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INVESTIGATING STUDENT TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) LEVELS BASED ON SOME VARIABLES

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Abstract:
This study investigates pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) levels based on different variables. A total of 609 final year student teachers who are trained in five different subject areas (elementary teaching, social science teaching, science teaching, mathematics, and Turkish Teaching) of an education faculty participated in the study. The study was carried out in the spring semester of the 2014-2015 academic year. An adapted Turkish version of the TPACK Scale was used as the data collection instrument. The data was analyzed using SPSS 20.0 software. An independent *t*-test, ANOVA, Mann Whitney-U, and Kruskal Wallis Tests for non-parametric data were used for statistical analysis. The results show, in the current state, participants have good levels of TPACK. It is also found that there are meaningful relationships and significant differences between some variables such as gender, program attended, having a personal computer and Internet connection, and sub-factors of the TPACK scale. It is suggested that more practical opportunities should be facilitated for pre-service teachers at education faculties to prepare them for 21st century schools.

Keywords: student teachers, variables, TPACK

1. Introduction

Today the world we live in is changing fast politically, economically, socially, and technologically. Due to rapid globalization and fast-changing developments in Information and Communications Technology (ICT), societies had been forced to transform their structures and particularly educational systems to meet the demands of

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economies (Esteve, 2000). In the 21st century, citizens of the countries need to acquire new skills and competencies to survive in this fast-changing environment. Education systems have primary role on educating citizens to prepare them to be ready for technology-oriented working environments. For that reason, many countries around the world have been investing considerably in terms of money, expertise, resources, and research to integrate technology in education as smoothly as possible so that the classroom environment is made more conducive for enhanced teaching and learning (Jhurree, 2005:468).

The revolution in digital technologies has brought new opportunities to schools and classrooms and has had an effect on learning and teaching activities to a great extent (Altun, 2002:13). Hence, teaching in 21st century schools has become a more complex and difficult profession as students of current generation are exposed to digital technologies more than ever and are highly competent users of new technologies. Prensky (2001:1) points out that "*Our students have changed radically. Today's students are no longer the people our educational system was designed to teach."* In recent years, the term "digital natives" has become common in literature that attempts to identify the characteristics of learners of the current century. Digital natives are young people born in the last two decades and have always been surrounded by, and interacted with, new technologies (Helsper and Eynon, 2010). According to Prensky (2001) digital natives are all native speakers of the digital language of computers, videogames and the Internet (p.1). Another view suggests today's students are labeled as Generation Z who was born after 1995 (Schroer, 2015). In traditional education system, the paper and pencil are not interesting for Z generation students; instead, the Internet and interactive games draw their attention (Kovács and Sik-Lány, 2014, p.11).

Under these circumstances, as with other professionals, to be more effective in classrooms, teachers are expected to use technology integrated with pedagogy and content. Related literature reveals that it is no longer appropriate to suggest that teachers' low-level uses of technology are adequate to meet the needs of the 21st-century learner. Using technology simply to support lecture-based instruction falls far short of recommended best practice (Lawless and Pellegrino, 2007; Partnership for 21st Century Skills, 2007; Zemelman, Daniels, and Hyde, 2005; cited in Ertmer and Ottenbreit-Leftwich, 2010, pp. 257).

Now teachers are expected to integrate technology into their instruction in an effective and appropriate way. In other words, they need to be confident and competent in three areas of effective teaching: pedagogy, content of the area, and the use of technology. Most researchers agree that more technology training is needed for teachers during both in pre-service and in-service contexts (Brush et al., 2001). According to Koehler and Mishra (2009:62) "*At the heart of good teaching with technology are three core components: content, pedagogy, and technology, plus the relationships among and between*

them." On the basis of this notion, Mishra and Koehler (2006) developed a technology integration model for teacher education named as Technological Pedagogical Content Knowledge (TPACK) inspired from Schulman's (1986) Pedagogical Content Knowledge (PCK) theory. Simply, TPACK explores teachers' comprehension of how ICT can be used as a pedagogical tool in teaching and learning (Mishra and Koehler, 2006). Koehler and Mishra (2009:66) describe TPACK as follows:

