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An Examination of Pre-service Teachers' Technological Pedagogical Content Knowledge and Beliefs Using Computer Technology in Mathematics Instruction*

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Abstract
The aim of this study was to examine the pre-service mathematics teachers' technological pedagogical content knowledge and beliefs using computer technology in mathematics instruction, as well as the effects of teacher training programs on these beliefs and knowledge. Participants included 199 pre-service elementary mathematics teachers. Of these, one hundred-eighteen were freshman and eighty-one were senior. Two instruments (Technological Pedagogical Content Knowledge (TPACK) instrument and Belief Scale towards Using Computer Technology in Mathematics Instruction) were used to determine pre-service teachers' TPACK and beliefs about using computer technology in their instruction. To evaluate pre-service teachers' TPACK and beliefs, both descriptive and inferential statistics were used. The data showed that the teacher education program has a positive effect on pre-service teachers' TPACK for mathematics teaching and beliefs using computer technology in mathematics instruction. In addition, there was a positive correlation between pre-service teachers' belief scores and TPACK scores. So, it can be said that the beliefs using computer technology into instruction is a significant predictor for TPACK.
Keywords: *Technological pedagogical content knowledge, belief, pre-service teachers, teacher education program.*

Introduction

Teachers' knowledge is one of the most important factors relating to the quality of teaching. Thus, a number of studies have recently been carried out to investigate the teachers' knowledge. Those studies have focused on teachers' knowledge structures such as their subject matter knowledge and their pedagogical knowledge. Shulman (1986) divides teachers' knowledge into three categories, namely subject matter knowledge, pedagogical content knowledge and curriculum knowledge. The subject matter knowledge is a teachers' knowledge that can be used to understand the structures of subject matter. Curricular knowledge is the knowledge of the programs that are designed for teaching a domain. Pedagogical content knowledge is the knowledge of how to teach by transforming information into a form that is easy for students to understand (Shulman, 1986). So, transformation is a process whereby subject matter knowledge is converted into a form appropriate for teaching (Kinach, 2002). At present time, technology has changed and developed very fast, and it has affected education system. With increasing degree of importance of technology in education, technology dimension has been added to Shulman's (1986) framework of pedagogical content knowledge by Koehler and Mishra (2009). This new framework is called technological pedagogical content knowledge (TPACK). (See Figure 1.)

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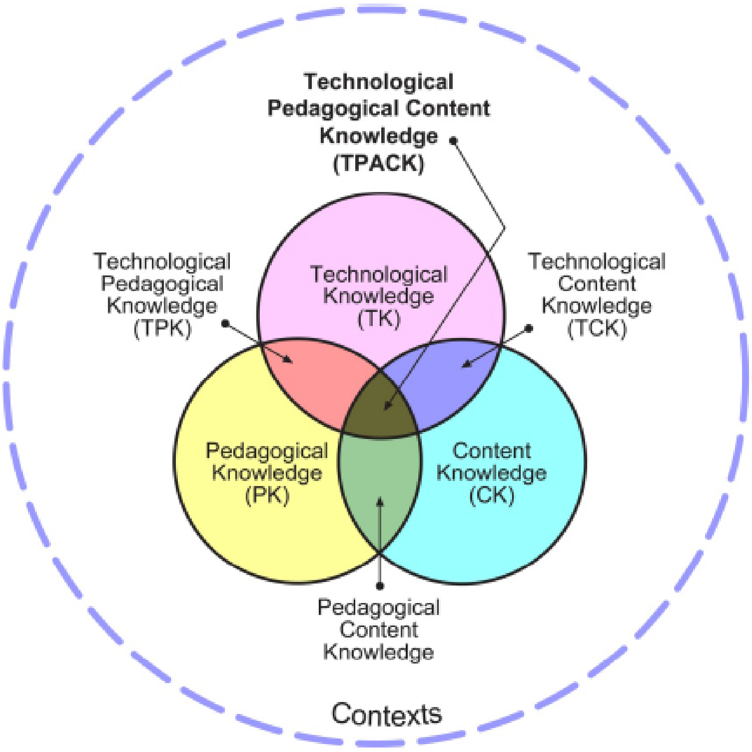

Figure1. Technological Pedagogical Content Knowledge Framework, adapted from Koehler and Mishra (2009), p.63.

