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Examining Turkish Pre-service Science Teachers' Technological Pedagogical Content Knowledge (TPACK) Based on Demographic Variables

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ABSTRACT

Technological pedagogical content knowledge (TPACK) can be viewed as a new concept for the educational technology world. However, there are many studies related to TPACK and TPACK cannot be considered out of context. Instead, researchers should have a deep understanding about how the results of a TPACK study may change due to its context. This study demonstrates the importance of context. The Survey of TPACK was utilized to identify 591 pre-service science teachers' (PSTs) TPACK levels and examine the validity and reliability of data obtained from 591 PSTs. Exploratory and confirmatory factor analyses were conducted for validity. After factor analyses a TPACK model with four factors (technological knowledge, content knowledge, knowledge of pedagogy, knowledge of teaching with technology) were obtained. There were, however, seven factors in the original form of the survey. This change was interpreted as the effect of the context, because the participants in the original survey and in this survey were different in terms of their teacher preparation programs and the opportunities that the teacher preparation programs provided for them. In addition, pre-service science teachers' TPACK levels were investigated on the basis of demographic variables (gender, owning computer, computer usage level and grade level). An important result obtained from the demographic variables is that pre-service science teachers' TPACK levels develop in direct proportion to their grade level. This finding supports the idea that experiences with technology and in teaching have a positive impact on TPACK.

Keywords: Pre-service Science Teachers, Technological Pedagogical Content Knowledge, TPACK Survey.

INTRODUCTION

The most important progress made in education in the last decade has been the integration of technology (Lee & Tsai, 2010). Instructional technology tools such as computers, data collecting and analyzing software, digital microscopes, hypermedia/multimedia, and interactive smart boards help students understand the nature of science and research, and obtain scientific knowledge. Using these tools in science classrooms also effectively and appropriately develops students' active participation in the process of

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producing information, thinking and learning problem-solving skills (Guzey & Roehrig, 2009).

Even though opportunities to access technology are increasing, teaching practices in the classroom are not showing the expected level of improvement (Inan & Lowther, 2009; Lim & Chai, 2008). Research findings show that pre-service teachers (PSTs) and beginning teachers are using technology in an inadequate way (Tondeur, Braak, Sang, Voogt, Fisser & Ottenbreit-Leftwich, 2012). Studies related to using technology reveal that teachers have a lack of knowledge about how they can effectively integrate technology into education, and their efforts are limited in terms of content, variety and depth (Koehler, Mishra, Kereluik, Shin & Graham, 2014).

It is important to link subject-specific technology and pedagogical principles to use technology effectively in classrooms. Starting from this point of view, Mishra and Koehler (2006) extended Shulman's idea of pedagogical content knowledge (PCK) by adding technology to PCK and developed the technological pedagogical content knowledge (TPACK) framework.

The TPACK Framework

Koehler and Mishra (2005) defined technological pedagogical content knowledge as the relationships between content knowledge, technological knowledge (e.g. computer, internet, digital video) and pedagogy knowledge (practices, processes, strategies, procedures and methods of teaching and learning). Niess (2005) reported that pre-service teachers' ability to integrate technology with PCK and their views about the nature of their disciplines are important for the development of technological pedagogical content knowledge. According to Archambault and Crippen (2009), TPACK includes relationships between students, teachers, contents, and technology and its applications.

The TPACK framework consists of three main domains: knowledge of content, pedagogy and technology. Knowledge bases, represented as pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK), and the relationships between these knowledge bases are equally important (Koehler & Mishra, 2009).

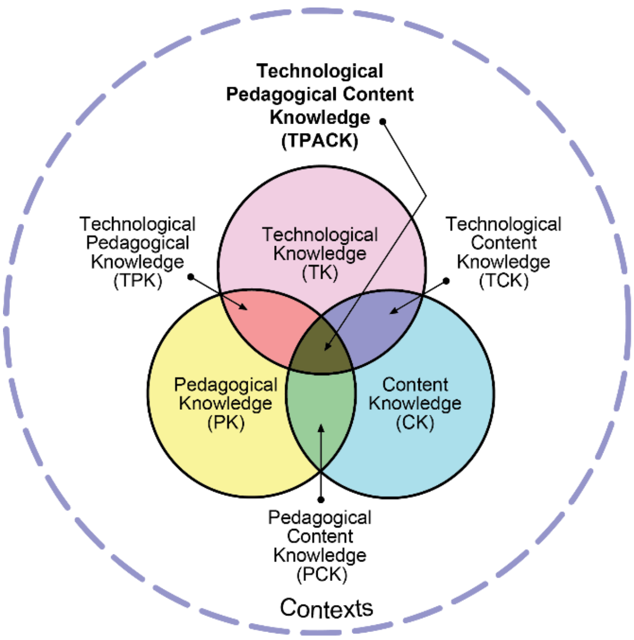

Figure 1. Components of the TPACK Framework (from tpack.org)

As seen in Figure 1, TPACK includes technology, pedagogy and content knowledge, and the intersections of these domains. The seven sub-domains of TPACK are described briefly as follows:

Technology Knowledge (TK): This includes internet, digital video, advanced technologies such as the different approaches used in providing information, as well as standard technologies like chalk, blackboard and book (Koehler, Mishra, & Yahya, 2007).

Pedagogy Knowledge (PK): Teaching and learning processes and practices including the goals of the teaching, teaching methods and strategies related to student assessment, classroom management and lesson plans are found in this sub-domain (Koehler, Mishra & Yahya, 2007; Sahin, 2011).

Content Knowledge (CK): Content knowledge is the teacher's knowledge about the subject matter that he/she teaches (Koehler & Mishra, 2009). According to Shulman (1986), content knowledge identifies knowledge and its organization in the minds of teachers.

Pedagogical Content Knowledge (PCK): PCK is the teacher's ability to transfer his/her knowledge to students in such a way as to make the content understandable to learners (Shulman, 1986; Zeidler, 2002). Shulman (1986) asserted that PCK includes teachers' understanding about what is easy or difficult in teaching specific content and that PCK distinguishes teachers from content experts.

Technological Pedagogical Knowledge (TPK): This knowledge focuses on the components and characteristics of existing technologies used in teaching and learning, and shows how particular technologies can be used in teaching (Harris & Hofer, 2011; Koehler et al., 2007).

Technological Content Knowledge (TCK): Technology and content have a deep historical relationship. Improvements in different disciplines such as medicine, history and archaeology are related to new technologies that support organizing and showing data in new and fruitful ways. For example, the viewing of X rays or the use of Carbon 14 in dating techniques is evidence of technology's effect on medicine and archaeology respectively (Koehler & Mishra, 2009). According to Harris and Hoffer (2011), TCK illuminates how to utilize technology in teaching and how to embody the basic laws of a specific content in the best way.