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

TPACK is a framework that presents a way of thinking about effective technology integration, specifically knowledge associated with integrating technology effectively into learning environments (Polly and Brantley-Dias, 2009:46). In other words, TPACK is a useful model that helps us to comprehend what sorts of knowledge needs to be acquired by teachers to integrate technology into classroom practices and how they might develop this knowledge (Voogt et al., 2013). Additionally, TPACK could be used to assess teachers' knowledge in a way that provides useful insights for teacher educators about how to train teachers effectively for today's technology oriented classrooms. As Schmidt et al. (2009) contend, "*there is a continual need to rethink our preparation practices in the teacher education field and propose new strategies that better prepare teachers to effectively integrate technology into their teaching*" (p.126). In other words, today graduates of teacher education programs are expected to acquire many capabilities, including the appropriate use of ICTs, having pedagogical formation skills, and being confident in content knowledge in their subject specialism. The Initial Teacher Education (ITE) institutions are the places where those skills and capabilities can be attained (Altun, 2007).

In a general sense, TPACK is an integrated model combining three sources of teacher knowledge: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) (Mishra and Koehler, 2006; Chai, Koh, and Tsai, 2010) (see Figure 1).

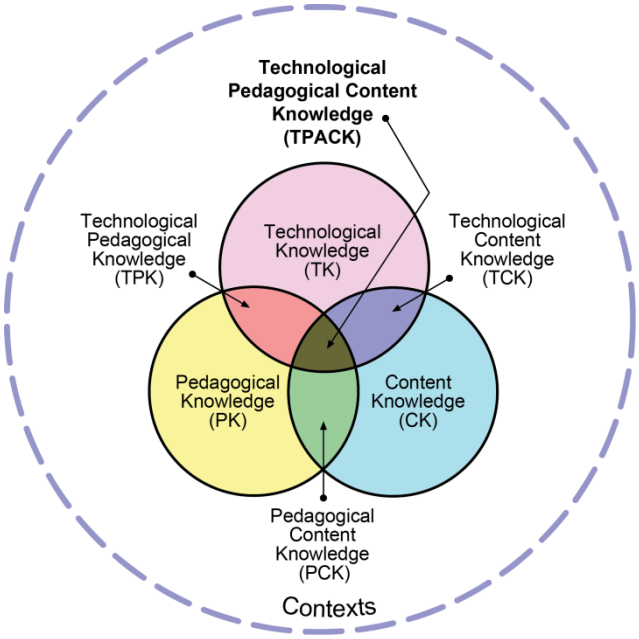

Figure 1: Components of TPACK model (Source: http://tpack.org)

Since the introduction of model to the research world, TPACK has drawn a great attention from researchers and teacher educators around the globe and a great deal of studies has been carried out about developing pre-service teachers' TPACK (Niess, 2005; Kocoglu, 2009; Schmidt et al., 2009; Chai et al., 2010; Koh, Chai and Tsai, 2010; Karal and Bahcekapili, 2011; Koh and Sing, 2011; Semiz, 2011; Kaya etal., 2011; Kurt, 2012; Hofer and Grandgenett, 2012; Bilici, 2012; Gündoğmuş, 2013; Koh and Divaharan, 2011; Sancar, Yanpar, and Yavuz, 2013; Keser, Yılmaz and Yılmaz, 2015); and about investigating in-service teachers' TPACK development (Hofer and Swan, 2007; Graham et al., 2009; Groth et al., 2009; Shin, 2009; Jang and Tsai, 2013; Altun, 2013; Phillips, 2013; Karadeniz and Vatanartıran, 2015; Lehiste, 2015).

