Education and Science tedmem

Vol 41 (2016) No 186 119-135

Investigating Preservice Teachers' TPACK Competencies Through the Lenses of ICT Skills: An Experimental Study

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Abstract

The purpose of this study is to investigate pre-service teachers' TPACK competencies with respect to variables of ICT usage level, ICT usage phase and gender. A pretest-posttest quasi-experimental design with no control group has been implemented. The study has covered 61 pre-service teachers attending education faculty of a state university between 2011-2012 academic year. TPACK-deep Scale, ICT Usage Level and ICT Usage Phase surveys have been employed. TPACK competencies which were in medium level prior to taking TPACK-based activities increased to higher level at the end of the process. Furthermore, certain amount of progress was found in the TPACK-deep subdimensions namely design, exertion, ethics and proficiency. At the end of the intervention, it was also determined that ICT usage phase of pre-service teachers increased. Consequently the rise in ICT usage levels of pre-service teachers correspondingly elevated their TPACK competencies. However no significant difference was found between TPACK competencies and gender. Most of the correlations between ICT usage phases and TPACK competency subdimensions were at medium-level significance. Some suggestions were provided based on the results.

Keywords

Technological pedagogical content knowledge
Technology integration
Competency based instruction
Human-computer interaction
Higher education

Article Info

Received: 14.03.2016
Accepted: 10.05.2016
Online Published: 04.09.2016

DOI: 10.15390/EB.2016.6345

Introduction

In order to access information and utilize already-existing information via technology, it is crucial to put the essential competencies into practice. The competencies for integrating Information and Communication Technologies (ICT) into learning environments require pedagogical knowledge on using any specified technology for instruction. ICT-integration to education is explained as the use of technology for educational purposes (Hew & Brush, 2007), and it is broadly refers to designating the appropriate learning tools and methods for specific educational situations (Robyler, 2006). Teachers are expected to transfer their knowledge in learning settings via conducive teaching methods and technology. There are various studies on teachers' perceptions, attitudes and conceptions toward technology integration (Ertmer, 1999), problems in having any ICT usage skill (Hew & Brush, 2007)

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and competency (Lim, 2007), access to educational resources (Hutchinson, 2007), expectations from educational system and instructional climate (Bingimlas, 2009), professional and personal development (Hixon & Buckenmeyer, 2009), lack of technological pedagogical knowledge (Jimoyiannis, 2010), deficiencies in ICT usage (Hsu, 2011) and practice (Chai, Koh, Ho, & Tsai, 2012), which can be addressed as the issues in ICT integration into education.

As evidenced from the certain factors above, teachers are expected to be well-trained on the integration of technology. At this stage technology integration models have been formed to utilize technology in desired level in teaching environments. Pierson (1999) defined the process of technology integration as "focusing on students' effective learning and structuring teachers' knowledge on content, pedagogy and technology-usage". Five-Stage Computer Integration Model devised by Toledo (2005) entails shareholders such as financial dimension, institute administrators and teachers. Robyler (2006) presented Technology Integration Planning Model which deals with technology-usage methods that teachers employ in solving teaching-relevant problems. In the integration of ICT with instructional design models Wang and Woo (2007) concocted Systematic ICT Integration Model. Wang (2008) developed Social Model based on pedagogy, social interaction and technology components and assisting teachers to regulate their teaching environments. Technological Pedagogical Content Knowledge (TPACK) model which constitutes the focal point of present study was created by adding technology dimension to Shulman's (1986) Pedagogical Content Knowledge. The intersection point among three main components named as content, pedagogy and technology has been detected as TPACK. In practice, it is tough to separate those three main components from one another and they collectively exist in a dynamic equilibrium (Koehler, Mishra, Hershey, & Peruski, 2004; Koehler, Mishra, & Yahya, 2004; Koehler & Mishra, 2005, 2008; Mishra & Koehler, 2006; Koehler, Mishra, & Yahya, 2007). In a different saying TPACK is launched as a dynamic bond among the three main components and their interaction with one another (Koehler, Mishra, Hershey, & Peruski, 2004). In this model, providing an effective education stands upright at the intersection point of the three main components. TPACK model not only provides an approach to ensure effective education, but also renders assistance in developing teachers' knowledge on the use of technology. TPACK is also utilized in guiding the teachers to refine their teaching knowledge, contemplate on teaching knowledge and inform them about the kind of knowledge as a matter of awareness (Mishra & Koehler, 2006).

