Research Article

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Investigating the technological pedagogical content knowledge of preservice teachers*

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Abstract

This paper examined the profile of Turkish preservice science and elementary teachers in terms of their technological pedagogical content knowledge (TPACK). Moreover, the difference between TPACK of preservice teachers in terms of grade level, gender, Cumulative Grand Point Average (CGPA), participation in a technology-related course, and following a popular technology magazine were investigated. The Survey of Preservice Teachers' Knowledge of Teaching and Technology was administered to 202 preservice teachers of a state university in Turkey. The results indicated that the participants had above-average TPACK scores. In addition, the influence of grade level, gender, and CGPA on TPACK scores is not significantly different for preservice science teachers and preservice elementary teachers. On the other hand, the influence of participation in a technology-related course and following a popular technology magazine on TPACK scores is significantly different for both groups in favor of preservice elementary teachers. The results and implications were discussed.

Keywords: TPACK, Preservice science teachers, Preservice elementary teachers

Introduction

When we consider the act of learning, we can notice that it occurs in a variety of settings. For example, the family is at the forefront where learning takes place. Parents also educate us a lot in this regard. However, we are unable to accept parents as certified teachers. Then, what distinguishes a teacher from ‘others’? What is the difference, for example, between a biology teacher and a biologist? Do both of them know specific biology topics such as the circulatory system? Both of them most likely know what the circulatory system is, the organs that constitute the circulatory system, the circulation of blood, functions as well as the structure of

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the heart, and other related subtopics covered under the circulatory system. The things that a biologist would not be competent in are; how to help students develop an understanding of the circulatory system, what kind of teaching materials can be used for the specific group of students, what students already know about it, what challenges students will face in learning, and how to evaluate students' understanding of the topic. In brief, a biology teacher is expected to know better the "ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986, p. 9), compared to a biologist. These issues require a distinctive type of knowledge for teaching known as pedagogical content knowledge (PCK). PCK refers to the combined knowledge of content and pedagogy. It refers to an "understanding of how particular topics, problems, or issues are organized [sic], represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). To conclude, pedagogical content knowledge is expected to differentiate a biology teacher from a biologist.

Based on Shulman's conceptualization of PCK, Technological Pedagogical Content Knowledge was developed to understand teachers' knowledge for the use of technology in the classroom (Mishra & Koehler, 2006). Today, various technologies have been widely used in classrooms. With the development in the field of education, technology is considered as a set of knowledge and skills which teachers need to possess in addition to content and pedagogical knowledge. This is important since it is the teacher who chooses the appropriate technology for effective teaching. The knowledge of technology should not be considered independent of others components. Rather it is closely related to other components (Mishra & Koehler, 2006). Each type of knowledge -content, pedagogy, and technology- has its identifiable attribute while they are connected. The framework (Figure 1) developed by Mishra and Koehler (2006) emphasizes each set of knowledge separately as well as the interconnection between them. The figure summarizes that, for effective teaching, teachers should possess the knowledge of technology, the knowledge of pedagogy, and the knowledge of content as well as the technological content knowledge, technological pedagogical knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. Each type of knowledge is described as follows:

Technology Knowledge (TK): Technology knowledge "refers to the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs" (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009, p. 125).

Pedagogical Knowledge (PK): Pedagogical knowledge is the knowledge about methods, techniques, and strategies of teaching and learning to achieve educational goals. This includes, among others, the issues of how students learn, how to manage a classroom, how to organize the lesson, how to implement a lesson, and how to evaluate student learning.

Content Knowledge (CK): Content knowledge is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p. 1026). It is the knowledge in the mind of the teacher including accepted facts and principles as well as why they are accepted, why students should know them, and how they are related to other disciplines (Shulman, 1986). The critical point is that teachers should have an understanding of the nature of the subject matter they are teaching (Harris, Mishra, & Koehler, 2009).

Technological Content Knowledge (TCK): Technological content knowledge is defined as using technology to teach a specific subject matter better. It includes the use of technology to prepare new representations for specific content (Schmidt et al., 2009). Teachers having this knowledge "can change the way learners practice and understand concepts in a specific content area" (Schmidt et al., 2009, p. 125). Many teachers use different technologies. However, how teachers use different technologies for different subject matters requires technological content knowledge.