Technological Pedagogical Content Knowledge (TPACK): TPACK requires an understanding of how to formulate concepts and present them using technology; pedagogical techniques in teaching the subject matter while using technology in a constructive way; knowledge about what makes it difficult or easy to learn concepts and how technology engages with these issues; students' prior knowledge and epistemological/theoretical understanding; using technology to build new knowledge bases on existing ones and developing new epistemologies or strengthening the old ones (Koehler et al., 2007). Effective instruction with technology does not mean adding technology to the existing instruction and content. Instead, technology should enable new concepts to be defined and a developing sensibility of the dynamic relationships between the core elements of TPACK: Technology, pedagogy, and content (Koehler & Mishra, 2005). TPACK shows how to teach with subject-specific technologies in a way that will best support students' needs and choices, as well as embodying the topics (Harris & Hoffer, 2011).

The studies aiming to measure TPACK began with self-reported surveys about teachers' and PSTs' TPACK level (Schmidt, Baran, Thompson, Mishra, Koehler & Shin, 2009). Koehler, Shin and Mishra (2012) examined 303 publications including journal articles, and full texts of conference presentations and proceedings. They found 141 TPACK measurement tools after their revision. 31 of them were self-report measures, 20 of them were open-ended questionnaires, 31 of them were performance assessments, 30 of them were interviews and 29 of them were observations (Koehler et al., 2014).

Researchers mostly use the survey developed by Schmidt et al. (2009) (Chai, Koh, Tsai & Tan, 2011b; Koh & Chai, 2011; Koh, Chai & Tsai, 2010; Lin, Tsai, Chai & Lee, 2013). There is research that finds a factor number different from seven (Chai et al., 2011b; Koh et al., 2010), as well as research that finds a model consistent with the TPACK model that Mishra and Koehler (2006) proposed (Koh & Chai, 2011; Lin et al., 2013). Koh and Chai (2011) found seven sub-domains of TPACK with PSTs, and Lin et al. (2013) with both PSTs and in-service teachers. Contrary to these, Chai et al. (2011b) found five factors: *Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge of Meaningful Learning (PKML), Technological Pedagogical Knowledge (TPK)* and *Technological Pedagogical Content Knowledge (TPACK)*. Koh et al. (2010) studied with PSTs. They found the same number of factors as Chai et al. (2011b), but their factor constructs and names were different. They found a TPACK model with five factors: *Technological Knowledge (TK), Content Knowledge (CK), Knowledge of Pedagogy (KP), Knowledge of Teaching with Technology (KTT),* and *Knowledge from Critical Reflection (KCR).* Obtaining different factors when a survey was administered to different participants can mean that factors may change due to the characteristics of participants. Mishra and Koehler (2006) reported that data from TPACK studies should not be evaluated ignoring context. An important feature of the TPACK framework is that it is not separate from outer events and effects, rather it is grounded on the context (Koehler et al., 2014). Archambault and Barnett (2010) conducted research to examine the validity of the TPACK framework. They found that it is too difficult to distinguish the sub-domains and that Technology Knowledge is the only separable knowledge base. Also, they reported that measurement of TPACK is so complex and difficult to understand because it includes inseparable components. They obtained three factors (Pedagogical Content Knowledge, Technological Curriculum-content Knowledge, and Technological knowledge) in their study.

Gaps

There are very many studies that use surveys to measure TPACK (Archambault & Crippen, 2009; Burgoyne, Graham & Sudweeks, 2010; Graham, Burgoyne, Cantrell, Smith, St Clair & Harris, 2009; Koehler & Mishra, 2005; MaKinster, Boone & Trautmann, 2010; Schmidt et al., 2009; Sahin, 2011). Most of the studies that use surveys do not refer to reliability and validity (Koehler et al., 2014). A limited number of studies have performed factor analysis for construct validity (Archambault & Barnett, 2010; Archambault & Crippen, 2009; Burgoyne, 2010; Burgoyne et al., 2010; Lee & Tsai, 2010; Lux, 2010; Schmidt et al., 2009). It is necessary to provide construct validity for the components of the model when engaging theoretical frameworks like TPACK (Archambault & Crippen, 2009). However, the relationships between demographic variables of participants and their TPACK levels have not been elaborated sufficiently (Koh et al., 2010). The most commonly used demographic variable is gender (Jang & Tsai, 2012, 2013; Koh, Chai & Tsai, 2014; Lin et al., 2013).

Examining PSTs' technology, pedagogy and content knowledge and how they link these knowledge domains is a very important research topic. More studies about the measurement of relationships between TPACK sub-domains are needed because the TPACK framework is challenging (Archambault & Barnett, 2010). In this study, PSTs' TPACK levels and their *gender*, *owning computer*, *computer usage level* and *grade level* are investigated together. It is expected that this study will give a different perspective on TPACK to the educational world in terms of different demographic variables and the model obtained from factor analysis.

Taking into account these gaps, this study aims to:
(1)Identify PSTs' TPACK levels,
(2)Examine the validity and reliability of the Survey of Technological Pedagogical Content Knowledge (Sahin, 2011) in a different context, and
(3)Examine significant differences between PSTs' TPACK levels and their demographic variables.

METHODOLOGY

Cross-sectional survey research design was used in this study. This design is one of the most popular research designs used in educational studies (Christensen, Burke Johnson & Turner, 2014; Creswell, 2012). In this study, it was proposed to describe and correlate PSTs' effectiveness with regard to Technological Pedagogical Content Knowledge (TPACK) and their demographic variables. A survey (likert scale) was utilized for the purpose of collecting data. To enhance the validity of data obtained, researchers contacted PSTs one by one, used paper and pencil surveys; gave them enough time to complete the survey and helped them by explaining points with which they had difficulty (Christensen et al., 2014). All of the data collecting processes were carried out by researchers. The aim was thus to gain honest and accurate answers from the PSTs.

Participants

The participants in this study were 591 pre-service science teachers studying at a state university in a small rural city in central Anatolia. Universities in Turkey are administered by the *Council of Higher Education (CoHE)*. According to *Higher Education Statistics* there were 23 360 (N_{male}=6 998; N_{female}= 16 362) pre-service science teachers in the colleges of education in 2013 (CoHE, 2013). It was assumed that participants represent PSTs across Turkey for two reasons. First, if the size of population (N) is 23 360, deviation amount (d) .05 and reliability level is .95 (α=.05), the sample size needs to be at least 377 (Chow, Shao, & Wang, 2003; Cohen, Manion, & Morrison, 2007). Starting from this point of view, it can be said that the size of our sample (n=591) was enough to provide external validity (i.e. to represent the population) (Christensen et al., 2014; Levy & Lemeshow, 1999). Second, participants were determined via random sampling in which all of the individuals had the same opportunity to participate in the study and choosing one of them did not affect the others (Christensen et al., 2014). This study tried to predict the efficacies of PSTs with regard to TPACK by using multiple variables. Participants' characteristics relating to their grade and gender are given below in Table 1. About 70% of the participants were female (N=413). More than half of PSTs (N=373; 63%) owned their own computer.