Niess (2005) on the other hand defined TPACK concept as the compilation of all the knowledge that teachers need to present for an instructional subject, suited to the class dynamics, via utilizing technology. He also reported that since each teaching activity is unique on its own there is not one single technology, solution or narration method for all. TPACK structure exhibits the transformation in the design of pedagogical strategies and effective teaching via technology (Mishra & Koehler, 2006). In a complex and multidimensional area such as ICT integration in education, the previous studies on teacher training figure out that TPACK model can provide solutions for encountered problems (Allan, Erickson, Brookhouse, & Johnson, 2010; Hewitt, 2008; Lee & Tsai, 2010). It was further claimed that during technology integration in educational settings, it is also possible to develop individuals' TPACK competencies (Koh & Chai, 2014). Upon the introduction of TPACK model a new attempt has been made to develop data collection tools that can boost TPACK competencies of teachers; more specifically that can improve teachers' TPACK-based understandings and motivation for professional development (Guzey & Roehrig, 2009). The instruments of TPACK-based studies in recent years give the impression of a high-level tendency towards data collecting tools like open-ended questions, performance evaluations, interviews, observations, scales and questionnaires (Koehler, Shin, & Mishra, 2011).

In the present study, TPACK-deep Scale developed by Kabakçı Yurdakul et al. (2012) has been employed to unveil the general structure of TPACK competencies. TPACK-deep scale presents a structure measuring pre-service teachers' TPACK skills by focusing on TPACK components. The scale consists of design, exertion, ethics and proficiency factors. Design factor involves refining of the content via technological and pedagogical knowledge. Exertion relates to technology usage skills in the evaluation of process. Ethics is related to intellectual rights, access, confidentiality and accuracy. Proficiency on the other hand addresses problem-solving skills. The dimensions are as seen in Figure1:

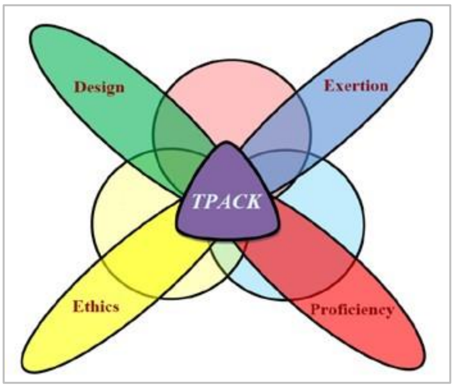

Figure 1. The Framework of TPACK-deep

TPACK- deep scale provided assistance in the measurement of the effectiveness of TPACK-based activities that were held among pre-service teachers. The intervention encompasses a 11 -week instructional content designed for pre-service teachers from Department of Primary School Teaching. In line with this syllabus pre-service teachers improved their knowledge on educational technologies, content and pedagogy (Kabakçı Yurdakul, Odabaşı, Şahin, & Çoklar, 2013).

By focusing on the knowledge on educational technologies, content and pedagogy in educational environments, the instructional content briefly has a mind to transform the teachers for integrating design, exertion, ethics and proficiency issues in an ICT context. Owing to these qualities the developed TPACK-based content and TPACK-deep scale take up a different position than the former studies that have a discourse on scale development and modeling.

The review of the recent literature discloses a broad range of studies on theoretical and applied understandings of TPACK (Angeli & Valanides, 2009; Chai, Koh, & Tsai, 2011; Jang & Chen, 2010; Jimoyiannis, 2010; Kabakçı Yurdakul et al., 2012; Harris, Mishra, & Koehler, 2009; Hofer & Grandgenett, 2012; Lee & Tsai, 2010; Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009). These studies mostly focus on the dimensions of TPACK competencies, TPACK knowledge, development of TPACK, measuring TPACK, adaptation of TPACK and modeling TPACK. In particular, TPACK competencies of participants have been examined with respect to variables such as ICT usage and gender. As ICT usage and TPACK variables were examined it surfaced that ICT usage increased (Jamieson Proctor, Finger, & Albion, 2010; Otrel Cass, Khoo, & Cowie, 2012). As gender and TPACK variables were analyzed it was identified in a number of studies that a significant differentiation existed between the two variables (Altun, 2013; Jang & Tsai, 2012, 2013; Jordan, 2011, 2013; Koh, Chai & Tsai, 2010; Lin, Tsai, Chai, & Lee, 2013). A major amount of recent studies however manifested that in reality there is not a significant difference between TPACK and gender variables (Chang, Tsai, & Jang, 2014; Chen & Syh Jong, 2013; Efilti & Çoklar, 2013; Horzum, 2013; Hosseini & Kamal, 2013; Koh, Chai, & Tsai, 2014; Meriç, 2014; Tuysuz, 2014). A series of data collection tools were developed such as scales, surveys, open-ended questions, reflective essays, interviews and observations for evaluating participants' TPACK competencies (Koehler, Shin, & Mishra, 2011).