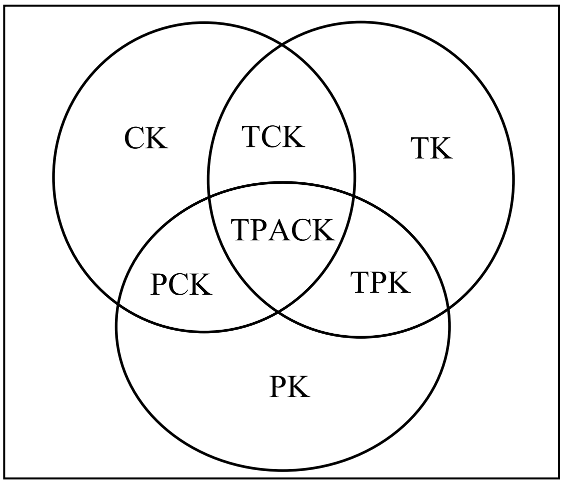

Figure 1. The Technological Pedagogical Content Knowledge Framework [*Adapted from Mishra and Koehler (2006)]*.

Technological Pedagogical Knowledge (TPK): Different technologies can be used in the classroom for teaching. Teachers should have the knowledge and ability to use these technologies for effective teaching. Mishra and Koehler (2006) called this knowledge as Technological Pedagogical Knowledge.

Pedagogical Content Knowledge (PCK): Pedagogical content knowledge goes beyond content knowledge. PCK includes "for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations in a word, the ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986, p. 9). Moreover, PCK includes "an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons" (Shulman, 1986, p. 9).

Technological Pedagogical Content Knowledge (TPACK): Technological Pedagogical Content Knowledge also goes beyond knowledge of emerging technology. Teachers need this knowledge for "integrating into their teaching in any content area" (Schmidt et al., 2009, p. 125). Schmidt et al. emphasized that teachers understand the relationship between technology, pedagogy, and content knowledge and teach subject matter with suitable teaching methods and technologies. The acronym "TPCK" had been used formerly then it was renamed as TPACK for the purpose of making it easier to remember (Schmidt et al., 2009).

As technology has started to support teaching and learning, the knowledge and the skills of the teachers for efficient integration of technology become more important. The capacity of teachers to adapt to any changes, including technology, is expected to increase the quality of teaching and learning (Aldunate & Nussbaum, 2013; Cansiz & Cansiz, 2019). On the other hand, Jang and Tsai (2012) emphasized that the use of new technology in the teaching process requires adequate technological knowledge associated with pedagogical content knowledge. Therefore, many researchers have investigated the technological pedagogical content knowledge of in-service teachers or pre-service teachers (e.g. Baran, Canbazoğlu Bilici, Albayrak Sari, & Tondeur, 2019; Doğan, 2012; Gömleksiz & Fidan, 2013; Kaleli Yılmaz & Ergün, 2017; Karakaya, 2013; Kaya, 2010; Koh, Chai, & Tsai, 2010; Lai & Lin, 2018; Lau, 2018; Lee & Tsai, 2010; Niess, 2005; Öztürk, 2013; Şad, Açıkgül, & Delican, 2015). For example, Şad et al. (2015) focused on preservice teachers' TPACK. In the study, they found that senior preservice teachers (n = 365) in different departments hold an average knowledge of TPACK while they have a relatively low score in the domain of technology knowledge. In another study, Koh et al. (2010) investigated 1185 Singaporean preservice teachers' TPACK. The research team (2010) found that preservice teachers showed slightly above-average performance for technological knowledge, content knowledge, pedagogical knowledge, and knowledge of teaching with technology. In terms of investigating teachers' willingness and adequacy to teach using technology, Doğan (2012) found that primary mathematics teacher candidates (n = 361) were enthusiastic about teaching mathematics with computers, but they do not have sufficient knowledge about it. Regarding the TPACK and associated demographic variables, Mutluoğlu and Erdoğan (2016) found that TPACK of mathematics teachers is independent of gender but it was associated with the experience. Moreover, they reported that mathematics teachers who have computers have higher technology, content, and technological pedagogical knowledge. Baran et al. (2019) investigated pre-service teachers' perceptions about the effect of the support provided to them during teacher education programs on their TPACKs. They found that the use of different strategies in teacher education programs was positively related to TPACK. Cetin-Dindar, Boz, Yildiran Sonmez, and Demirci Celep (2018) conducted a mixed-method study to develop the pre-service chemistry teachers' TPACK through a semester-long course on instructional technology. This study revealed that the pre-service chemistry teachers were able to develop their TPACK on some components.