Table 1. *Participants' demographic variables*

Department	Grade			Gender			Owning A Computer			
							Yes		No	
		N	%		N	%	N	%	N	%
Pre-service Science Teachers	Freshman	145	25	Male	32	5	18	5	14	6
				Female	113	19	46	12	67	31
	Sophomore	141	24	Male	33	6	25	7	8	4
				Female	108	18	64	17	44	20
	Junior	173	29	Male	50	8	35	9	15	7
				Female	123	21	89	24	34	15
	Senior	132	22	Male	63	11	42	11	21	10
				Female	69	12	54	15	15	7
Total		591	100		591	100	373	100	218	100

Data Collection Tool

The survey used for this study consisted of two sections:

The Survey of Technological Pedagogical Content Knowledge: The original form of the survey developed by Sahin (2011) consisted of 47 items and seven factors [TK (15 Items), PK (6 Items), CK (6 Items), TPK (4 Items), TCK (4 Items), PCK (7 Items) and TPACK (5 Items)]. The survey was developed through five stages: item pool, validity and reliability, discriminant validity, test-retest reliability and translation. In the beginning there were 60 items in the item pool. After views were taken from 10 experts, 47 items remained. A form including 60 items was created and experts were asked to decide on one of three options (‘fully measuring’, ‘somewhat measuring’ or ‘not measuring’) for each item. The survey was in the form of 5 point Likert type (1=not at all, 2=little, 3=moderate, 4=quite, and 5=complete).

The Cronbach’s alpha coefficient was used for the reliability of the scale. Sahin (2011) found internal consistency scores to be .93 for TK, .90 for PK, .86 for CK, .88 for TPK, .88 for TCK, .92 for PCK and .92 for TPACK. According to the test-retest reliability scores, the reliability coefficient was found to be .80 ($p< .01$) for the TK subscale, .82 ($p< .01$) for the PK subscale, .79 ($p< .01$) for the CK subscale, .77 ($p<.01$) for the TPK subscale, .79 ($p< .01$) for the TCK subscale, .84 ($p<.01$) for the PCK subscal, and .86 ($p<.01$) for the TPACK subscale.

Personal Information Form (PIF): The PIF included information about the PSTs’ gender and grade levels. In this section PSTs were also are asked whether they had their own computers (Yes/No) and asked to choose one of the level options from ‘beginning’, ‘intermediate’, ‘good’ or ‘advanced’(e.g. Muslu Kaygısız, Baglıbel & Samancıoglu, 2011). Gender affects the perspectives of pre-service teachers about computer usage (Teo, 2008), and the most common demographic variable examined in participants’ TPACK has been gender (Archambalt & Barnett, 2010; Jang & Tsai, 2012; Koh et al., 2010; Lee & Tsai, 2010; Lin et al., 2013; Schmidt et al., 2009; Tsai, 2008). In view of the fact that participants were living in a different sociocultural structure from the participants in other studies mentioned below, it was decided that gender would be included in the Personal Information Form.

It was expected that those who had sufficient technological knowledge would be able to demonstrate an improvement in their TPACK levels (Chai, Koh & Tsai, 2010). Kartal, Kartal and Uluay (2016) found that the level of computer usage is a strong predictor of the TPACK sub-domains. For this reason, factors affecting technological knowledge such as owning computer and computer usage levels were included in the PIF (Mathews & Guarino, 2000; Robinson, 2003).

Those in the pre-service years gain experience and knowledge of their disciplines, pedagogical approaches and technological applications during their time in teacher preparation programs. Mathews and Guarino (2000) found that the teachers’ year of experience had a direct effect on computer proficiency. It can be assumed that pre-service teachers’ years of experience may be taken as their grade levels. So the grade level was the last demographic variable in the PIF.

Data analysis

The Statistical Package for the Social Sciences (SPSS) and the Linear Structural Relation Statistics Package (LISREL) were used in analyzing the data. All of the PSTs’ answers for each item were examined and missing values were taken out of the data set before starting analysis. The reliability and validity of the survey were provided for with a step-by-step approach. Researchers decided to perform exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) with their data because they thought that the participants of the original survey and the participants of this study were different in terms of education they had been receiving. First, EFA was performed with the SPSS. In the EFA process, the convenience of the data set for factor analysis (e.g., sample size, missing data, normality, Kaiser-Meyer-Olkin and Barlett's test of sphericity) was first examined (Field, 2009; Tabachnick & Fidell, 2013). In determining the factor numbers, principal component analysis and varimax kaiser normalization were used. The items which had eigenvalues above 1 and factor loadings equal to and above .5 were kept in the survey and items with cross loadings were omitted. Second, CFA was carried out with the help of LISREL to make sure of the survey's construct validity. CFA was seen as the natural extension of EFA (Lee, 2007). CFA aims to reveal the latent construct of the items in the survey (Brown, 2015). The findings of the survey obtained from CFA were evaluated according to different fit indexes. The evaluation began with the significance level (p) for chi-square (χ^2) and the chi-square per degree of freedom (χ^2/df). Also, the root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), root mean squares residuals (RMR), normed fit ındex (NFI), non-normed fit index (NNFI), comparative fit index (CFI), goodness of fit (GFI) and adjusted goodness of fit-index (AGFI) were calculated. The Item Discrimination Statistics test and Corrected Item-Total Correlation test were used for reliability. In addition, the Cronbach's alpha of each factor in the survey and correlation between factors were examined. Whether the scores of PSTs differed due to demographic variables was tested with the independent-sample t test (e.g., gender, owning computer) and One-Way Anova (e.g., computer usage level, grade level). To determine the source of significance in One-Way Anova, the Tukey test was used. In the case of a significant difference in demographic variables, the effect size was examined. Cohen's d for t test and eta-square *(η^2)* for One-Way Anova were calculated for the effect size of differences. Finally, multiple regression analysis was performed to examine which items predicted PSTs Knowledge of Teaching with Technology (KTT) and to what extent.

RESULTS AND DISCUSSION

Construct validity of the survey

EFA and CFA were conducted to provide the construct validity of survey. Factor analysis proposes to formulate unrelated and meaningful new factors, gathering a great number of interrelated variables (Field, 2009; Tabachnick & Fidell, 2013). The availability of the data set for factor analysis was examined in terms of (a) sample size and missing data, (b) normality, (c) linearity, (d) Kaiser-Meyer-Olkin (KMO) and Barlett's test of sphericity (BToS).