Developing data collection tools such as surveys and scales and conducting TPACK modeling studies provide a good support to evaluate in-service and pre-service teachers' TPACK competencies and TPACK usage levels. Initially Mishra and Koehler (2006) devised a survey to measure TPACK. Originally devised by Schmidt et al. (2009) the survey contained a TPACK in which mathematics, social sciences, science and language subjects were separately integrated. Archambault and Crippen (2009) formed a survey that included the subject of online learning. In addition Graham et al. (2009) developed a scale on science knowledge. Web- Technological Pedagogical Content Knowledge (Web-TPACK) developed by Lee and Tsai (2010) is one of these scales. Another domain is related to studies in which ICT component is integrated with TPACK (Angeli & Valanides, 2009; Chai, Koh, Tsai, & Tan, 2011). For science courses Technological Pedagogical Science Knowledge (TPSK) Model was proposed by Jimoyiannis (2010). Adding to these models, scales that tested TPACK model were also formed (Archambault & Barnett, 2010; Chai, Koh, & Tsai, 2010). Lastly Zelkowski, Gleason, Cox, and Bismarck (2013) developed a TPACK scale for high school mathematics teachers. In addition to scale-development studies some studies were related to TPACK modeling. E-TPACK structure was created to detect how English teachers, during their lesson plan and teaching process, were affected by TPACK's component domains (Hughes & Scharber, 2008). Jang and Chen (2010) demonstrated a model that combined TPACK and transformative learning. Koh, Chai, and Tsai (2014) aimed to create with the teachers a Constructivist Oriented- TPACK model.

Scale and modeling studies and studies in which these scales were employed contributed collectively to the development of TPACK structure. Voogt, Fisser, Pareja Roblin, Tondeur, and van Braak (2013) classified TPACK studies as studies in which theoretical origins of TPACK term were clarified and discussed, and practical studies that evaluated professional development of the teachers. By further analyzing literature studies they pointed out that experimental and practical studies would hold importance for teachers to devise strategies for targeting their TPACK skills. It has also been reported that in TPACK studies it would be more beneficial to provide practical data that involve teacher experiences and assist in-service teachers and pre-service teachers on the process (Archambault & Crippen, 2009; Cox & Graham, 2009). Raising the awareness of pre-service teachers and in-service teachers and developing their competencies via experiencing the educational technology is one of the goals of TPACK structure. Furthermore, conducting studies that are fit for both quantitative and qualitative research methods would provide contribution to develop, regulate and even update the structure of TPACK.

Purpose of the Study

The purpose of this study is to investigate pre-service teachers' TPACK competencies in a TPACK based experimental process with respect to variables of ICT usage level, ICT usage phase and gender. The following research questions were considered to address the purpose of the study:

1. Is there a significant difference between average TPACK competency pretest and posttest scores?
2. Is there a significant difference between average ICT usage phase pretest and posttest scores?
3. Is there a significant difference between pre-service teachers' average TPACK competency scores with respect to ICT usage level and gender variables?
4. When pre-service teachers' ICT usage level, gender, and pretest scores are controlled, is there any relationship between each TPACK competency subdimension and ICT usage phase?

Method

In this experimental model study which analyzed the results of techno-pedagogical education, a pretest-posttest quasi-experimental design with no control group has been implemented. Dependent variable of the research is TPACK competency whereas independent variables are gender, ICT usage phases and ICT usage level. Data on the group and process in research design are given in Table 1:

Table 1. Research Design

ICT Use Level	Pretest	Intervention	Posttest
Low Middle High	TPACK-deep	Technopedagogy Activities	TPACK-deep

Participants

The participants of this research are 61 pre-service teachers attending a state university in Turkey during 2011-2012 academic year. 29 participants are female and 32 are male students, the average age range is between 19 and 23.