TPACK is defined as an interrelationship of three knowledge types: content, pedagogy and technology (Niess, 2005). It presents a framework about what knowledge teachers must have to integrate technology into their instruction. In other words, it is the knowledge of teachers regarding how to use technology for helping students to learn a topic (Mishra & Koehler, 2006).

Most developed and developing countries' governments have already initiated technology integration projects with large amount of budgets to transform their educational programs (Cakiroğlu, Akkan & Guven, 2012). The aim of these projects was to provide better instructional and training facilities and enable equal opportunities to all students. Turkey has also started technology integration projects called "Movement of Enhancing Opportunities and Improving Technology" known as "FATIH Project in Education" in 2012 at 52 public schools. The aim of this project is to enable equal opportunities in education and to improve technology in schools for the efficient usage of computer technologies in the learning and teaching process. FATIH Project in Education consists of five components, which are; (i) provision of hardware and software infrastructure, (ii) provision and management of educational e-content, (iii) effective information technology (IT) usage in curriculum, (iv) provision of in-service training for teachers and (v) conscious, reliable, manageable, measurable use of IT (Ministry of National Education (MoNE), 2012). In this project, MoNE aimed to equip K-12 school with information and communication technologies (ICT) all over the country (Gök & Yıldırım, 2015). For this purpose, all classrooms were converted into "Technology-Enhanced Classrooms" which were equipped with smart boards, tablet PCs and internet connection.

Such projects provide opportunities for teachers to use technology in teaching and learning. Similarly, The National Council of Teachers of Mathematics (NCTM, 2000) stated that technology can be used to improve students' mathematical problem solving, reasoning and communication skills. Although effective technology integration is highlighted to enhance and expand student learning in mathematics, there is a little attention given to how it can be used in schools or how it intersects with pedagogical and content knowledge in the teacher education programs (Crompton, 2015; Sweeney & Drummond, 2013). Niess (2005) also highlights that teachers often learn technology, but fail to connect it to subject matter knowledge. Research has indicated that beginning teachers do not feel sufficiently prepared to integrate computer technology into their classroom (Enochsson & Rizza, 2009; Voogt & McKenney, 2017). The reason can be that the teachers' negative beliefs about using technology in the teaching and learning process (Karatas, 2014). Teachers who have more traditional beliefs will implement low-level technology uses, whereas teachers who have more constructivist beliefs will implement high-level technology uses (Judson, 2006). For that reason pre-service and in-service teachers' beliefs are crucial for the effective use of instructional technologies in teaching and learning. Beliefs are static, resistant to change and generally unaffected by new information (Raymond, 1997). However, Thompson (1992) expressed that beliefs are both shaped and changed by experiences. Pre-service teachers enter teacher education programs with pre-existing beliefs based on their past experiences as students at grade 1-12 (Karatas, 2014). Moreover, they could have little experience teaching a topic with technology in school. This may have caused them to developed negative beliefs toward using technology in the teaching and learning process (Crompton, 2015). Karatas (2014) emphasizes that the instruction during the computer-assisted environments have a positive effect on pre-service teachers' beliefs about using computers to teach and learn mathematics. Although there is an increase in the use of technology in teacher education programs, it is not enough. Teacher education programs should not only focus on how to use technology but also how technology connects with pedagogical and content knowledge (Sweeney & Drummond, 2013). Research indicated that stand-alone courses are ineffective in providing pre-service teachers with appropriate preparation to successfully integrate technology into their instruction (Crompton, 2015; Karatas, 2014). On the other hand, technology-infused method courses are very effective for pre-service teachers to successfully integrate technology into their instruction (e.g. Brown & Warschauer, 2006; Lee, Chai, Teo & Chen, 2008). In addition, integration technology into method courses improve pre-service teachers' TPACK and positively influence their belief about using computers in their instruction (Chai, Koh & Tsai, 2010; Hardy, 2010; Harrington, 2008; Mudzimiri, 2010). Although there were studies about pre-service teachers' TPACK and beliefs about using computer technology in teaching and learning, TPACK and belief together were less studied. Moreover, there is no evidence of any research intended for revealing whether belief using computer technology in mathematics instruction can be a predictor of TPACK for mathematics instruction.