There are different views about the sufficient sample size for factor analysis. According to Comrey and Lee (1992) and Field (2009), a sample of 300 is enough to conduct factor analyses, while some researchers (Kline, 1994; Tabachnick & Fidell, 2013) find a sample of 200 enough. It is generally known that a sample size should be at least ten times the number of items and that this is important for construct validity. Taking into account all of these, we can say that the sample size was sufficient to perform factor analysis. The Kolmogrow-Simirnov (Lilliefors) test was used for normal distribution of data. According to the test results, the data had a normal distribution (Z=.818, p>.05). Linearity between variables was provided with scatter plots (Tabachnick & Fidell, 2013). KMO value was calculated as .968. For a good factor analysis, a KMO value larger than .60 is suggested (Kaiser, 1974; Sharma, 1996; Tabachnick & Fidell, 2013). The KMO value can have a value between 0 and 1, and is interpreted as 'normal' if it is between .60 and .70; as 'good' if it is between .70 and .80; as 'very good' if it is between .80 and .90; and as 'excellent' if it is equal to or larger than .90 (Field, 2009; Sharma, 1996; Tabachnick & Fidell, 2013). When taking into consideration the results of Barlett's Test of Sphericity (Chi-square=15,619.465, df=820; p<.001), it was seen that data were available for factor analysis.

To determine the new factors, principal component analysis and varimax with Kaiser normalization were utilized (Field, 2009; Tabachnick & Fidell, 2013). In the EFA, 6 items (CK1, CK2, TK14, TPK1, TPK2, TCK2) with eigenvalues less than 1 (Tabachnick & Fidell, 2013), factor loadings less than .5 (e.g., Kartal et al., 2016; Koh et al., 2010; Lee & Tsai, 2010) or cross-loadings (e.g., Koh et al., 2010; Lee & Tsai, 2010; Lux, 2010) were omitted from survey. After omitting each item, factor analysis was conducted again. At the end of the EFA, the remaining 41 items formed four factors. TPK (TPK3 and TPK4), TCK (TCK2, TCK3, TCK4) and TPACK (TPACK1, TPACK2, TPACK3, TPACK4 and TPACK5) constituted the first factor; TK (except TK14) constituted the second; PK and PCK the third and CK (except CK1 and CK2) formed the forth factor (Table 3). Koh et al. (2010) labeled the factor including TPK, TCK, and TPACK as *Knowledge of Teaching with Technology (KTT)*; the factor including PK and PCK as *Knowledge of Pedagogy (KP).* These new factor names were used in this study (Tables 2 and 3). The final form of survey had 41 items and 4 factors (KTT, TK, KP and CK). These four factors explain 58.523% of the total variance. Eigenvalues, percentage of variance and percentage of cumulative variance values about factors are given below in Table 2.

Table 2. *Total variance after rotated component matrix*

Factor	Eigenvalues	Percentage of Variance (%)	Percentage of Cumulative Variance (%)
Knowledge of Teaching with Technology (KTT)	9.504	23.181	23.181
Technological Knowledge (TK)	7.619	18.583	41.764
Knowledge of Pedagogy (KP)	4.009	9.779	51.543
Content Knowledge (CK)	2.862	6.980	58.523

If the variance for each factor is less than 5%, this means that the maximum factor number is gained in explaining total variance. Henson and Robert (2006) reported that the total variance explained by factors should be at least 52%, Kline (1994) argued this value should be at least 40% and Streiner (1994) at least 50%. In similar studies (Archambault & Barnett, 2010; Kartal et al., 2016; Scherer, Wiebe, Luther & Adams, 1988; Schmidt et al., 2009), it is seen that the total variance after factor analysis is equal to and more than 50%. As a result, the total variance of this study may be seen as sufficient.

In the factor analysis, no items were omitted from the PK and PCK domains. But these domains came together and formed a new factor. This may be because PSTs could not distinguish the items. This new factor is called *Knowledge of Pedagogy* (Koh et al., 2010). Similarly, PSTs could not distinguish TPK (TPK1 and TPK2 omitted), TCK (TCK1 omitted) and TPACK items, so these three domains formed a new factor called *Knowledge of Teaching with Technology* (Koh et al., 2010). Factors and items' factor loadings are given in Table 3. When the studies that perform construct validity are reviewed, there are models with seven factors (Lin et al., 2013; Kartal, et al., 2016; Koh, Chai & Tsai, 2013; Koh et al., 2014) as well as models with different numbers of factors (Chai et al., 2011b; Chai, Koh & Tsai, 2011a; Koh et al., 2010). In the second group, the most attention-grabbing is the research of Chai et al. (2011a). Although the original TPACK framework has seven sub-domains, they find eight sub-domains in their study. They obtained these eight factors because content knowledge (CK) was divided into two parts called CKCS1 (the first teaching subject), and CKCS2 (the second teaching subject).

Table 3. *Factor loading from exploratory analysis, and reliability values*

		Common Factor loading	Rotated Factor loading
Factor 1 – Content Knowledge (CK, α= .817)			
1	CK3-Following recent developments and applications in my content area	.667	.551
2	CK4-Recognizing leaders in my content area	.599	.695
3	CK5-Following up-to-date resources (ex, books, journals) in my content area	.589	.668
4	CK6-Following conferences and activities in my content area	.539	.666
Factor 2 – Technological Knowledge (TK, α= .933)			
5	TK1-Solving a technical problem with the computer	.515	.722
6	TK2-Knowing about basic computer hardware (ex., CD-Rom, mother-board, RAM) and their functions	.546	.697
7	TK3-Knowing about basic computer software (ex., Windows, Media Player) and their functions	.563	.775
8	TK4-Following recent computer technologies	.518	.649
9	TK5-Using a word-processor program (ex., MS Word)	.575	.773
10	TK6-Using an electronic spreadsheet program (ex., MS Excel)	.529	.706
11	TK7-Communicating through Internet tools (ex., e-mail, MSN Messenger)	.541	.717
12	TK8-Using a picture editing program (ex., Paint)	.569	.738
13	TK9-Using a presentation program (ex., MS Powerpoint)	.640	.756
14	TK10-Saving data into a digital medium (ex., Flash Card, CD, DVD)	.625	.699
15	TK11-Using area-specific software	.642	.576
16	TK12-Using printer	.623	.649
17	TK13-Using projector	.600	.619
18	TK15-Using digital camera	.564	.589
Factor 3 – Knowledge of Pedagogy (KP, α= .930)			
19	PK1-Assessing student performance	.690	.668
20	PK2-Eliminating individual differences	.675	.679
21	PK3-Using different evaluation methods and techniques	.720	.679
22	PK4-Applying different learning theories and approaches (ex, Constructivist Learning, Multiple Intelligence Theory, Project-based Teaching)	.682	.629
23	PK5-Being aware of possible student learning difficulties and misconceptions	.656	.669
24	PK6-Managing class	.610	.585
25	PCK1-Selecting appropriate and effective teaching strategies for my content area	.687	.656
26	PCK2-Developing evaluation tests and surveys in my content area	.671	.650
27	PCK3-Preparing a lesson plan including class/school-wide activities	.667	.712
28	PCK4-Meeting objectives described in my lesson plan	.691	.706
29	PCK5-Making connections among related subjects in my content area	.666	.703
30	PCK6-Making connections between my content area and other related courses	.668	.702
31	PCK7-Supporting subjects in my content area with outside (out-of-school) activities	.699	.699
Factor 4 – Knowledge of Teaching with Technology (KTT, α= .919)			
32	TPK3-Being able to select technologies useful for my teaching career	.708	.549
33	TPK4-Evaluating appropriateness of a new technology for teaching and learning	.708	.509
34	TCK2-Using technologies helping to reach course objectives easily in my lesson plan	.738	.595
35	TCK3-Preparing a lesson plan requiring use of instructional technologies	.702	.647
36	TCK4-Developing class activities and projects involving use of instructional technologies	.702	.628
37	TPACK1-Integrating appropriate instructional methods and technologies into my content area	.720	.726
38	TPACK2-Selecting contemporary strategies and technologies helping to teach my content effective	.705	.733
39	TPACK3-Teaching successfully by combining my content, pedagogy, and technology knowledge	.690	.759
40	TPACK4-Taking a leadership role among my colleagues in the integration of content, pedagogy, and technology knowledge	.603	.666
41	TPACK5-Teaching a subject with different instructional strategies and computer applications	.680	.733