Instruments

The Techno-pedagogical Competencies Scale or abbreviated as "TPACK-deep Scale", which is the primary data collection tool of this research was designated to determine participants' techno-pedagogical education competencies. In scale-development process an item pool was created and validity-reliability studies were conducted. Out of the emerging 20 competencies and 120 indicators, 40 potential items for the scale were selected under the guidance of field experts. After conducting face and content validity studies 36 items were left in the scale. Cronbach Alpha reliability coefficient of the scale was measured as α=.96. Cronbach Alpha reliability coefficients of scale's subdimensions were found to be between α=.85 and α=.92 interval (Kabakçı Yurdakul et al., 2012). Some of the cases that the 5-point (I can manage easily-I can never manage) Likert type scale focuses on are: "leading the diffusion of cutting-edge technologies that enhance my field of study in instructional process", "acting ethically in using technology for pedagogical purposes", "using technology in evaluating the success about a specific topic" and "utilizing technology in designing materials that fit the requirements for effective teaching".

In Knowledge and Communication Technologies Usage Phases Survey which was developed for determining participants' ICT usage phases, ICT usage was categorized under five parts as "Problem Solving", "Effective Usage", "Innovativeness", "Knowledge Updating" and "Integration with Teaching". The reliability coefficient of the survey was determined as .96. The items were scored 1 to 4 points which indicated a specific condition of usage.

Another data collection tool devised to meet the purpose of this research is "Information and Communication Technologies Usage Level Survey". In the survey-development process 23 common technology forms were listed initially. Next by analyzing recognition, comprehension and usage levels of particular technologies a data collection tool was shaped. The reliability coefficient of the survey was determined as .92. The survey items were categorized under four headings: "Information Processing Technologies", "Communication Technologies", "Internet Technologies" and "Instructional Technologies".

The Study

Prior to conducting the study, an instructional content was designed based on the educational indicators treated in the previous stages. This instructional content was created by conducting an analysis with respect to design, exertion, ethics and proficiency which are the subdimensions of TPACK competency. Asynchronous student interaction of the intervention was initially tested on Moodle platform as a pilot practice. In the upcoming stage the platform was replaced with Facebook in line with student feedbacks. Table 2 summarizes the prepared syllabus:

Table 2. Instructional Content Created for the Intervention

Week	Theoretical Lesson (2 hours)	Activities (2 hours)
Week 1	Introduction to content	An Introduction to Moodle • Introduction • An activity on the examples of pedagogical usage
Week 2	Technology use in education Teacher qualifications	Web page evaluation • Main goals • Criterion • An activity on the examples of pedagogical usage
Week 3	Visual literacy Using images in education	Digital photography and Image processing • Sharing knowledge for photographing hints • An activity on the examples of pedagogical usage
Week 4	Technology and copyright	Digital imagebooks • A handout on creating a digital imagebook • An activity on the examples of pedagogical usage
Week 5	Lesson plans	Creating a lesson plan and a weekly schedule • Choosing the appropriate theme • Alternative lesson plans • An activity on creating a lesson plan
Week 6	Digital storytelling	Digital storytelling project • Basic components • Story-driven design examples
Week 7	Technology integration	Digital storytelling project (cont.) • An activity on the examples of pedagogical usage
Week 8	Web tools in education	E-portfolio • A handout on creating a digital portfolio • An activity on the examples of pedagogical usage
Week 9	Web 2.0 use in education	Blogs and Wikis • Basic steps for creating blogs and Wikis • Activities on the examples of pedagogical usage of blogs and Wikis
Week 10	Social networks' potential in education	Effective use of Facebook • Sharing knowledge on social network literacy • An activity on the examples of pedagogical Facebook use
Week 11	Interactive whiteboard use	Google Apps • Google for Work • An activity on the examples of pedagogical usage

In the following stage of the study, data collection tools were used at the beginning of the intervention. At the end of the 11-week process, the tools were reapplied and data analysis was commenced by classifying the collected data as pretests and posttests.