This study, similarly, targets to explore preservice teachers' TPACK. It aims to contribute to the related literature in two important ways. First, it provides research results on TPACK of PTs with a distinctive characteristic of the sample. The participants of this study consisted of PTs whose university entrance examination score is at the bottom quartile among those who choose the teaching profession as a future career. In this way, it would also provide further reliability evidence of the Turkish version of the Survey of Preservice Teachers' Knowledge of Teaching and Technology. Second, it will contribute to the literature by providing results for different variables associated with TPACK. Although there are studies on some variables including gender and grade level (e.g. Karaca, 2015; Öztürk, 2013; Şad et al., 2015) more research is needed on other variables potentially associated with TPACK (e.g. participation in a technology-related course and following a technology-related magazine). The results regarding the latter variables would be valuable for future research.

In this respect, the following research questions guided this study:

1. What is the TPACK profile of preservice science and elementary teachers?

2. What is the difference between TPACK of preservice science teachers (PSTs) and preservice elementary teachers (PETs) in terms of grade level, gender, Cumulative Grand Point Average (CGPA), participation in a technology-related course, and following a popular technology magazine?

Method

In this study, causal-comparative research design, a form of associational research, was utilized. It is a type of quantitative research methodology where researchers search for the variation that already exists between different groups of individuals (Fraenkel, Wallen, & Hyun, 2011).

Participants

Convenient sampling, which means individuals are conveniently available for the study (Fraenkel et al., 2011), was used to draw the sample of the study. The Survey of Preservice Teachers' Knowledge of Teaching and Technology was administered to 202 preservice science and elementary teachers of a state university located in the northeastern part of Turkey. The first investigation of the raw data revealed that seven participants respond to the survey partially. Therefore, their data was deleted for further analysis. Of the remaining 195 participants, 134 were female and 59 were male. Two of the participants did not report their gender. Preservice teachers (PTs) from the first, second, third, and fourth years of the science education and elementary education program participated in the study. Participants' CGPA values are categorized into three as low (CGPA ≤ 2.5), medium (2.5 < CGPA < 3.0) and high (CGPA ≥ 3.0). In addition, within the scope of the research, PTs were asked to indicate whether they attended a technology-related course or whether they followed a technology magazine.

More information about participants is given in Table 1. Readers are reminded that the total number of participants in each variable in the table does not match the total sample size due to the missing responses of participants. For example, when the CGPA variable is considered in the table, there seems to be a total of 170 participants including 108 PETs and 62 PSTs although the total number of participants is 195 in the study. This means that 25 participants did not report their CGPA.

Table 1. Background Characteristics of Participants

	Preservice Science Teachers		Preservice Elementary Teachers	
	Frequency	*Percent*	*Frequency*	*Percent*
Grade Level				
1	46	56.8	37	32.5
2	9	11.1	39	34.2
3	14	17.3	17	14.9
4	12	14.8	21	18.4
Gender				
Female	50	61.7	84	73.7
Male	31	38.3	28	24.6
CGPA				
1 (≤ 2.5)	33	40.7	25	21.9
2 (2.5 - 3.0)	18	22.2	50	43.9
3 (≥ 3.0)	11	13.6	33	28.9
Participation in a technology-related course				
Yes	13	16.0	6	5.3
No	63	77.8	107	93.9
Following a technology magazine				
Yes	30	37.0	28	24.6
No	45	55.6	85	74.6