The common factor loadings of items were between .515 and .738; their rotated factor loadings were between .509 and .775. Cronbach's alpha was calculated to be .817 for Content Knowledge (CK); .933 for Technological Knowledge (TK); .930 for Knowledge of Pedagogy (KP) and .919 for Knowledge of Teaching with Technology (KTT).

The model obtained from the EFA was tested with CFA with LISREL. The sample size was sufficient for CFA (Kline, 2005; Schermelleh-Engel, Moosbrugger & Müleer, 2003). Statistics related to the model-data fit are given in Table 4.

Table 4. *Fit values and standard fit criteria*

Index	Good Fit Values	Acceptable Fit Values	Survey Fit Values
χ^2	$0 \le \chi^2 \le 3df$	$3df < \chi^2 \le 5df$	1,738.78
p value	$.05 \le p \le 1.00$	$.01 \le p \le .05$	.048
χ^2/df	$0 \le \chi^2/df \le 3$	$3 < \chi^2/df \le 5$	3.184
RMSEA	$0 \le RMSEA \le .05$	$.05 < RMSEA \le .08$	.038
SRMR	$0 \le SRMR \le .05$	$.05 < SRMR \le .10$	.044
RMR	$0 \le RMR \le .05$	$.05 < RMR \le .10$	.047
NFI	$.95 \le NFI \le 1$	$.90 < NFI < .95$	.96
NNFI	$.97 \le NNFI \le 1$	$.95 \le NNFI < .97$	.92
CFI	$.97 \le CFI \le 1$	$.95 \le CFI < .97$	.94
GFI	$.95 \le GFI \le 1$	$.90 \le GFI < .95$	.98
AGFI	$.90 \le AGFI \le 1$	$.85 \le AGFI < .90$	.90

Results in Table 4 were examined in two parts. The first part used *Descriptive Measures of Overall Model Fit* and the second part used *Descriptive Measures Based on Model Comparisons*. Significant difference occurred at an acceptable level according to values (χ^2=1,738.78; p=.048). However, it is expected that χ^2 between fit indexes will not be significant and the null hypothesis will be accepted (Schermelleh-Engel et al., 2003). Although the significance level of χ^2 was too close to the acceptable upper limit, it was seen that the p value was significant. The reason for this situation may be that χ^2 is considerably sensitive to sample size. As sample size increases, the significant level of the p value will increase. On the other hand, reducing the sample size makes χ^2 decrease and it will show a level at which model is not significant (p>.05). Therefore, Jöreskog and Sörbom (1993) suggested not using χ^2 alone, but instead to compare the expected value of the sample distribution (e.g., df value) with χ^2. In this study χ^2/df was calculated as 1,738.78/546=3.184. This value can be considered as an acceptable fit level (Kline, 2005; Schermelleh-Engel et al., 2003). Because of χ^2 value's sensibility to sample size, alternative fit indexes were examined. Good fit and acceptable fit value ranges related to these indexes are shown in Table 4 (Brown, 20015; Chermelleh-Engel et al., 2003; Jöreskog & Sörbom, 1993; Kline, 2005; Tabachnick & Fidell, 2013). Root Mean Square Error of Approximation (RMSEA) was found to be .038; Standardized Root Mean Square Residual (SRMR) to be .044 and Root Mean Squares Residual (RMR) to bes .047; Normed Fit Index (NNFI) to be .92; Comparative Fit Index (CFI) to be .94; Goodness of Fit (GFI) to be .98; Adjusted Goodness of Fit-Index (AGFI) to be .90. It can be agreed that these values confirmed the model.

Reliability of the survey

To evaluate the reliability of items, item discrimination and the Corrected Item-Total Correlation test were investigated (e.g. Aydın & Kara, 2013). 27% (n_{upper}=160) of the participants who had the highest scores were considered as the upper group, 27% (n_{lower}=160) of them who had the lowest scores were considered as the lower group, and for each item the significance of difference between the upper and lower groups was examined by t-test (Kelley, 1939). The Item Total Correlation was calculated with the Pearson Product-Moment Correlation coefficient test (Tabachnick & Fidell, 2013). According to the item analysis given in Table 5, there was no change in the number of items. When taking into consideration the items' t-test, it was clear that item correlation values were between .684 and .825 and that each item in the scale significantly discriminated the individuals belonging to the lower and upper groups (p<.01). Items were compatible with the whole survey and it can be assumed that they measure what they aimed to measure. The item of "Recognizing leaders in my content area" (CK, Item 2) had the highest and the item of "Using a digital camera" (TK, Item 18) had the lowest item-total correlation (Table 5).

Table 5. *Means of the items, standard deviations, t-test results and item total correlations*