Data Analysis

In the analysis of data collected before and after the experimental practice towards techno-pedagogical education, a series of analyses was conducted by applying arithmetic means, standard deviation and maximum-minimum values. In order to detect the changes in design, exertion, ethics and proficiency competencies which are the four subdimensions of TPACK competency throughout pretest and posttest, dependent groups t-tests were put into practice. In the next stage TPACK competency scores were analyzed singly. To see if a significant differentiation existed between pretest - posttest average scores of TPACK competency scores with respect to gender and ICT usage levels of participants, independent groups t-test and variance analysis were employed. Since there were limitations for MANOVA, ICT usage levels were separated among 3 categories as low-medium-high level and then variance analysis was initiated. To the end of analyzing the relation between every single TPACK competency dimension and ICT usage phases, partial correlation technique was used by controlling pretests, ICT usage level and gender variable. The participants' identity and the names of the organizations remained confidential throughout the research process.

Findings

In this section the changes in TPACK competency subdimensions, ICT usage phases, gender and ICT usage level variables have been elaborated. Hattie (2009, p.97) uses three types of effect size namely *developmental effects* ($\eta^2<.010$), *teacher effects* ($.010 \leq \eta^2<.039$) and *zone of desired effects* ($.039 \leq \eta^2<.200$) for interpreting the effects of the intervention actually. This recent interpretation of the effect size seems more strict than Cohen's (1988) broadly accepted intervals. Developmental effects here can be ascribed to student and interpreted as a natural progress, while teacher effects and zone of desired effects are ascribed to the intervention noticeably. The effect size of the intervention for each sub-category was interpreted by considering these intervals.

Effect of Techno-pedagogical Education on TPACK Competency's Subdimensions

Within the scope of research the changes witnessed in pre-service teachers as regards overall TPACK-deep scale and its subdimensions are provided in Table 3:

Table 3. T-Test Results of Pre-service Teachers' Average Scores Regarding TPACK-deep Subdimensions

TPACK Subdimensions	TPACK Measurements	N	$\overline{X}$	sd	df	t	P	η^2
Design	Pre-intervention	61	3.48	546	59	6.891	.001	.040
	Post-intervention	61	4.11	.456				
Exertion	Pre-intervention	61	3.53	.465	59	5.964	.001	.020
	Post-intervention	61	4.02	.440				
Ethics	Pre-intervention	61	3.17	.533	59	5.472	.001	.010
	Post-intervention	61	3.84	.802				
Proficiency	Pre-intervention	61	3.76	.471	59	4.562	.001	.015
	Post-intervention	61	4,13	.416				
TPACK competency score	Pre-intervention	61	3,48	.458	59	6.839	.001	.030
	Post-intervention	61	4,03	.423				

Table 3 manifests that TPACK competency level of pre-service teachers significantly increased ($t_{(59)}=6.839$, $p<.05$, $\eta^2=.030$). The conducted analysis revealed that there is a statistically significant difference between TPACK competency levels before and after the intervention. Thus, education process proved to be effective. To put this statement differently 11 -week long 2-hour theoretical and

2-hour practical techno-pedagogical activities offered to pre-service teachers triggered a positive change in their TPACK competency. The effect size (η^2=.030) here shows that, a medium level effect can be ascribed to the teachers' competency on the issue.

On the other hand, t-test that tested the difference in TPACK competency measurements in design dimension revealed that the difference was significant ($t_{(59)}$=6.891, $p<.05$, η^2=.040). As is seen with this result TPACK competency in design dimension was higher and pre-service teachers considered themselves more competent at the end of the educational process, and a desired effect of the intervention (η^2=.040) was statistically noted.

TPACK competency in exertion dimension averaged to 3.53 before the education but increased to 4.02 after the education as illustrated in Table 2 which manifests the significance of differentiation ($t_{(59)}$=5.964, $p<.05$, η^2=.020). In line with this conclusion it surfaced that the intervention positively affected pre-service teachers in the exertion dimension too. The result of t -test which examined ethics dimension points out that the difference is significant ($t_{(59)}$=5.472, $p<.05$, η^2=.010). The TPACK based continuum affected pre-service teachers' TPACK competency positively in ethics dimension as well. However, both two dimensions' effect size related to the intervention was at medium-level.

Lastly in proficiency dimensions consisting of 5 items, pre-service teachers' TPACK competency before (◎=3.76) and after the intervention (◎=4.13) was compared via t- test and it was seen that the difference in between was significant ($t_{(59)}$=6.839, $p<.05$, η^2=.030). As can be concluded in proficiency dimension which is the last dimension the intervention proved to be effective and positively affected TPACK competency in proficiency dimension likewise. A medium level effect (η^2=.030) here again can be ascribed to the teachers' competency on the issue.