Instrument

In this study, The Survey of Preservice Teachers' Knowledge of Teaching and Technology was used. Schmidt et al. (2009) developed the survey to assess the TPACK of PTs. It consisted of seven domains of TPACK. There were 47 items in total; 7 for TK, 12 for CK, 7 for PK, 4 for PCK, 4 for TCK, 5 for TPK, and 8 for TPACK. The instrument is a five-point Likert-type scale (strongly disagree, disagree, undecided, agree, and strongly agree). The options were coded from 1 to 5 respectively (strongly disagree = 1; strongly agree = 5). The Survey was translated into Turkish and validated by Öztürk and Horzum (2011). First, they translated the survey into Turkish. Next, they modified the Turkish version based on the comments of 14 experts. At the end of this process, an agreement was established on the Turkish version. Once the translation and modification were completed, Öztürk and Horzum administered the original and the translated versions of the survey to 32 academicians in a two-week interval. Then they calculated the correlation between them and found it as .98 which shows that the two versions were measuring a quite similar construct. Then they collected data from 291 teachers to perform exploratory and confirmatory factor analyses. These allowed researchers to investigate the survey's factor structure and confirm it. Finally, the analyses produced a seven-factor structure that was similar to the original survey. In confirmatory factor analyses, the goodness-of-fit indexes were found to be highly satisfactory. ($\chi^2 = 2585.11$, $\chi^2/sd = 2.58$, $RMSEA = .074$, $GFI = .72$, $AGFI = .70$, $CFI = .97$, $NFI = .94$ and $NNFI = .96$). The reliability of the survey was calculated using Cronbach Alpha and found to be .96 for the whole survey. For each factor the reliability coefficients were: .95 for TK; .95 for CK; .97 for PK; .97 for PCK; .93 for TCK; .89 for TPK; and .94 for TPACK (Öztürk & Horzum, 2011). The coefficients obtained by Schmidt et al. (2009) were close to the ones obtained by Öztürk and Horzum (2011). In this study, the reliability coefficients were found as .81 for TK; .81 for CK; .88 for PK; .73 for PCK; .69 for TCK; .78 for TPK; and .86 for TPACK. Furthermore, the whole survey's reliability coefficient was found to be .95.

Data Collection and Data Analysis

The instrument was administered to the preservice science and elementary teachers in each grade level. The survey and its implementation were explained to them. They were informed about the study's principal goal and asked if they wished to participate in it voluntarily. The survey was completed by PTs who were willing to participate.

Data analysis was performed in two steps. In the first step, the researcher figured out the profile of PTs' TPACK. To do this, descriptive statistics were examined by using the Statistical Package for the Social Science (SPSS). In the second step, two-way ANOVA was performed to explore how TPACK of preservice science and elementary teachers differ in terms of grade level, gender, CGPA, participation in a technology-related course, and following a technology-related popular magazine. To investigate the role of the major area, two-way ANOVAs were used. The major area and one of the other variables were included in each ANOVA analysis.

Result

Assumption Checking

For the sake of drawing inferences based on the analysis, assumptions must be met (Tabachnick & Fidell, 2012). Therefore, required assumptions of two-way ANOVA were checked before the analyses. The skewness and kurtosis values were between -2 and +2 indicating that there was no violation of the assumption of normality. The inspection of scatterplots provided evidence that the linearity assumption is also met. Similarly, Levene's test for homogeneity of variance provided a non-significant result ($p > .05$) indicating that the variance of the dependent variable across the group is equal. The outliers were checked by using the Mahalanobis distance which showed that six cases were possible outliers. Therefore, they were removed from the data set.

The TPACK of preservice science and elementary teachers

The first part of the analysis examined the overall TPACK scores of two groups. The result for each domain is also provided for an in-depth understanding of their TPACK. Mean and standard deviation for each domain and survey overall were presented in Table 2. The descriptive analysis indicated that the mean scores of PSTs and PETs were all above average (5-level Likert type scale) and close to each other. Moreover, in the survey overall, PETs' score is slightly higher than PSTs' score. In both groups, the lowest mean score belongs to CK.

Table 2. Mean and Standard Deviation of the PSTs and PETs for Each TPACK Domain

	Preservice Science Teachers		*Preservice Elementary Teachers*	
	M	SD	M	SD
TK	3.58	.06	3.67	.05
PK	3.86	.06	4.05	.04
CK	3.49	.05	3.59	.05
TPK	3.86	.06	3.83	.06
TCK	3.58	.06	3.75	.06
PCK	3.77	.07	3.94	.06
TPACK	3.79	.06	3.92	.05
Survey Overall	*3.68*	*.05*	*3.79*	*.04*

The difference between TPACK of PETs and PSTs in terms of grade level, gender, CGPA, participation in a technology-related course, and following a popular technology magazine

In the second research question, the aim was to find out if there is a difference between PETs and PETS in terms of grade level, gender, CGPA, participation in a technology-related course, following a technology-related popular magazine on overall TPACK for PETs and PSTs.

Two-way between groups analysis of variance was conducted to explore the impact of the major area and grade level on the overall TPACK. The result revealed that the interaction effect between major area and grade level was not statistically significant, F (3, 187) = .84, p = .473. The main effect of grade level was not significant as well, F (3, 187) = 1.43, p = .237.