2. The Context of the Study

The present study was carried out in a faculty of education at a large state university in Turkey. Since the 1970s, Turkey has made major efforts to improve the conditions of the educational system to catch up with European Union standards (Altun, 2007). The university in which this study was conducted has more than forty thousand students and is a technical university situated on the coast of Eastern Black Sea region of Turkey. The foundation of the faculty of education dates back to 1963 and has a considerable experience in teacher education. Today, there are 10 departments at the faculty and teacher candidates are educated under 24 different programs (from pre-school education to high-school grades). More than six thousand teacher candidates are trained to be graduates of four-year B.Ed. programs. The faculty also provides

certificate courses as well as master's and doctorate degrees in different fields of education.

The present study was carried out within the Department of Primary Education at the faculty of education, which includes five different teacher education programs. Those programs are Pre-school Teaching, Elementary(Classroom)Teaching (grades 1-4), Social Science Teaching (grades 5-8), Science Teaching (grades 5-8), and; Mathematics Teaching (grades 5-8). Turkish Teaching is an independent department within the faculty of education in which student teachers are trained to teach Turkish in middles schools (age 10-14) of Turkey. In all programs of the faculty, courses provided can be classified under three main categories:

- Professional Knowledge courses (pedagogical formation)
- Subject Matter Knowledge courses
- General Culture Knowledge courses

There are common compulsory courses for student teachers (STs) across the faculty whatever program they are in. Particularly, these are pedagogical formation courses such as Classroom Management, Teaching Principles and Methods, and Introduction to Educational Sciences. In addition, "Computer" and "Instructional Technologies and Material Design" courses are also compulsory across the faculty. Other than that, student teachers are taught other subject specialism courses depending on their program and optional general culture courses.

The courses offered by the faculty require an integrated knowledge skills and capabilities for student teachers similar to TPACK model. Student teachers of this faculty are required to combine their technological, pedagogical, and subject matter knowledge effectively by achieving the objectives of courses they attend. In this context, a survey research seemed to be appropriate and important to determine whether student teachers with different subject specialism have good level of technological, pedagogical, and content knowledge.

3. Aim of the Study

The current study examines the final year STs' TPACK level in general and investigate its relationship with different variables (gender, subject specialism, and having a personal computer and Internet connection). It is predicted that the mentioned variables are effective in developing TPACK for STs. Under this general hypothesis, following questions were directed:

1. What is the level of student teachers' TPACK in general?
2. Does student teachers' level of TPACK differ with respect to their gender?
3. Does student teachers' level of TPACK differ with respect to having a personal computer and Internet connection?

4. Does student teachers' level of TPACK differ with respect to their subject specialism?

4. Method

This study designed within the framework of quantitative approach. Aligned with the aim and objectives of the study, a survey method was used to seek answers to the research questions.

4.1 Study Group

The research participants were randomly selected and consisted of 609 final year (fourth grade) STs attending to the five different ITE programs (Elementary Teaching, Social Science Teaching, Science Teaching, Mathematics Teaching, and Turkish Teaching), at the Faculty of Education in Karadeniz Technical University, in Turkey. The data obtained was in the spring semester of 2014-2015 academic year. Demographic information about participants is presented in Table 1 below:

Table 1. Demographic information about participants

Variables	Categories	n	%
Gender	Female	400	65.7
	Male	209	34.3
Having a PC (including. laptop or tablet)	Yes	479	78.7
	No	130	21.3
Internet Connection	Yes	426	70.0
	No	183	30.0
Teaching Area	Elementary Teaching	156	25.6
	Primary Mathematics	83	13.6
	Primary Science	164	26.9
	Social Sciences Teaching	124	20.4
	Turkish Teaching	83	13.5
Total		609	1000

More than half of the participants are female (65.7%) and most STs own a personal computer and laptops or tablet PCs. It shows that young people today get a PC or other technology as they are attached to technology very much in their daily lives. In terms of Internet connection, again we can see that most STs have an Internet connection to their personal technologies as they have more opportunities today in home and school environment due to the spread of wireless Internet connection opportunities almost everywhere. Finally, the distribution of STs in terms of subject specialism seem to be relatively even; only mathematics teaching and Turkish teaching

areas seem to be lower than the other areas. This is due to low enrolment numbers in those areas.