Hence it can be concluded that at the end of an 11-week long educational program devised and applied on the pillars of TPACK philosophy and provided a collective presentation of technology, field knowledge and professional knowledge on education; pre-service teachers' TPACK competency increased in both overall scale and in all the subdimensions of the scale. It is thus safe to argue that an instructional content focusing on this method could prove to be effective in developing TPACK competency with all its aspects.

Effect of Techno-pedagogical Education on the Changes in ICT Usage Phase

Table 4 summarizes the results of t-test that examines the changes in ICT usage phases before and after the process of techno-pedagogical education:

Table 4. T-Test Results Representing the Change in ICT Usage Phases

ICT Usage	Measurement	N	$\bar{X}$	sd	df	t	p	η^2
Problem solving	Pre-intervention	61	1.80	.813	120	-6.525	<.001	.030
	Post intervention	61	2.77	.824	120			
Effective usage	Pre-intervention	61	2.26	.480	120	-4.961	<.001	.017
	Post intervention	61	2.74	.575	120			
Innovativeness	Pre-intervention	61	2.15	.749	120	-3.874	<.001	.033
	Post intervention	61	2.67	.747	120			
Knowledge updating	Pre-intervention	61	2.30	.558	120	-4.015	<.001	.035
	Post intervention	61	2.74	.656	120			
Integrating knowledge with teaching	Pre-intervention	61	2.23	.589	120	-5.034	<.001	.058
	Post intervention	61	2.84	.734	120			

As exhibited in Table 4, ICT usage phase scores of pre-service teachers after the intervention significantly differed in all subdimensions compared to the score before the intervention. As the average scores that participants received in 1 to 4 scoring were examined at length it surfaced that the highest development level was measured in ICT usage for problem solving purposes and the score varied between $\overline{X}$=1.80 and $\overline{X}$=2.77. The development witnessed in the rest of subdimensions was also statistically significant, but comparatively lower than ICT usage.

Effect of ICT Usage Level and Gender Variables on the Change in TPACK Competencies

One-way ANOVA test was utilized to see if TPACK competency differed significantly with respect to ICT usage levels. Table 5 provides a list of the results pertaining to this test:

Table 5. ANOVA Results for TPACK General Competency and ICT Usage Phases

Source of Variance	Sum of Squares	df	Mean Square	F	p
Between groups	4527.009	2	2263.504	11.853	<.001
Within groups	11075.844	58	190.963		
Total	15602.852	60			

As exhibited in Table 5, TPACK competency scores of participants significantly differed with respect to ICT usage levels ($F_{(2,58)}$=11.853,p<.001, η^2=.29). Scheffe Test was used to compare average score differentials of ICT usage among participants with low, middle and high level usage. At the end of conducted test techno-pedagogical content knowledge competency was found to be higher in the group with high level of ICT usage ($\overline{X}$=139.700) compared to the group with medium ($\overline{X}$=122.487) and low ($\overline{X}$=111.000) level usage. Likewise competency scores of group in middle-level ICT usage are higher than the low-level group. Obtained results demonstrate that parallel to the rise in ICT usage level there is a significant rise in teachers' techno-pedagogical content knowledge competency. %29 of total variance is accounted for by the intervention. Although Scheffe Test is a strict way of comparing the sub categories of a within-subjects variable, the underlying reason may be creating an artificial trichotomy for ICT Usage. In order to test if TPACK competency significantly varied with respect to gender variable, independent groups t-test was employed and obtained results are as listed in Table 6:

Table 6. Independent Groups t-test Results of TPACK Competencies in Terms of Gender

Gender	N	$\overline{X}$	sd	df	t	p
Female	29	120.551	17.561	59	-1.155	.253
Male	32	125.312	14.616			

As shown in Table 6 that deals with gender variable, TPACK competency scores did not significantly differ with respect to gender ($t_{(59)}$=-1.155, p=.253). The mean scores related to TPACK competency were found close to each other across females and males.

Partial Correlations Between TPACK Competency Dimensions and ICT Usage Phases

In order to determine whether every single TPACK competency dimension is related with all ICT usage phases, partial correlation test was employed. Pretests were conducted to exhibit the position at the end of practice, and in addition gender and ICT usage level variables were controlled. Table 7 summarizes the test results:

Tablo 7. The Results of the Partial Correlation Test Regarding TPACK Competencies and ICT Usage

	Problem Solving	Effective Usage	Innovativeness	Knowledge Updating	Integrating with Teaching
Design	.304*	.251*	.309*	.278*	.266
Exertion	.281	.267	.282	.265	.273
Ethics	.420*	.345*	.388	.346	.317*
Proficiency	.298	.366	.258	.334	.277

*p<.05, N=61.