Survey Item	Subscale	Mean	Standard Deviation	t (Up-low-27-percent group)	Corrected Item-Total Correlation
1	CK	3.079	.872	17.548[a]	.793[a]
2	CK	2.890	.913	16.902[a]	.825[a]
3	CK	2.903	.901	16.650[a]	.822[a]
4	CK	2.639	.879	16.264[a]	.774[a]
5	TK	2.543	.985	11.812[a]	.733[a]
6	TK	2.966	1.022	12.688[a]	.723[a]
7	TK	3.321	1.020	13.610[a]	.779[a]
8	TK	2.839	1.001	12.341[a]	.690[a]
9	TK	3.516	1.024	13.550[a]	.767[a]
10	TK	3.318	1.003	11.635[a]	.697[a]
11	TK	3.835	.939	13.146[a]	.730[a]
12	TK	3.722	.976	13.453[a]	.751[a]
13	TK	3.793	1.034	15.547[a]	.794[a]
14	TK	3.900	1.063	15.422[a]	.754[a]
15	TK	2.912	.991	16.097[a]	.702[a]
16	TK	3.225	1.156	16.438[a]	.743[a]
17	TK	2.939	1.158	14.787[a]	.719[a]
18	TK	3.477	1.122	13.620[a]	.684[a]
19	KP	3.138	.993	16.771[a]	.733[a]
20	KP	3.160	.949	16.511[a]	.738[a]
21	KP	3.098	.960	19.126[a]	.770[a]
22	KP	3.067	1.009	17.978[a]	.745[a]
23	KP	3.047	.921	15.769[a]	.739[a]
24	KP	3.287	.941	15.971[a]	.708[a]
25	KP	3.214	.892	16.713[a]	.746[a]
26	KP	3.267	.903	16.269[a]	.735[a]
27	KP	3.103	.962	15.842[a]	.729[a]
28	KP	3.148	.874	16.813[a]	.744[a]
29	KP	3.262	.873	17.075[a]	.730[a]
30	KP	3.360	.888	16.525[a]	.732[a]
31	KP	3.326	.926	18.358[a]	.734[a]
32	KTT	3.404	.883	16.539[a]	.745[a]
33	KTT	3.243	.864	17.150[a]	.731[a]
34	KTT	3.138	.915	19.804[a]	.775[a]
35	KTT	3.033	.978	17.545[a]	.751[a]
36	KTT	3.088	.938	18.301[a]	.759[a]
37	KTT	3.228	.924	19.106[a]	.784[a]
38	KTT	3.191	.929	18.149[a]	.780[a]
39	KTT	3.184	.959	17.894[a]	.791[a]
40	KTT	2.994	.975	16.208[a]	.720[a]
41	KTT	3.257	.919	17.332[a]	.774[a]

[a]p<.01, ($N=591$, $N_1= N_2=160$)

The highest and the lowest mean scores were in Technological Knowledge (Table 5). The item for which PSTs had the highest mean is "Saving data into a digital medium (e.g., Flash Card, CD, DVD)" (TK, Item 14) (M=3.900; Sd=1.603), and the lowest was "Solving a technical problem with the computer" (TK, Item 5) (M=2.543; Sd=.985).

Correlation and regression analyses

Pearson product-moment correlation coefficient and effect size values between factors (CK, TK, KP, KTT) are given in Table 6.

Table 6. *Correlations among subscales*

Survey Subscales	CK (4 Items)	TK (14 Items)		KP (13 Items)		KTT (10 Items)	
			r^2		r^2		r^2
Content Knowledge (CK)	-	.469[a]	.220	.665[a]	.442	.659[a]	.434
Technology Knowledge (TK)		-		.538[a]	.289	.556[a]	.309
Knowledge of Pedagogical (KP)				-		.851[a]	.724
Knowledge of Teaching with Technological (KTT)						-	
Mean	2.878	3.307		3.191		3.176	
Standart Deviation	.716	.759		.685		.706	

[a]p<.01

As seen in Table 6, there was a positive correlation at a high level between KTT-CK (r=.659; p≤.001); KTT-TK (r=.556; p≤.001) and KTT-KP (r=.851; p≤.001). PSTs' KTT levels had a strong correlation with CK, TK, and KP levels. Also there was a positive correlation at a high level between KP-CK (r=.665; p≤.001); and between KP-TK (r=.538; p≤.001). Determination values were investigated to find out the extent to which factors explain the variance of KTT and KP (Table 6). 43.4% of the total variance of KTT stemmed from CK (r^2 =.434; large effect); 30.3% from KP (r^2=.303; large effect); 72.4% from KP (r^2=.724; large effect). However 44.2% of the total variance of PSTs' KP derived from CK (r^2=.442; large effect) (e.g., Cohen, 1988, 1992, 1994; Field, 2009; Muijs, 2004; Rosnow & Rosenthal, 1996). Determination values related to correlation coefficients were mainly at the 'large effect' level. Similarly to these findings, Archambault and Crippen (2009) found a low correlation between technology and content (r=.323; p<.01), and technology and pedagogy (r=.289, p<.01), but they found a high correlation between pedagogy and content (r=.690; p<.01) and they reported that the low relationships between technology and pedagogy, technology and content were to be expected. Lin et al. (2013) found high and statistically significant correlation between TPC and TCK (.83), TPK (.76), and TK (.70) among science teachers. They reported that teachers with higher self-confidence in TPACK felt the same in the factors involving technology (e.g., Technological Content Knowledge, Technological Pedagogical Knowledge, and Technological Knowledge). Also there was a comparatively weaker correlation between PCK and TPC (.30), TCK (.36), TPK (.32), and TK (.29) in science teachers.

In the study, the PSTs found themselves the most proficient in Technological Knowledge (Mean=3.307; Sd=.759) and the least proficient in Content Knowledge (Mean=2.878; Sd=.716). This correlation was especially prevalent between KTT and other factors. Chai et al. (2010) found a moderate effect between TPACK and TK, PK, and CK and determined that the PK of PSTs had an important impact on their TPACK due to the stepwise regression model on the pre-test and post-test scores. Based on this result, it can be determined that integrating technology into teaching is related to PSTs' knowledge of pedagogy. Multiple regressions were used to determine the extent to which items of CK, TK and KP predict PSTs' KTT. The assumptions of multiple regressions (normal distribution, linearity, constant variance, absence of multiple connections between independent variables) were provided by carrying out necessary evaluations on the data set (Tabachnick & Fidell, 2013). Regression analysis results for each item that predicted PSTs' KTT levels are shown in Table 7.

Table 7. *Beta and Adjusted R^2 results of regression analyses*

		KTT (Beta)	Adjusted R^2
TK	Using a presentation program (ex., MS Powerpoint)	.124[a]	.015
	Saving data into a digital medium (ex., Flash Card, CD, DVD)	.128[b]	.016
	Using area-specific software	.222[c]	.049
	Using printer	.144[b]	.021
	Using projector	.104[a]	.011
KP	Assessing student performance	.090[b]	.008
	Being aware of possible student learning difficulties and misconceptions	.074[a]	.005
	Selecting appropriate and effective teaching strategies for my content area	.143[c]	.020
	Developing evaluation tests and surveys in my content area	.142[c]	.020
	Preparing a lesson plan including class/school-wide activities	.113[c]	.013
	Meeting objectives described in my lesson plan	.177[c]	.031
	Making connections among related subjects in my content area	.113[c]	.013
	Making connections between my content area and other related courses	.075[a]	.006
	Supporting subjects in my content area with outside (out-of-school) activities	.155[c]	.024
CK	Recognizing leaders in my content area	.343[c]	.118
	Recognizing leaders in my content area	.114[b]	.013
	Following up-to-date resources (ex, books, journals) in my content area	.185[c]	.034
	Following conferences and activities in my content area	.182[c]	.033

[a]p<.05, [b]p<.01, [c]p<.001

Analyses were conducted with items that formed a statistically significant difference on KTT (e.g., .05, .01 or .001 significance level). CK, KP and TK were predictors of KTT, but mainly of CK. In the CK factor the highest predictor item was "Recognizing leaders in my content area" (β=.343; p<.001). This item predicted 11.8% of KTT. The highest predictor in the TK factor was "Using area-specific software" (β=.222; p<.001) which predicted 4.9% of KTT. Finally, the highest predictor item for the KP factor wass "Meeting objectives described in my lesson plan" (β=.177; p<.001) and this item predicted 3.1% of KTT.