4.2 Data collection tools and processes

A Turkish version of the TPACK survey was used as the main data collection tool. The original TPACK scale was constructed by Schmidt et al. (2009). This scale was translated into Turkish and adapted by Bahcekapili, (2011) after a series of analysis that found it to be a working tool in a Turkish context. In the current study, Cronbach-alpha reliability co-efficient of the whole scale was calculated as 0.946. The TPACK scale consists of 47 Likert-type items and categorized under seven sub-dimensions. These dimensions are: Technological Knowledge (TK); Content Knowledge (CK); Pedagogical Knowledge (PK); Pedagogical Content Knowledge (PCK); Technological Content Knowledge (TCK); Technological Pedagogical Knowledge (TPK) and Technological Pedagogical and Content Knowledge (TPACK). In addition, a demographic information part constructed by the authors was included at the beginning part of the TPACK scale sheet.

The prepared demographic questionnaire and the Turkish version of the TPACK scale was double-checked by three other researchers at the faculty in terms of its structure and language and the final version of the scale photocopied and distributed to fourth grade (final year) STs who attend five different programs at the faculty of education. The survey was completed by the participants in classrooms during their course hours with the authors of the study present.

5. Findings

Collected data was logged into SPSS 19.0 software and series of statistical analysis techniques were employed including an independent *t*-test, ANOVA, Levene, and variance analysis test.

5.1 Student Teachers' Level of TPACK in General

First, STs' general TPACK levels in all areas were to be calculated in terms of mean score to see the perception of STs about their level of TPACK. For this reason, a descriptive analysis was carried out. As Likert-type scale was used in the study, means score about whole TPACK was calculated to following categorization:

Table 2. Meanings of the Likert scale's mean scores

Interval	Degree	Level
4.21-5.00	Strongly Agree	Very Good
3.41-4.20	Agree	Good
2.61-3.40	Neither Agree or Disagree	Average

1.81-2.60	Disagree	Weak
1.00-1.80	Strongly Disagree	Too weak

First, general TPACK levels of STs were calculated using mean scores. Table 3 summarizes the general TPACK levels of participants.

Table 3. Descriptive statistics about student teachers' level of TPACK in general

Factor	**Programs**	**N**	$\overline{X}$	**sd**
Technological Pedagogical Content Knowledge	Elementary Teaching	156	3.61	.48
	Primary Maths Teaching	83	3.33	.43
	Primary Science Teaching	164	3.51	.53
	Social Science Teaching (Humanities)	124	3.28	.50
	Turkish Teaching	82	3.42	.45
Total		**609**	**3.46**	**.50**

As can be seen from the above table, the study group obtained $\overline{X}$=3.46 mean score in total, which means that STs signed mostly "Agree" option on the scale. This score can be interpreted that sample group of STs perceive that they have "good" level of TPACK in general. It can also be seen that mean score of Elementary Teaching students is higher than all of the other programs ($\overline{X}$=3,61).

5.2 Gender Variable and TPACK

Independent *t*-test results about STs' gender and its relationship with TPACK and sub-dimensions illustrated below in Table 3.

Table 4. T-test results about relationships between gender of student teachers and TPACK

Dimensions of TPACK	**Gender**	**n**	$\overline{X}$	**sd**	**df**	**t**	**p**
Technological Knowledge (TK)	Female	400	3.41	.70	607	-1.112	.267
	Male	209	3.49	.82			
Content Knowledge (CK)	Female	400	3.31	.56	607	-.662	.508
	Male	209	3.34	.53			
Pedagogical Knowledge (PK)	Female	400	3.78	.68	607	2.523	.012*
	Male	209	3.64	.66			
Pedagogical Content Knowledge (PCK)	Female	400	3.21	.72	607	.357	.721
	Male	209	3.19	.62			
Technological Content Knowledge (TCK)	Female	400	3.21	.76	607	-1.345	.179
	Male	209	3.30	.67			
Technological Pedagogical Knowledge (TPK)	Female	400	3.75	.73	607	1.185	.237
	Male	209	3.67	.73			
Technological Pedagogical Content Knowledge (TPACK)	Female	400	3.50	.65	607	.045	.964
	Male	209	3.50	.62			