As can be seen in Table 7 demonstrating the results of partial correlation, in the measurements conducted after the test no statistically significant relation was found between exertion & proficiency dimensions and ICT usage phases. The highest correlation was found (.420) between ethics competency and problem solving. The lowest level of relation (.251) was found between design competency and effective usage variables. As correlation levels are examined overall, it can be argued that there exists a medium level correlation between the variables.

Discussion

In the present study TPACK competencies, ICT usage levels, ICT usage phase and gender variables were explored. At the end of analyses conducted to serve the objective of the research it was found that TPACK competency of pre-service teachers increased. It is also safe to claim that TPACK competency was in satisfactory level. ICT usage phases also changed in a positive way. Furthermore it was also found that coincident with the increase in ICT usage levels, TPACK competency increased. With respect to gender TPACK competencies did not differ. Besides it is reasonable to state that there is a medium-level relationship between TPACK competency and subdimensions of ICT usage level variables.

The first finding of the study is that pre-service teachers' medium-level TPACK competency increased to high level at the end of the intervention. In relevant literature focusing on TPACK development it was also echoed that TPACK competency levels of pre-service teachers progressed (Ceylan, Turk, Yaman, & Kabakçı Yurdakul, 2014; Chai, Koh, Tsai, & Tan, 2011; Koh & Divaharan, 2013). In this study, developments were tracked in TPACK competency's subdimensions namely design, exertion, ethics and proficiency. Consequently it can be argued that activity structure in TPACK-based activities supported pre-service teachers in a positive direction hence the instructional content proves to be effective. Forssell (2010) reported that TPACK structure plays vital role in supporting teachers via activities. Jang and Chen (2010) in their course explored that TPACK-based technology use and experience are substantial factors in developing pre-service teachers' TPACK skills.

Another finding is that pre-service teachers' ICT usage phase and ICT level scores at the end of TPACK- based activities varied in a significant level. In a different saying, parallel to the rise in ICT usage level and ICT usage phase levels of pre-service teachers, a corresponding rise was observed in their TPACK competencies. Ertmer (2005) argues that in the regulation of learning experiences with an effective integration, teachers' positive attitudes towards ICT integration holds importance. It has been witnessed that among frequent users of ICT, skills in technology-supported activities proved to be more successful (Polly, 2008, 2014). Pre-service teachers as ICT users possessed higher TK scores in teaching experience (Chang et al., 2014) compared to non-users. It is also reported that with the integration of technology, ICT skills of teachers can also be enhanced (Swain, 2006; Simpson, 2006). It can be argued that pre-service teachers gaining ICT knowledge or TK become more equipped in technology integration and also having effective teaching skills (McGrath, Karabas, & Willis, 2011). Technology knowledge promotes effective learning for pre-service teachers and in-service teachers, and learning to create this educational setting bears critical significance (Sweeney & Drummond, 2013). Fransson and Holmberg (2012) reported that students felt themselves much more independent while using ICT tools and that TPACK could be employed in learning, teaching and evaluation dimensions in teacher training. It has also been stated that ICT-development courses leave positive effects on pre-service teachers’ understandings of TPACK (Chai, Koh, & Tsai, 2011; Chai, Koh, Tsai, & Tan, 2011; Kabakçı Yurdakul & Çoklar, 2014).

Another conclusion drawn from the current study is that pre-service teachers' TPACK competencies did not vary with respect to gender. The latest studies also found the same conclusion and manifested that there was no significant change in the competencies with respect to gender. Chang et al. (2014) in their research reported that TPACK competency did not manifest a significant difference with respect to gender. Koh, Chai, and Tsai (2014) likewise argued that teachers' ICT usage did not vary with respect to gender hence there was no differentiation in their TPACK scores. However, there are a few studies in literature claiming that TPACK differentiated with respect to gender (Koh, Chai, & Tsai, 2010; Lin et al., 2013), and Sweeney and Drummond (2013) stated that male pre-service teachers demonstrated a more positive attitude towards technology. Briefly, this conclusion was generally in line with other studies (Chang et al., 2014; Chen & Syh Jong, 2013; Efilti & Çoklar, 2013; Horzum, 2013; Hosseini & Kamal, 2013; Koh, Chai, & Tsai, 2014; Meriç, 2014; Tuysuz, 2014).