When the gender effect was examined in two groups of PTs, a nonsignificant interaction effect between major area and gender was found, F (1, 189) = .2.34, p = .128. The main effect for gender has also no impact on the overall TPACK, F (1, 189) = .81, p = .370.

A nonsignificant interaction effect was also found between CGPA and major area on the overall TPACK, F (2, 164) = .08, p = .926. There was not a significant main effect for CGPA, F (2, 164) = .17, p = .845.

A significant difference was found in the effect of participation in a technology-related course on the overall TPACK for PETs and PSTs, F (1, 185) = 5.80, p = .017. Due to a significant interaction effect, follow-up tests were conducted to explore the results for each group of PTs separately. The plot of the overall TPACK scores for PETs and PSTs according to the participation in a technology-related course was presented in Figure 2. It is evident in the plot that PETs who participated in such a course have higher overall TPACK than the ones who did not. On the other hand, PSTs who did not participate in such a course have slightly higher overall TPACK than the ones who did. To test this difference, the data was split according to the major area and then investigated the effect of participation in a technology-related course on the overall TPACK by performing one-way ANOVA.

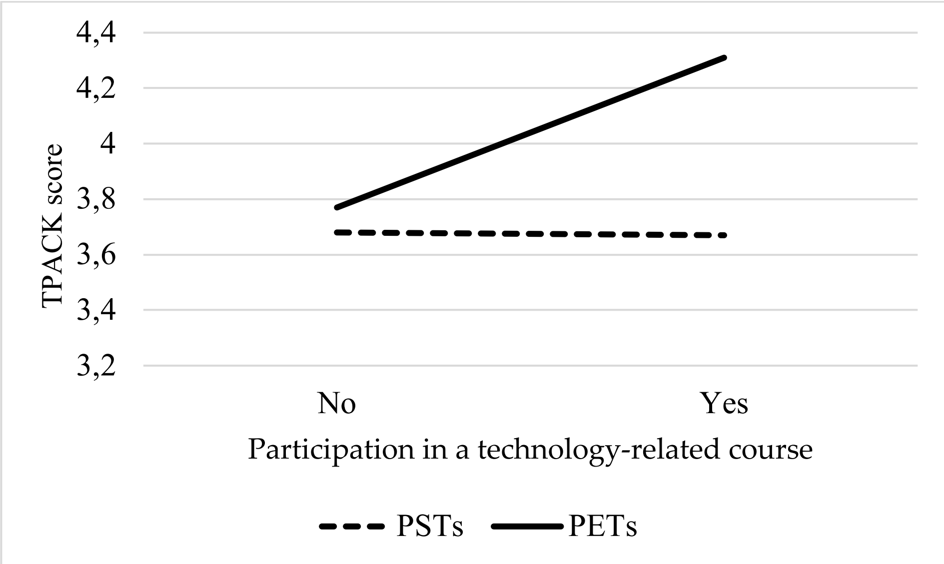

Figure 2. TPACK scores of PETs and PSTs across participation in a technology-related course

One-way ANOVA result indicated that PETs who participated in a technology-related course had significantly higher overall TPACK scores than those who did not, F (1, 111) = 8.68, p = .004. The mean of PETs who participated in the course was 4.31 with a standard deviation of .47 while the mean of PETs who did not participate in such courses was 3.77 with a standard deviation of .43. On the other hand, the one-way ANOVA for PSTs did not yield a significant difference F (1, 74) = .01, p = .912.

In terms of each domain of the survey, PETs' mean scores were presented in Table 3. The PETs who participated in a technology-related course had higher mean scores for each domain than those who did not.

Table 3. The mean and standard deviation of PETs in terms of each domain across participation in a technology-related course

	PETs who participated in a technology-related course		PETs who did not participate in a technology-related course	
	M	SD	M	SD
TK	4.19	.64	3.63	.53
PK	4.36	.37	4.05	.46
CK	4.01	.71	3.57	.56
TPK	4.43	.61	3.80	.58
TCK	4.66	.38	3.71	.64
PCK	4.34	.60	3.93	.64
TPACK	4.54	.49	3.81	.58
Survey Overall	*4.31*	*.47*	*3.77*	*.43*

Another significant effect was found for the other variable "following a popular technology magazine". Two-way ANOVA yielded a significant interaction between major areas and following a popular technology magazine F (1, 184) = 9.10, p = .003. The mean plot (see Figure 3) indicated that PETs who follow a popular technology magazine had higher TPACK than those who do not follow such magazines. However, the TPACK scores of PSTs who follow a popular technology magazine are slightly lower than those who do not follow a popular technology magazine.