Examining sub-scales according to demographic variables

Different factors formed when factor analysis were performed with developed or adopted surveys (Archambault & Barnett, 2010; Chai et al., 2010, 2011b; Koh et al., 2010; Lee & Tsai, 2010; Sahin, 2011; Schmidt et. al., 2009). The presumed reason for this situation is that the different contexts in which studies were conducted led to different factors being revealed. Context is as important as other TPACK sub-domains (TK, PK, CK, TPK, TCK, PCK, and TPACK) (Niess, 2013). Kelly (2008) indicated that the components of TPACK context were a school's philosophy and expectations; the demographic characteristics of students and teachers; teachers' knowledge, skills and disposition; cognitive, experimental, physical, psychological, social characteristics of students and teachers and the physical features of the classroom. However, a gap in the literature is the lack of analysis related to contextual components such as gender and grade level. Researchers (Kartal et al., 2016; Koh et al. 2010; Lee & Tsai, 2010) have addressed the lack of studies about relationships between

TPACK and demographic variables. With the aim of filling this gap, the PSTs' mean scores for CK, TK, KP and KTT were examined with reference to their gender, grade level, owning computer and computer usage level. The results with regard to PSTs' gender are given in Table 8.

Table 8. *Results of t-test and Cohen's d according to gender variable*

	Gender	N	Mean	Standard Deviation	t	p	Cohen's d
KTT	Male	178	3.280	.738	2.354	.019[a]	.211
	Female	413	3.131	.618			
KP	Male	178	3.256	.604	1.519	.129	-
	Female	413	3.163	.716			
TK	Male	178	3.490	.806	3.882	.000[b]	.349
	Female	413	3.229	.725			
CK	Male	178	2.931	.717	1.181	.238	-
	Female	413	2.855	.715			

[a]p<.05, [b]p<.001

Even though 70% of the participants (N=413) were female, the results in TK (t=3.882; p<.05) and KTT (t=2.354; p<.001) were in favor of male participants. The effect size of this significant difference in TK (d=.349) and KTT (d=.211) was small (Cohen, 1988, 1992, 1994; Rosenthal & Rosnow, 1991). TK has the highest effect size among these two factors. Tsai (2008) suggested that males have high levels of TK because they have a more positive attitude, higher confidence and greater efficacy with regard to technology. The effect size related to the gender variable in CK and TK is small, and in KTT it is smaller. Most of the research (e.g., Archambault & Barnett, 2010; Lee & Tsai, 2010; Schmidt et al., 2009) has examined participants' gender descriptively but only a few of them examined TPACK sub-domains according to gender. Koh et al. (2010) found that males have higher scores than females in the CK, TK and KTT factors. Erdogan and Sahin (2010) reported a significant difference in TPACK, TCK, TPK, PCK and TK domains in favor of male participants.

Lin et al. (2013) compared all the sub-domains of TPACK scores with participants' (PSTs' and in-service teachers') gender. They found a statistically significant difference only for Pedagogical Knowledge and Technological Knowledge in favor of in-service male teachers. Jang and Tsai (2012) examined the effect of using interactive whiteboards (IWBs) on science and mathematics teachers' TPACK sub-domains. In their study, there was no difference in the Content Knowledge (CK), Pedagogical Content Knowledge in Context (PCKCx), Technological Knowledge (TK), and Technological Pedagogical Content knowledge in Context (TPCKCx) due to gender. Similarly, Koh and Chai (2011) did not find a significant difference in the seven sub-domains of TPACK due to gender. Jang and Tsai (2013) found a significant difference in TK and the TPACK factors they had previously obtained (Jang & Tsai, 2012) in favor of male teachers. In the study of Koh et al. (2014), related to constructivist-oriented TPACK, there were differences in the factors connected with technology such as C-TK, TCK, and C-TPACK. For these factors male teachers' awareness was higher than females' but the effect size was small.

Table 9. *Results of t-test and Cohen's d according to the owning computer variable*

	Owning Computer	N	Mean	Standard Deviation	t	p	Cohen's d
KTT	Yes	373	3.227	.650	2.284	.023[a]	.195
	No	218	3.090	.788			
KP	Yes	373	3.224	.644	1.546	.123	-
	No	218	3.134	.749			
TK	Yes	373	3.484	.668	7.751	.000[c]	.662
	No	218	3.006	.810			
CK	Yes	373	2.937	.675	2.653	.008[b]	.227
	No	218	2.776	.772			

[a]p<.05, [b]p<.01, [c]p<.001

Table 9 shows the results of the t-test and Cohen's d according to the owning computer. A majority of the participants (f=373; 63%) had their own computers. In CK (t=2.653; p<.01), TK (t=7.751; p<.001) and KTT (t=2.284; p<.05) factors, there wass a significant difference in favor of having their own computer. The factor that had the highest effect size was TK (d=.662) and the effect size was at a medium level (Cohen, 1988, 1992, 1994; Rosenthal & Rosnow, 1991). Having their own computer substantially affected their levels of technological knowledge.

Table 10. *One-Way Anova and Eta-Square Results related to computer usage level*

	Computer Usage Level	Mean	Standard Deviation	F	p	η^2	Difference
KTT	Beginning level (N=45)(a)	2.564	.830	29.496	.000[e]	.046	a-b a-c a-d
	Intermediate level (N=277)(b)	3.073	.638				
	Good level (N=228)(c)	3.316	.651				
	Advanced level (N=41)(d)	3.768	.652				
KP	Beginning level (N=45)(a)	2.747	.767	24.544	.000[e]	.040	a-c b-d
	Intermediate level (N=277)(b)	3.061	.657				
	Good level (N=228)(c)	3.336	.617				
	Advanced level (N=41)(d)	3.744	.607				
TK	Beginning level (N=45)(a)	2.157	.637	216.493	.000[e]	.137	a-b a-c a-d
	Intermediate level (N=277)(b)	2.993	.543				
	Good level (N=228)(c)	3.708	.489				
	Advanced level (N=41)(d)	4.466	.437				
CK	Beginning level (N=45)(a)	2.461	.790	18.533	.000[e]	.035	a-c a-d
	Intermediate level (N=277)(b)	2.760	.669				
	Good level (N=228)(c)	3.012	.689				
	Advanced level (N=41)(d)	3.384	.661				

[e]p<.001

Table 10 shows the relationships between PSTs' computer usage levels and the factors in the survey. As PSTs' efficacy in using computers increase, their KTT, KP, TK and CK levels also increase. The highest effect size with regards to computer usage level is in TK (η^2=.137) and it has a small size (Cohen, 1988, 1992, 1994; Rosenthal & Rosnow, 1991). The lowest effect size is in the CK factor and it has an effect lower than small. Chai et al. (2010) suggested that for the development of TPACK, PSTs should have technological knowledge at a good level. Also, Wang and Chen (2006) argued that teachers ought to have an adequate knowledge of technology to use it effectively in their classes. These two findings correspond to ours.