The results of the partial correlation test show that there was not a significant correlation between exertion and proficiency subdimensions of TPACK competency and ICT usage phases. The two variables with the highest ratio of correlation are ethics subdimension and problem- solving subdimension within ICT usage phase. The two variables with the lowest ratio of relation are design subdimension and effective usage subdimension within ICT usage phase. With a general outlook on the correlation levels, a medium-level correlation can be observed amongst the variables. Kabakçı Yurdakul and Çoklar (2014) in their study manifested that there is a high-level relation between ICT usage phase and TPACK competency. Echoing these findings Kabakçı Yurdakul and Çoklar (2014) also reported that ICT usage phase is a vital predictor of TPACK competency. This discrepancy may be interpreted as a natural outcome of the experimental process since various variables can be discussed within the issue, and this may call for another study focusing on regression models.

Conclusion and Recommendations

The purpose of this study was to investigate pre-service teachers' TPACK competencies before and after taking TPACK-based activities with respect to variables of ICT usage level, ICT usage phase and gender and to determine the changes measured in the listed variables. The results of the study demonstrated that TPACK-based activities focusing on the components of TPACK model and factored in design, exertion, ethics and proficiency dimensions proved to be effective in enhancing preservice teachers' TPACK competencies. Pre-service teachers' TPACK competencies that were in medium level advanced to high level. It was also determined that the intervention developed ICT usage level and ICT usage phase concurrently. In terms of ICT usage phase it was found that pre-service teachers achieved progress in problem solving, effective usage, innovativeness, updating knowledge and integration with teaching. Furthermore a positive correlation existed between the rise in ICT usage level and TPACK competencies. TPACK competency of the group with high level of ICT usage was higher than the group with medium and low level of usage. Similarly the group with medium level of ICT usage had higher TPACK competencies than the group with low usage level. With respect to gender variable TPACK competencies did not significantly differentiate. The effect sizes in general show that more research studies should be conducted on teachers' competency on the pedagogical issues, or student-teacher collaboration in the educational process. Another result manifested that there exists a medium-level correlation between ICT usage phase and TPACK competency subdimensions. The two variables with the highest level of correlation are ethics and problem solving.

There is a list of studies probing into the proper use of technology in the field of education and these studies underpin the gravity of technology with the integration of ICT. In literature studies it has also been pointed out that TPACK model could be employed in ICT integration (Lee & Tsai, 2010; Ritter, 2012). In parallel with these findings it can be argued that TPACK competencies of pre-service teachers can be improved. In order to gain this skill to pre-service teachers in their undergraduate education, elective courses could be integrated into the syllabus.

In the light of these result it is reasonable to claim that IT courses and instructional content needs to be restructured based on TPACK. Therefore teacher training programs could be updated and TPACK skills could be embraced not only via a separate IT course but also via integrated IT courses aided by content and pedagogy. Bearing in mind that technology integration is linked to pedagogy, technology and content knowledge it is necessary to correct this complexity in more dynamic and multi-faced classrooms (Koehler & Mishra, 2009). By regulating course content of ITMD in the syllabus of Education Faculties it is quite reasonable to form a structure that supports learner skills in particular. Since TPACK-based activities, as found out, developed pre-service teachers' competencies it is possible to conduct experimental studies structured in this way. In relevant literature there are some emerging studies implying this research trend. It is now underlined that the focus should be directed to experimental studies (Koehler, Mishra, & Cain, 2013; Voogt et al., 2013). On the other hand, an important point is that gender is a controversial independent variable for meeting the prerequisites of MANOVA backgrounded by an experimental continuum, especially when dependent variables are subdimensions when dealing with a bigger structure. Furthermore based on these studies it could be possible to devise and revise TPACK -based instructional content according to a variety of contexts.

In addition to studies organized in line with quantitative research models, it is necessary to conduct studies based on qualitative research models that would reflect in-depth analysis of TPACK practices. It is also suggested to conduct action researches that aim to focus on TPACK competency. By conducting case studies TPACK-based activity structures can be examined related to technology integration process, hence it can be viable to extract more detailed information and data from such studies.

Acknowledgements

This study is fully supported by the Scientific and Technological Research Council of Turkey (TUBITAK), with grant number 109K191.

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