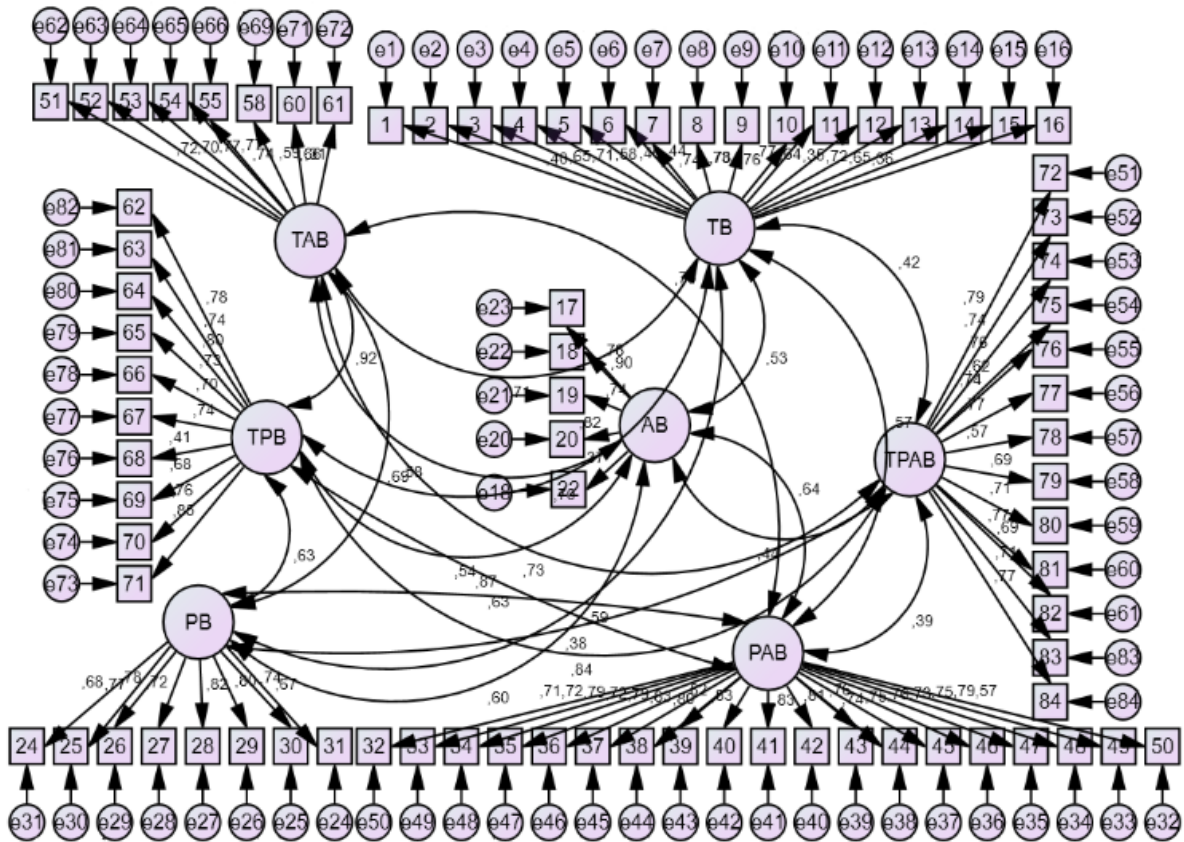


Figure 3: Second CFA Results of TPACK self-efficacy results

As a result of CFA, the factor loads of the items in the dimensions of CK, PCK, PK, TCK, TK, TPACK and TPCK are .37-.90, .57-.83, .67-.80, .61-.78, .36-.78, .53-.82 and .40-.84, respectively (Figure 3). Each factor load is found significant at .001 level.

The Relations between dimensions of TPACK scale

It is aimed to obtain information about the internal consistency of the scale by calculating the relations between the dimensions of the TPACK competency scale. For this, the relationships between the scale dimensions CK, PCK, PK, TCK, TK, TPACK and TPCK are analyzed using Pearson correlation technique. The findings are shown in Table 3.