p<0.05

Results in Table 4 indicate that there is a meaningful difference between gender of the participants and some of the sub-dimensions of TPACK scale. According to Table 3 there are meaningful differences between female and male participants in dimension of "pedagogical knowledge" [$t_{(609)}$= 2.523; p=,001]. When mean scores ($\overline{X}$) of participants are examined, it can be seen that female STs' have higher scores than male teachers (PK_{Female}: $\overline{X}$=3.78>PK_{Male}: $\overline{X}$=3,64). No significant difference was found between other dimensions of TPACK and gender variable.

5.3 Having a PC and TPACK

To examine the relationship between "Having a PC" variable and TPACK, an independent *t*-test was carried out and results are presented in Table 5 below:

Table 5. T-test results about relationships between having a PC and TPACK

Dimensions of TPACK	Having a PC	n	$\overline{X}$	sd	df	t	p
Technological Knowledge (TK)	Yes	479	3.50	.74	607	4.478	.000*
	No	130	3.18	.69			
Content Knowledge (CK)	Yes	479	3.32	.56	607	-.297	.766
	No	130	3.34	.53			
Pedagogical Knowledge (PK)	Yes	479	3.74	.69	607	.620	.536
	No	130	3.70	.64			
Pedagogical Content Knowledge (PCK)	Yes	479	3.22	.68	607	.835	.404
	No	130	3.16	.72			
Technological Content Knowledge (TCK)	Yes	479	3.26	.74	607	1.338	.181
	No	130	3.16	.69			
Technological Pedagogical Knowledge (TPK)	Yes	479	3.73	.74	607	.898	.370
	No	130	3.67	.71			
Technological Pedagogical Content Knowledge (TPACK)	Yes	479	3.53	.64	607	1.991	.047*
	No	130	3.40	.61			

p<0.05

As illustrated in the above table, no meaningful relationship was found between having a PC variable and most of the TPACK dimensions except one dimension: TK [$t_{(609)}$= 4.478; p=,000). Student teachers who own a PC or other technologies (laptop or tablet PC) apparently obtained higher mean scores (TK_{Yes}: $\overline{X}$=3.50) than STs who do not own a PC (TK_{No}: $\overline{X}$=3.18).

5.4 Internet Connection and TPACK

To examine the relationship between "having a PC" variable and TPACK, an independent *t*-test was carried out and results are presented in Table 6 below:

Table 6. T-test results about relationships between having an Internet Connection and TPACK

Dimensions of TPACK	Internet Connection	n	$\overline{X}$	sd	df	t	p
Technological Knowledge (TK)	Yes	426	3.50	.75	607	3.475	.001*
	No	183	3.28	.71			
Content Knowledge (CK)	Yes	426	3.33	.55	607	.300	.764
	No	183	3.31	.55			
Pedagogical Knowledge (PK)	Yes	426	3.76	.70	607	1.530	.127
	No	183	3.67	.62			
Pedagogical Content Knowledge (PCK)	Yes	426	3.20	.68	607	-.181	.856
	No	183	3.21	.71			
Technological Content Knowledge (TCK)	Yes	426	3.26	.73	607	1.164	.245
	No	183	3.18	.73			
Technological Pedagogical Knowledge (TPK)	Yes	426	3.75	.75	607	1.428	.154
	No	183	3.65	.70			
Technological Pedagogical Content Knowledge (TPACK)	Yes	426	3.53	.63	607	1.589	.112
	No	183	3.44	.64			

$p<0.05$

Similar to the previous variable, again no meaningful relationship was found between having an Internet Connection and most of the TPACK dimensions except one dimension: TK [$t_{(609)}$= 3.475; p=.001). Student teachers who have Internet connection apparently obtained higher mean scores (TK_{Yes}: $\overline{X}$=3.50) than STs who have no PC (TK_{No}: $\overline{X}$=3.28).