Purpose of the study

The purpose of this study was to examine the pre-service mathematics teachers' TPACK and belief using computer technology in mathematics instruction, as well as the effects of teacher training programs on these belief and knowledge. Another aim was to reveal whether belief using computer technology in mathematics instruction can be a predictor of TPACK for mathematics instruction. Therefore, the research problems of this study were as follows:

- What are the pre-service teachers' technological pedagogical content knowledge for mathematics instruction?
- What are the pre-service teachers' belief using computer technology in mathematics instruction?
- Do teacher education programs have an effect on pre-service teachers' belief using computer technology in mathematics instruction and technological pedagogical content knowledge for mathematics instruction?

- Could beliefs regarding the use of computer technology in mathematics instruction be a predictor of technological pedagogical content knowledge for mathematics instruction?

Method

The research methodology of this study was a case study. In a case study, the researcher is primarily focused on understanding a specific individual or situation (Fraenkel, Wallen, & Hyun, 2012). Case study research focuses on individuals' experiences of certain phenomenon and describes the cases in depth.

Participants. The research sample of this study was selected via convenience sampling; volunteers were requested from the body of students who were enrolled in the elementary mathematics teaching program at the researcher's university, as these students were easily accessible for administration of the data collection instruments. The research group consisted of 199 pre-service elementary mathematics teachers. Of these, one hundred-eighteen were freshmen and eighty-one were seniors. The aim in selecting pre-service teachers from different levels was to examine the changes in their TPACK and belief using technology in mathematics instruction in the teacher education program. At the time of the study, the freshman pre-service teachers had completed Computer-I course which was a stand-alone course. This course aims to prepare students with the knowledge and skills regarding the basic concepts of computers, hardware and computer ethics and usage of computers. For example, in this course, pre-service teachers use some software such as word or excel. With these software, they create a file, copy, delete or transfer it. In addition they create tables, graphs or draw an object by using a word processor. The senior pre-service teachers had completed Computer Supported Mathematics Education which was a technology-infused method course. The aim of this course is to provide the ability of using different software that contribute to primary mathematics teaching. In this course, pre-service teachers discover and use different dynamic mathematical software such as Geogebra and Cabri. They prepare activities in computer-aided teaching of mathematics and use a software to perform mathematical modelling. For example, in the 5-8 grade elementary mathematics curriculum, transformation geometry is taught from the fifth through eighth grades. Pre-service teachers prepare a task by using Geogebra. In this task, the dynamic feature of the Geogebra enabled students to easily study the different types of transformations and observe the dynamic effects of change on the main object and the image object. For instance, in this task, students could easily change the angle of rotation and observe the effects of the change.

Instrument and Data Collection Procedure. To determine the pre-service teachers' TPACK at each grade level, "Technological Pedagogical Content Knowledge (TPACK)" instrument developed by Schmidt, Baran, Thompson, Mishra, Koehler and Shin (2009) was used. The instrument was adapted to Turkish by Övez-Dikkartın and Akyüz (2013) for mathematics field. The adapted instrument includes 27 items in a five-point likert-type ranging from "strongly agree" to "strongly disagree". Within this adapted instrument, TPACK consists of 4 broad dimensions: Technology Knowledge (TK), Content Knowledge for Mathematics (CKM), Pedagogical Content Knowledge for Teaching of Mathematics (PCKM), and Technological Pedagogical Content Knowledge for Teaching of Mathematics (TPCKM). The Cronbach alpha reliability coefficient was calculated as .82 for technology knowledge, .83 for content knowledge, .85 for pedagogical content knowledge, and .86 for technological pedagogical content knowledge subscales.

To determine the pre-service teachers' beliefs towards using computer technology in mathematics instruction at each grade level, "Belief Scale towards Using Computer

Technology in Mathematics Instruction (BSCTM)" instrument developed by Yılmaz Kaleli (2012) was used. The instrument consists of 31 items in a five-point Likert type ranging from "strongly agree" to "strongly disagree". Within this instrument, BSCTM includes 4 broad dimensions: Learning, Content, Teaching and Measurement and Evaluation. The reliability coefficient for the overall instrument was calculated as .90. The Cronbach alpha reliability coefficient was calculated as .84 for learning, 0.71 for content, .72 for teaching and .70 for measurement and evaluation subscales.