Table 3: The mean, standard deviation values points obtained from the TPACK scale dimensions and the relation between the scale dimensions

Dimensions	X	Ss	PCK	TCK	TPACK	PK	TK	TPK
PCK	38,98	13,81						

Dimensions	X	Ss	PCK	TCK	TPACK	PK	TK	TPK
TCK	19,32	5,93	0,65*					
TPACK	37,29	10,73	0,33*	0,66*				
PK	17,57	5,90	0,81*	0,58*	0,32*			
TK	37,55	11,78	0,43*	0,63*	0,44*	0,47*		
TPK	24,86	8,03	0,58*	0,82*	0,76*	0,58*	0,63*	
CK	12,45	4,13	0,59*	0,52*	0,41*	0,56*	0,47*	0,49*

Table 3 shows the mean, standard deviation values points obtained from the TPACK scale dimensions and the correlation between the scale dimensions. If the correlation coefficient is between .70-1.00 absolute value, it is a high; if it is between .30-.70, it is a medium; if it is between .00-.30, it is a low relation (Buyukozturk, 2007: 32). The correlation values are found between .32-.82. When the correlation values are examined, it is seen that scale dimensions show high and medium level positive relations with each other. When Table 3 is examined, between TPACK and PCK, a high-level relation and between TCK and TK, a medium level relation is seen. The mean points obtained from 94 scale dimensions are 12.45 (Ss=4.13), 38.98 (Ss=13.81), 17.57 (Ss=5.9), 19.32 (Ss=5.93), 37.55 (Ss=10.73), 37.29 (Ss=10.73) and 24.86 (Ss=8.03) respectively for CK, PCK, PK, TCK, TK, TPACK and TPK dimensions.

Result of TPACK scale Cronbach Alpha Internal Consistency Reliability Analysis

It is seen that the calculated internal consistency coefficient for the overall scale is .98. As seen in Table 4, the coefficients of internal consistency calculated for CK, PCK, PK, TCK, TK, TPACK and TPK dimensions are .83, .97, .91, .85, .91, .94 and .91 respectively. These findings show that TPACK scale is a reliable data collection tool in different samples.

Table 4. Cronbach alpha coefficients calculated for TPACK scale dimensions

Dimensions	Cronbach Alfa
PCK	.97 (19 items)
TPACK	.94 (13 items)
PK	.91 (8 items)
TK	.91 (16 items)
TPK	.91 (10 items)
TCK	.85 (8 items)
CK	.83 (5 items)
Overall Scale	.98 (79 items)

Examination of discriminant validity of TPACK scale

Another way applied within the context of item analysis is to test the item mean points difference between the lower 27% and upper 27% groups using unrelated t-test. If the difference between the groups is significant in the desired direction, it is seen as the sign of consistency of test in terms of internal consistency (Buyukozturk, 2007:172). Item total correlation refers to the relationship between the point obtained from the test items and the point obtained from the overall test.

The discriminant validity study of the scale is conducted with data from 453 participants. In the first step of the discriminant validity study, participants are divided into two groups with 27% upper and lower according to the overall point of the scale. Then, the average point of these two groups are compared with the independent sample t test. When the results obtained are examined, it is seen that the average of points got from each item in CK, PCK, PK, TCK, TK, TPACK and TPK dimensions are significantly higher when compared to the points of participants in 27% group (Table 5)

When Table 5 is examined, it is seen that item-total correlations for all the items in the scale change between .33 and .86, and the t-values are significant ($p < .001$). In general, item total correlations of 0.30 and above indicate that items distinguish individuals well (Buyukozturk, 2010). From these results it can be said that the items in the measure are high in reliability and the items in each dimension of the scale are successful in distinguishing, in a word discriminating, the 27% upper and lower group. In other words, each item on the scale is sufficient to distinguish the people who it measures in terms of the dimensions (the features they measure).