5.5 Subject Area and TPACK

In the study, the final calculation involved investigating relationships between participant STs' subject specialism and their level of TPACK. To analyze data, variance analysis and Scheffe tests were used. Table 7 below summarizes the findings:

Table 7. Variance analysis results about relationships between subject specialism and STs' level of TPACK

Factors	Subject Area	N	X	sd	Source of Variance	Sum of Squares	df	F	p	Scheffe
Technological Knowledge (TK)	1.Elementary T.	156	3.52	.70	Between Groups	3.805	4	1.732	.141	-
	2. Mathematics T.	83	3.44	.71						
	3. Science T.	164	3.48	.72						
	4. Social Science T.	124	3.32	.78	Within Groups	331.671	604			
	5. Turkish T.	82	3.35	.83						
	Total	609	3.44	.74	**Total**	335.476	608			
	Levene: 1.411	p=.229								
Content Knowledge (CK)	1.Elementary T.	156	3.42	.53	Between Groups	10.557	4	9.164	.000*	1-4 3-4 4-5
	2. Mathematics T.	83	3.20	.56						
	3. Science T.	164	3.42	.57						
	4. Social Science T.	124	3.10	.50	Within Groups	173.958	604			
	5. Turkish T.	82	3.40	.49						
	Total	609	3.32	.55	**Total**	184.514	608			
	Levene: .795	p= .528								

Pedagogical Knowledge (PK)	1.Elementary T.	156	3.76	.64	Between Groups	1.667	4	.908	.459	-
	2. Mathematics T.	83	3.65	.63						
	3. Science T.	164	3.75	.69						
	4. Social Science T.	124	3.67	.72	Within Groups	277.103	604			
	5. Turkish T.	82	3.81	.71						
	Total	609	3.73	.68	**Total**	278.769	608			
	Levene: 1.251	p= .288								
Pedagogical Content Knowledge (PCK)	1.Elementary T.	156	3.58	.64	Between Groups	41.268	4	25.314	.000*	1-2 1-3 1-4 1-5 2-3 3-4
	2. Mathematics T.	83	2.88	.69						
	3. Science T.	164	3.28	.60						
	4. Social Science T.	124	2.96	.65	Within Groups	246.164	604			
	5. Turkish T.	82	3.04	.62						
	Total	609	3.21	.69	**Total**	287.432	608			
	Levene: 1.142	p= .336								
Technological Content Knowledge (TCK)	1.Elementary T.	156	3.63	.67	Between Groups	42.509	4	22.757	.000*	1-2 1-3 1-4 1-5 3-4
	2. Mathematics T.	83	2.99	.69						
	3. Science T.	164	3.29	.70						
	4. Social Science T.	124	2.94	.68	Within Groups	282.053	604			
	5. Turkish T.	82	3.07	.66						
	Total	609	3.23	.73	**Total**	324.562	608			
	Levene: .172	p= .953								
Technological Pedagogical Knowledge (TPK)	1.Elementary T.	156	3.79	.67	Between Groups	1.461	4	.676	.609	-
	2. Mathematics T.	83	3.69	.70						
	3. Science T.	164	3.74	.77						
	4. Social Science T.	124	3.67	.76	Within Groups	326.452	604			
	5. Turkish T.	82	3.66	.76						
	Total	609	3.72	,73	**Total**	327,913	608			
	Levene: 1.977	p= .096								
Technological Pedagogical Content Knowledge (TPACK)	1.Elementary T.	156	3,76	,66	Between Groups	19,574	4	12,989	,000*	1-2 1-3 1-4 1-5 3-4
	2. Mathematics T.	83	3,31	,49						
	3. Science T.	164	3,54	,62						
	4. Social Science T.	124	3,30	,61	Within Groups	227,551	604			
	5. Turkish T.	82	3,40	,64						
	Total	609	3,50	,64	**Total**	247,125	608			
Levene: 2.050	p= .086									