Data Analysis. To evaluate pre-service teachers' technological pedagogical content knowledge and beliefs using computer technology in mathematics instruction, both descriptive and inferential statistics were used. Before the data analysis, it was examined whether the data were normally distributed. To determine the normal distribution of the data, the coefficients of skewness and kurtosis were examined. If the ratio of the coefficient of skewness (kurtosis) to the coefficient of the standard error of skewness (kurtosis) is staying between -1,96 and +1.96, the distribution of the data is considered normal (Field, 2009). The Table 1 indicates the normality of both instruments.

Table 1

The normality distribution of the data

Level	Instrument	Skewness	Std Error	Skewness /Std Error	Kurtosis	Std Error	Kurtosis /Std Error
Freshman	Learning	-.074	.223	-.332	-.60	.442	-1.351
	Content	.257	.223	1.152	-0,404	.442	-.914
	Teaching*	.955	.223	4.283	6.176	.442	13.97
	Measurement and evaluation	.328	.223	1.471	.667	.442	1.51
	BSCTM	.007	.223	.031	-.47	.442	-1.063
	TK	.042	.223	.188	.433	.442	.98
	CKM	.002	.223	.001	.123	.442	.28
	PCKM	-.393	.223	-1.762	.301	.442	.681
	TPCKM	.077	.223	.34	.372	.442	.84
	TPACK	.144	.223	.65	.287	.442	.65
Senior	Learning*	-.625	.267	-2.341	.784	.529	1.482
	Content	.122	.267	.457	.21	.529	.397
	Teaching	-.513	.267	-1.921	.74	.529	1.399
	Measurement and evaluation	-.434	.267	-1.63	.333	.529	.63
	BSCTM	-.507	.267	-1.89	.755	.529	1.427
	TK	-.052	.267	-.195	-.018	.529	-.034
	CKM*	-.722	.267	-2.704	1.344	.529	2.541
	PCKM*	-.636	.267	-2.382	3.252	.529	6.147
	TPCKM	-.502	.267	-1.88	1.013	.529	1.915
	TPACK	-.201	.267	-.75	.946	.529	1.78

* This data was not normally distributed.

The Table 1 indicated that teaching subscale of BSCTM for freshman and learning subscale of BSCTM for senior pre-service teachers, data were not normally distributed. In addition, both CKM and PCKM subscales of TPACK for senior pre-service teachers, data were not normally distributed. The total scores of both instruments and the other subscales of both instruments were normally distributed. For that reason, Mann-Whitney U test was conducted for the data which were not normally distributed and independent sample t-test was used for data which were normally distributed. Moreover, bivariate linear regression analysis was used to predict the impact of belief using computer technology in mathematics instruction (independent variable) on technological pedagogical content knowledge for mathematics (dependent variable). The pre-service beliefs and technological pedagogical content knowledge scores were graded as and presented in Table 2.

Table 2
Levels for interpreting pre-service teachers' BSCTM and TPACK scores.

Score	Level
1.00-1.79	Very low
1.80-2.59	Low
2.60-3.39	Moderate
3.40-4.19	High
4.20-5.00	Very high

Results

Table 3 indicates the descriptive analysis of the TPACK instrument for both freshman and senior pre-service teachers.

Table 3
Descriptive analysis of TPACK instrument

Subscale	Freshman			Senior		
	Mean	**Std. Deviation**	**Level**	**Mean**	**Std. Deviation**	**Level**
TK	3.36	.64	Moderate	3.52	.69	High
CKM	3.50	.61	High	3.77	.67	High
PCKM	3.58	.60	High	3.73	.52	High
TPCKM	3.54	.45	High	3.76	.56	High
TPACK	3.51	.44	High	3.70	.49	High

Table 3 shows that both freshman and senior pre-service teachers' technological pedagogical content knowledge for mathematics instruction were generally high. Moreover, there was an increase in the scores from freshman to seniors.

In order to determine whether the differences in the freshman and senior pre-service' scores were statistically significant, an independent sample t-test was applied for data which were normally distributed and a Mann Whitney-U test was used for data which were not normally distributed at a significance level of .05. Table 4 summarizes the results of the independent sample t-test analysis and Table 5 indicates the results of the Mann Whitney-U test for freshman and senior pre-service teachers.