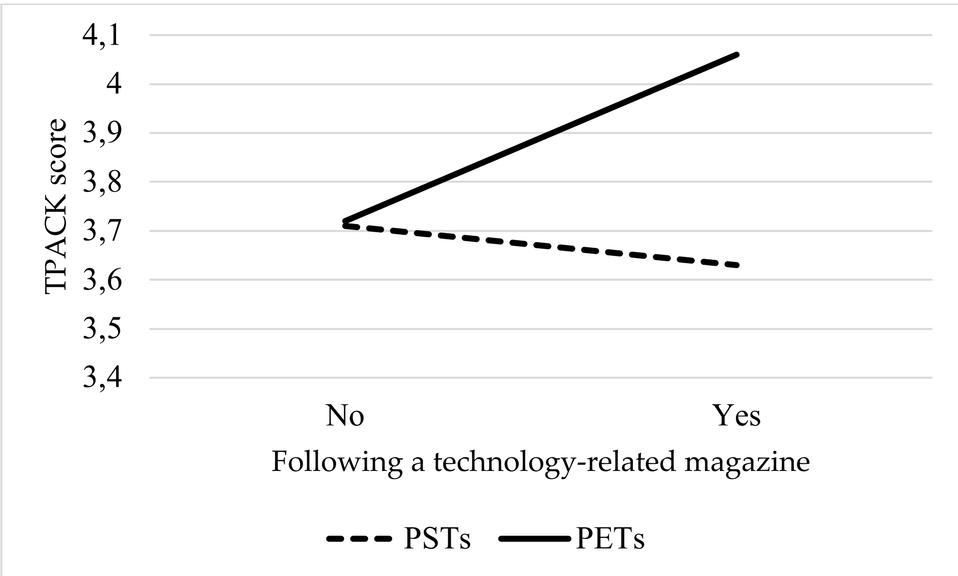

Figure 3. TPACK scores of PETs and PSTs across following a popular technology magazine

One-way ANOVA was performed to explore whether the difference in PETs' TPACK scores is significant. It was found that PETs who follow a popular technology magazine had significantly higher TPACK than those who do not follow a popular technology magazine, F (1, 111) = 14.03, p < .005. The mean of PETs who follow a magazine was 4.06 with a standard deviation of .40 while the mean of PETs who do not follow such a magazine was 3.72 with a standard deviation of .43. On the other hand, the one-way ANOVA for PSTs did not yield a significant difference F (1, 73) = .51, p = .477. The PETs were further investigated for each domain of the survey. Among them, those who follow a popular technology magazine had higher mean scores for each domain in the survey than those who do not follow. The mean and standard deviation values were given in Table 4.

Table 4. The mean and standard deviation of PETs in terms of each domain across following a popular technology magazine

	PETs who follow a popular technology magazine		PETs who do not follow a popular technology magazine	
	M	SD	M	SD
TK	4.02	.47	3.55	.52
PK	4.32	.44	3.99	.44
CK	3.81	.71	3.52	.51
TPK	4.10	.52	3.76	.60
TCK	3.98	.67	3.69	.65
PCK	4.21	.45	3.86	.67
TPACK	4.21	.46	3.85	.57
Survey Overall	*4.06*	*.40*	*3.72*	*.43*

Discussion and Implications

Based on Shulman's PCK framework, Mishra and Koehler (2006) introduced TPACK to measure teachers' knowledge of technology integration into their teaching. Being aware of the new technologies in education, researchers put more emphasis on teachers' TPACK. Therefore, this study investigated the TPACK of PETs and PSTs in terms of grade level, gender, CGPA, participation in a technology-related course, and following a popular technology magazine. The results suggested that the TPACK overall scores of PETs and PSTs were not significantly different across grade level, gender, and CGPA. On the other hand, the PETs' TPACK scores significantly differed among the groups of participants who attended in a technology-related course and followed a popular technology magazine. That is, PETs who participated in a technology-related course and have followed a popular technology magazine rated themselves significantly higher on overall TPACK scores than those who did not. Further examination of the data revealed that PETs who participated in a technology-related course and followed a popular technology magazine had also higher scores for each domain of the survey (TK, PK, CK, TPK, TCK, PCK, and TPACK). For PSTs, the results regarding participation in a technology-related course and following a technology-related magazine were not similar to those of PETs. Although the results for the two groups were not the same, it would not be wrong to claim that doing extra technology-oriented things has a positive effect on TPACK. Actually, we do not have direct evidence from the data set of this study to explain them confidently. Therefore, further research should be conducted to explore if the same results are obtained with different samples of PSTs and PETs.