As can be seen from Table 7, results indicated no meaningful relationships between subject area and STs' TK ($F_{(4-604)}$= 1.732, p>0.05). However, variance analysis show there is a meaningful difference between STs' subject specialism and their CK ($F_{(4-604)}$= 9.164, p<0.05). Scheffe test results indicate this result derives from the difference between groups 1-4, 3-4, and 4-5. Mean scores for the level of CK for Elementary Teaching ($\overline{X}$ =3.42) and Science Teaching ($\overline{X}$=3.42) can be labeled as "good" while mean scores for Mathematics Teaching ($\overline{X}$=3.20), Social Science Teaching ($\overline{X}$=3.10), and Turkish Teaching ($\overline{X}$=3.40) can be labeled as "average" level. According to this result, it can be interpreted that the CK level of Elementary Teaching, Science Teaching, and Turkish Teaching is higher than Social Science Teaching students. Analysis results indicate no meaningful difference between STs' subject specialism and their level of PK ($F_{(4-604)}$= .908, *p*>0.05).

According to variance analysis results, there is a meaningful difference between STs' subject area and their PCK levels ($F_{(4-604)}$= 25.314, $p<0.05$). Scheffe test results indicate this result derives from the difference between groups 1-2, 1-3, 1-4, 1-5, 2-3, and 3-4. While mean scores of Elementary Teaching on PCK ($\overline{X}$=3.42) indicate their level of PCK is "good," Science Teaching ($\overline{X}$=3.28), Mathematics Teaching ($\overline{X}$=2,88), Social Science Teaching ($\overline{X}$=2.96), and for Turkish Teaching ($\overline{X}$=3.04) can be labeled as "average" level. According to this result it can be interpreted that PCK level of STs of Elementary Teaching is higher than the other STs with different subject specialism.

Similarly, it was found that there is a meaningful difference between STs' subject area and their TCK levels ($F_{(4-604)}$= 22.757, $p<0.05$). Scheffe test results indicate that the source of this result derives from the difference between groups 1-2, 1-3, 1-4, 1-5, and 3-4. When mean scores obtained by STs is investigated, it can be seen that STs in the Elementary Teaching program have a good level of TCK ($\overline{X}$=3.63); while other STs have an "average" level of TCK (Mathematics $\overline{X}$=2.99; Science $\overline{X}$=3.29; Social Science $\overline{X}$=2.94, and Turkish $\overline{X}$=3.07). According to this result, it can be said that the TCK level of STs of Elementary Teaching is higher than the other STs with different subject specialism. Similarly, the TCK level of STs of Science Teaching is higher than Social Science Teaching STs. Analysis results indicate there is no meaningful difference between STs' subject specialism and their level of TPK ($F_{(4-604)}$= .676, $p>0.05$).

Finally, according to variance analysis results, there is a meaningful difference between STs' subject area and their TPACK levels ($F_{(4-604)}$= 12.989, $p<0.05$). Scheffe test results indicate that this result derives from the difference between groups 1-2, 1-3, 1-4, 1-5, and 3-4. While mean scores of Elementary Teaching on TPACK ($\overline{X}$=3.76) and Science Teaching ($\overline{X}$=3.54) indicate their level of TPACK is "good", Mathematics Teaching ($\overline{X}$=3.31), Social Science Teaching ($\overline{X}$=3.30) and Turkish Teaching ($\overline{X}$=3.40) can be labeled as "average" level. According to this result it can be interpreted that TPACK level of Elementary Teaching students is higher than the other STs with different subject specialism. Similarly, the TPACK level of Science Teaching students is higher than Social Science Teaching students.

6. Discussion and Conclusion

This survey investigated different subject specialist pre-service teachers' TPACK levels in relation to gender, having a PC and Internet connection, and subject area variables.

Analysis of survey data illustrates that in a general sense, participant STs' level of TPACK is at a good level. This finding is similar with the findings of Gündoğmuş' (2013) survey carried out with 493 pre-service teachers in which teacher candidates' technological content, technological pedagogical content, and pedagogical content

knowledge were found to be "good." As the study was carried out with 4th year STs, it can be said that in four years' time STs were able to develop their TPACK as they receive pedagogical formation classes, subject matter knowledge classes, and technology learning classes throughout their pre-service education. A similar result was echoed in Hofer and Grandgenett's (2012) study in which participants' development of TPACK was documented within a three-semester pre-service teacher education program.