Table 5: Total correlations of corrected items of TPACK scale and material and results of t test results of upper 27%, lower 27% points *

Correlated total item correction (CTIC)** $p < .01$							
Factor	Item	t	CTIC*	Factor	Item	T	CTIC*
TK	m1	6.92**	0.5	PCK	m43	10.28**	0.77
	m2	10.28**	0.69		m44	10.64**	0.78
	m3	10.43**	0.72		m45	12.08**	0.80
	m4	9.85**	0.63		m46	13.62**	0.80
	m5	8.68**	0.58		m47	13.67**	0.80
	m6	7.63**	0.54		m48	11.01**	0.80
	m7	11.10**	0.67		m49	10.79**	0.82
	m8	10.08**	0.64		m50	10.80**	0.63
	m9	8.55**	0.64		m51	14.45**	0.73
	m10	9.52**	0.62		m52	15.42**	0.76
	m11	11.75**	0.68		m53	16.17**	0.79
	m12	9.96**	0.68		m54	12.78**	0.78
	m13	8.43**	0.47		m55	11.90**	0.74
	m14	9.25**	0.57		m58	10.55**	0.57
	m15	9.25**	0.58		m60	10.28**	0.33
	m16	7.81**	0.42		m61	13.17**	0.64
CK	m17	10.80**	0.72	m62	16.79**	0.80	
	m18	11.65**	0.78	m63	18.32**	0.79	
	m19	10.52**	0.66	m64	15.95**	0.79	
	m20	10.36**	0.72	m65	12.52**	0.71	
PK	m22	8.46**	0.34	m66	13.30**	0.74	
	m24	9.71**	0.69	m67	13.81**	0.77	
	m25	10.34**	0.82	m68	10.42**	0.44	
	m26	11.08**	0.82	m69	16.40**	0.75	
	m27	9.95**	0.75	m70	16.96**	0.79	
	m28	11.28**	0.78	m71	18.71**	0.86	
	m29	12.23**	0.79	m72	19.45**	0.76	
	m30	12.52**	0.75	m73	16.41**	0.69	
PCK	m31	10.89**	0.67	m74	16.03**	0.78	
	m32	12.19**	0.73	m75	12.38**	0.67	
	m33	12.21**	0.76	m76	15.99**	0.77	
	m34	10.90**	0.82	m77	15.08**	0.76	
	m35	10.75**	0.76	m78	8.60**	0.64	
	m36	10.16**	0.82	m79	11.73**	0.75	
	m37	11.23**	0.85	m80	11.41**	0.77	
	m38	11.26**	0.83	m81	14.25**	0.79	
	m39	11.84**	0.85	m82	9.55**	0.73	
	m40	12.25**	0.85	m83	9.93**	0.75	

Factor	Item	t	CTIC*	Factor	Item	T	CTIC*
	m41	11.64**	0.84		m84	12.59**	0.78
	m42	11.99**	0.84				

Conclusion

The scale which is developed to measure the efficiency of mathematics teacher candidates is conducted with 453 teacher candidates studying at elementary and secondary school mathematics teaching departments of 4 different universities. Only Confirmatory Factor Analysis (CFA) is performed on the 7 accepted sub-factors (dimensions) of the TPACK theory. The final scale consists of 79 items, CK (5 items), TK (16 items), PK (8 items), PCK (20 items), TCK (8 items), TPK (10 items) and TPACK (12 items).

The calculated Cronbach Alpha coefficient for the general scale is .98 while this value changes between .81 and .97 in sub-dimensions. As a result, this shows that the reliability of the scale is high. In parallel with the results of the study, the Cronbach Alpha coefficient of the 27-item TPACK scale, which was adapted to Turkish by Dikkartin and Ovez (2013) after being applied to 473 preservice mathematics teacher, was found .91. Similarly, it was seen that the Cronbach Alpha coefficients of subscales of TPACK scale were ranging between .82 and .86 values.

When the results of the research are examined, a high correlation is found between PK and PCK and between TPK and TCK. TPACK has a high-level relation with TPK, and TCK has a medium level relation with TK. The scale developed by Timur (2011) indicated that low level correlation with TK and, PK with TK and CK but PK and CK were high level correlation.

This scale, which is developed to measure the TPACK efficiency of preservice mathematics teachers and consist of 79 items in the 5-point Likert type, is a reliable and valid measuring tool that can be used by both researchers and educators. It is also at the level that can be used to determine the efficiency of teacher candidates and teachers in the educational environments that will be designed within TPACK framework.

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