When the literature examined, Farrell and Hamed (2017), similar to this study, did not find a significant difference for gender. They attributed this result to the individuals' abilities to learn new knowledge and skills if they are given the same opportunities. Jang and Tsai (2012) also could not a find significant difference in TPACK of Taiwanese elementary mathematics and science teachers in terms of gender. On the other hand, Koh et al. (2010) found that male Singaporean preservice teachers held higher technological knowledge than female preservice teachers. They explained that males have more positive attitudes toward technology and females should be supported in light of their findings. Men have more positive attitudes toward technology than women, according to Koh et al (2010), but this does not match the results of this study. In the Turkish context, there is a number of studies that also reported a nonsignificant relation between gender and TPACK (e.g. Cetin-Dindar et al., (2018); Çuhadar, Bülbül, & Ilgaz, 2013; Gömleksiz & Fidan, 2013; Karakaya, 2013; Mutluoğlu & Erdoğan, 2016) while there are few studies that reported a significant relationship between these two variables (e.g. Karaca, 2015).

In terms of grade level, PETs and PSTs did not differ in their TPACK. In line with the present result, Karaca (2015) found that 3rd and 4th-grade level PTs' technological pedagogical content knowledge did not differ significantly. In terms of GPA, contrary to the results in this study, Bozkurt (2014) found that GPA scores of physics and science teacher candidates were significantly related to the TPACK scores.

The unique results of this study were the significant relationship between TPACK and two important variables: PETs who participated in a technology-related course and follow a popular technology magazine. Farrell and Hamed (2017) found that the number of certifications held by the teachers was significantly related to the TPACK. This result can be matched with the variable participation in a technology-related course in this study. Teachers may participate in a technology-related course in or out of school and they get certifications for their participation and successful completion of the course requirements. In such courses, PTs may learn different technologies and develop their knowledge and skills in integrating them into their teaching. These courses may also help PTs to have positive attitudes toward technology and technology use in the classroom. Moreover, the more PTs deal with technology, the more self-confident they become in using technology. This result is important in terms of rethinking teacher education programs. It is necessary to provide PTs with many opportunities to increase their knowledge of technology to be used in the teaching process effectively. The results for the variable following a popular technology magazine has also the same effect on PETs' TPACK. Through following such a magazine, PTs may be informed about the new advances in technology and this may encourage them to learn and use it. Without knowing the new technologies, nobody can begin to use them. Therefore, it is reasonable to find high TPACK for those preservice teachers.

To conclude, this study contributed to the literature not only by confirming the previous results on gender, grade level, and CGPA but also by exploring the effect of participation in a technology-related course and following a popular technology magazine. For the latter variables, the study explored interesting findings which might have the potential to rethink the teacher education programs. In this regard, this study calls for researchers and educators to put effort into teacher education programs and professional development programs for increasing the knowledge of technology use in the specific content of teaching. Doğan (2012) found that Turkish primary mathematics teachers enjoy working with computers but they do not have sufficient knowledge to use it in teaching mathematics. That is, they need more training on technology to use it effectively in the teaching process. Before graduating, preservice teachers should learn about modern educational technologies. This is unavoidable due to the rapid advancement of technology. Teachers should remain updated on advances in educational research, including technology.

Limitations and Suggestions for Future Research

This study provides some practical information in terms of TPACK profiles of preservice teachers. However, there is a number of limitations that need to be considered. First, although homogeneity of variance assumption is met, there exists unequal group size as in gender and following a technology-related magazine. Because convenient sampling was used in this investigation, this was an unavoidable circumstance. If possible, equal-sized groups can be studied in future research. Second, the results are limited in their generalizability due to the use of convenient sampling. The use of random sampling would increase generalizability in future research. Furthermore, additional research should be undertaken to see if student achievement differs when technology is used.

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