25% of the participants (f_M=32; f_F=113) were freshmen; 24% (f_M=33; f_F=108) were sophomores; 29% (f_M=50; f_F=123) were juniors and 22% (f_M=63; f_F=69) were seniors (Table

11). Did PSTs' grade levels lead to difference in their KTT, KP, TK and CK? The answer to this question is given with one-way Anova and eta-square (η^2) in Table 11.

Table 11. *One-Way Anova and Eta-Square Results related to grade level*

	Grade Level	Mean	Standard Deviation	F	p	η^2	Fark
KTT	Freshman (N=145)(a)	3.031	.878	9.004	$.000^f$	.044	a-d b-d c-d
	Sophomore (N=141)(b)	3.135	.76				
	Junior (N=173)(c)	3.129	.563				
	Senior (N=132)(d)	3.444	.593				
KP	Freshman (N=145)(a)	3.034	.804	9.579	$.000^f$	.047	a-c a-d b-d
	Sophomore (N=141)(b)	3.149	.662				
	Junior (N=173)(c)	3.157	.608				
	Senior (N=132)(d)	3.451	.594				
TK	Freshman (N=145)(a)	3.083	.876	8.985	$.000^f$	.044	a-b a-c b-c
	Sophomore (N=141)(b)	3.363	.695				
	Junior (N=173)(c)	3.274	.678				
	Senior (N=132)(d)	3.538	.718				
CK	Freshman (N=145)(a)	2.724	.839	5.487	$.001^e$	.027	a-b a-c a-d
	Sophomore (N=141)(b)	2.822	.676				
	Junior (N=173)(c)	2.917	.623				
	Senior (N=132)(d)	3.054	.690				

$^e p<.01$, $^f p<.001$

As PSTs' grade levels increased, their mean scores for KTT (F=9.004; p<.001), KP (F=9.579; p<.001), TK (F=8.985; p<.001), and CK (F=5.487; p<.001) also increased (Table 11). An updated science teacher education program has been carried out in Turkey since 2006. This program follows a 4-year period (fall and spring terms in each year). In the first two years content courses (physics, chemistry, biology) are dominant, as well as a small number of pedagogy courses. Method courses related to technology use in education start in the third year. In the last year PSTs go into their practicum and teach with their practice teachers. Within this context, the source of the difference in PSTs' TK according to their year of study may be courses related to technology and technology-pedagogy in the second and third years of the program. The difference between KTT and KP is mainly among freshmen and seniors. KP and KTT levels in particularly go up in the final years, because in the last years of their program PSTs are provided with the professional experience in which to integrate or transfer pedagogy, technology and content knowledge. Niess, Suharwoto, Lee and Sadri (2006) found that naïve teachers with low pedagogic efficacy are less capable of linking technology, pedagogy and content knowledge; Pierson (2001) obtained the result that even if teachers with a low pedagogical knowledge understand technology well, they have difficulty in connecting pedagogy and technology. It is expected that these results will clarify why our results are in favor of seniors.

CONCLUSION

The original form of the survey consisted of 47 items and 7 factors (TK, PK, CK, TPK, TCK, PCK, and TPACK). In the EFA process 6 items were omitted and the survey included 4 factors. With CFA, the aim was to test the model obtained from EFA. After EFA, PSTs' TK and CK each constituted a distinct factor, but other domains merged into the KP (Knowledge of Pedagogy) and KTT (Knowledge of Teaching with Technology) factors. Although TK, CK, PK, TCK, TPK, PCK and TPACK domains are distinct in the original form, in this study these domains could not be separated. PK and PCK domains came together in the KP factor;

TPK, TCK and TPACK in the KTT factor (Koh et al., 2010). Similarly, TPACK surveys reveal different models with different factors when performed with different participants. Therefore, more studies about PSTs' TPACK should be performed; if different factors emerge these differences should be investigated, so the epistemological knowledge of PSTs can be approached from different perspectives. This study shows that teacher preparation programs provide limited experiences about teaching and learning with technology to pre-service teachers. PSTs failed to distinguish the subdomains. Only TK and CK emerged as separate factors. The others fell into two groups: Teaching and learning processes without technology formed KP; teaching and learning processes with technology formed KTT. PSTs seemed to distinguish only between the inclusion or exclusion of technology.

There was positive correlation between each factor (CK, TK, KP and KTT). The strongest correlation was between KP and KTT. It is expected that when the levels of PSTs' KP are high their KTT levels will also be high. The KTT levels of PSTs are predicted by the items in the CK, TK and KP. The highest predictor item is in the CK factor. With regard to gender, TK and KTT scores are in the favor of males. PSTs who owned a personal computer attained higher scores in TK, CK, and KTT. The computer usage levels showed significant differences in all of the factors. This difference was in favor of PSTs who could use a computer at an advanced level. In addition, as the participants' grade levels increased, their scores in all factors differed significantly and developed.

LIMITATIONS AND IMPLICATIONS

We wish the following implications of this study to be used as a guide for future research: Firstly, when a TPACK survey was administered to a different study group from the original group with which the survey was developed, structural differences were seen in the survey. The reason for these differences is presumed to be that PSTs' TPACK differs according to the context in which the study is carried out. It can be said that PSTs' schools, the regions they live in, the opportunities that their teacher preparation program provides for them (e.g., technological software and hardware, smart board, class size, equality of opportunity) and PSTs' individual differences (e.g., psychological, social, motivational and in terms of teaching experience) all have impacts on their TPACK. This study is different from others in many aspects. We investigated to what extent CK, TK, and KP factors predicted PSTs' KTT levels, and the differences in PSTs' CK, TK, KP and KTT levels due to demographic variables.

This study was limited to the survey as a data-collecting tool. The findings were obtained within the frame of PSTs' answers related to their personal views and the characteristics of the population,. By using different methodologies such as individual or focus group discussion, examining lesson plans and observing behaviors in the class, more detailed results could be derived. For example, PSTs' lesson plans could be incorporated in the data-collecting process to describe their TPACK level (Lyublinskaya & Tournaki, 2014). Interviews of participants enrich the data collecting process. Also, longitudinal studies in which different research designs are used together could be conducted to determine whether these measurements will predict to what extent PSTs will be successful in integrating technology when they start teaching in real classrooms (Abbitt, 2011).

This study was carried out with pre-service science teachers alone and only the CK, TK, KP, KTT factors were brought to light. Conducting this survey in different disciplines might lead to different factors. These different factors and results could provide the opportunity to better understand the complex relationships between technology, pedagogy and content knowledge. Also, there was no data about PSTs' prior knowledge and experiences of teaching with technology. In future research, after the workshops in which pre-service teachers are introduced to the technological software and hardware they can use in their teaching, their TPACK levels could be examined.

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