Findings of the study illustrate gender was not an important variable in terms of TPACK. There was no difference between female and male pre-service teachers with respect to overall TPACK except at the PK dimension. Female STs' scores in PK were higher than male participants only within the whole TPACK scale. Many studies reveal no significant difference between gender variable and participants' overall TPACK (Akgün, 2013; Öztürk, 2013; Çoklar, 2014; Karaca, 2015; Ersoy, Yurdakul and Ceylan, 2016; Karakaya and Yazıcı, 2017), however, there are some studies that documented the significance of gender variable in TPACK surveys at sub-dimensions especially (Altun, 2013; Öz, 2015). In this study, female participants' PK scores were found to be higher than male counterparts, which is similar to findings by Altun (2013) and Öz (2015).

Another conclusion drawn from the current study is that pre-service teachers' TPACK competencies did not vary with respect to "having a PC" and "Internet connection" in overall TPACK except in the TK dimension. Previous study carried out by Altun (2013) on teachers reveals that having a personal computer both at home and at school does not influence participants' TPACK competencies in general. However, teachers having an Internet connection make the difference with respect to TPACK. In the current study, both variables seem to influence STs' TK only. However, for teachers' there is a significant difference between having an Internet connection and TK, CK, PK, TPK, and TPCK, as revealed in the mentioned study. It can be argued that STs' usage of computers and the Internet is limited to social purposes mainly and educational purposes partly in their daily lives. In contrast, teachers' use computers and particularly the Internet for teaching-learning purposes in their daily lives more than undergraduate students. Perhaps it is for these reasons that the Internet connection variable has no significant impact on STs' TPACK level compared to teachers'.

Results of the current study also show that mean scores of Elementary Teaching students concerning TPACK is higher than all of the other subject specialism programs (Social Science Teaching, Science Teaching, Mathematics Teaching, and Turkish Teaching). Primary school teachers are generalist teachers and they receive an inter-disciplinary training during their undergraduate education for four years rather than focusing on a specific subject. Throughout their studies, they receive theoretical knowledge in technology, content, and pedagogy within a curriculum that consists of different subject areas (such as Turkish, Science, Math, etc.) and carry out practical

teaching and learning activities. Perhaps it is for this reason that primary STs are more capable of integrating TK, PK, and CK than the other subject specialist teacher candidates. This finding was consistent with that of a study carried out by Çoklar (2014), who reported that the TK, PK and CK training given to pre-service teachers are important in gaining TPACK efficacy.

On the basis of these findings, one may conclude that the general TPACK level of pre-service teachers is adequate. Teacher education programs could be effective in helping pre-service teachers to gain theoretical, methodological, and technical skills and knowledge (Pamuk, 2012). However, how these skills and knowledge are mirrored to teaching practice remains a question. Therefore, more practical opportunities should be provided to STs during their pre-service education to integrate technology into their teaching activities. In addition, as Niess et al. (2006) pointed out, modeling effective use of technology in teaching throughout the teacher education program is an important factor for preparing today's teachers to technology enriched classrooms. In other words, technology courses at teacher education programs should be given in combination with method courses and field (school) experience; otherwise, pre-service teachers could be left with technology skills but limited understanding about how to implement technology into their classroom (Mouza et al., 2014).

In the case of Turkey, it is suggested that pre-service teacher education curriculum should be re-visited and an effective TPACK model by considering contextual and cultural factors should be developed and implemented in education faculties. In addition, as Altun (2007), suggested *didactic* or *lecture-based* instruction at education faculties should be abandoned in method courses and more technology-pedagogy integrated activities for STs should be designed and implemented during undergraduate education.

Finally, further research should be conducted to find out how STs use their acquired TPACK and skills in real classroom settings in the future as they seem to have a sufficient level of TPACK at their final year in the faculty education.

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