Table 4
Independent sample t-test result of pre-service teachers' TPACK scores

Instrument	Grade level	N	Mean	Std. Deviation	t	p
TK	Freshman	118	3.366	.641	-1.594	.112
	Senior	81	3.519	.670		
TPCKM	Freshman	118	3.542	.455	-3.051	.003
	Senior	81	3.763	.566		
TPACK	Freshman	118	3.513	.442	-2.823	.005
	Senior	81	3.701	.491		

As seen in the Table 4, there was a significant difference between the freshman and the senior pre-service teachers' TPCKM (t=-3.051, p<.05) and TPACK (t=-2.823, p<.05) scores. Both the TPCKM mean scores and TPACK mean scores of senior pre-service teachers were higher than freshman pre-service teachers. However, there was no significant difference between the freshman and the senior pre-service teachers' TK scores.

Table 5
*Mann Whitney-U test result of pre-service teachers' scores on the subscales of TPA*CK

Subscale	Group	N	Mean Rank	Sum of Ranks	U	p
CKM	Freshman	181	88.80	10478.50	3457.50	.001
	Senior	81	116.31	9421.50		
PCKM	Freshman	181	93.92	11082.50	4061.50	.071
	Senior	81	108.86	8817.50		

As seen in the Table 5, although, there was a significant difference between the freshman and the senior pre-service teachers' CKM mean scores (U=3457.50; p<.05), there was no significant difference between the freshman and the senior pre-service teachers' PCKM mean scores.

Table 6 indicates the descriptive analysis of the BSCTM instrument for both freshman and senior pre-service teachers.

Table 6 shows that both freshman and senior pre-service teachers' beliefs using computer technology in mathematics instruction were generally high level. Moreover, there was an increase in the scores from freshman to seniors.

Table 6
Descriptive analysis of BSCTM instrument

Subscale	Freshman			Senior		
	Mean	Std. Deviation	Level	Mean	Std. Deviation	Level
Learning	3.46	.45	High	3.88	.54	High
Content	3.17	.57	Moderate	3.31	.55	Moderate
Teaching	3.63	.44	High	3.71	.52	High
Measurement and Evaluation	3.72	.47	High	3.82	.62	High
BSCTM	3.52	.36	High	3.74	.47	High

In order to determine whether the differences in the freshman and senior pre-service' scores were statistically significant, an independent sample t-test was applied for data which were normally distributed and a Mann Whitney-U test was used for data which were not normally distributed at a significance level of .05. Table 7 summarizes the results of the independent sample t-test analysis and Table 8 indicates the results of the Mann Whitney-U test for freshman and senior pre-service teachers.

Table 7
Independent sample t-test result of pre-service teachers' BSCTM scores

Instrument	Grade level	N	Mean	Std. Deviation	t	p
Content	Freshman	118	3.178	.573	-1.638	.103
	Senior	81	3.311	.556		
Measurement and Evaluation	Freshman	118	3.725	.472	-1.182	.239
	Senior	81	3.821	.622		
BSCTM	Freshman	118	3.521	.366	-3.653	.000
	Senior	81	3.740	.476		

As seen in the Table 7, there was a significant difference between the freshman and the senior pre-service teachers' BSCTM ($t=-3.051$, $p<.05$) scores, but there was no significant mean difference in the scores of both content and measurement and evaluation subscales.

As seen in the Table 8, there was a significant difference between the freshman and the senior pre-service teachers' learning scores ($U=2509$, $p<.05$). For the learning factor scores, senior pre-service teachers had stronger beliefs using technology in mathematics instruction in comparison to the freshman pre-service teachers.

Table 8
Mann Whitney-U test result of pre-service teachers' scores on the subscales of BSCTM

Subscale	Group	N	Mean Rank	Sum of Ranks	U	p
Learning	Freshman	181	80.76	9529.50	2508.50	.000
	Senior	81	128.03	10370.50		
Teaching	Freshman	181	94.31	11128	4107	.091
	Senior	81	108.30	8772		

Whether the belief about using technology in mathematics instruction is a predictor of pre-service teachers' technological pedagogical content knowledge was tested using simple linear regression analysis. To analyze data using linear regression, there needs to be a linear relationship between the two variables (Büyüköztürk, Çokluk & Köklü, 2011). For that reason, before using linear regression, the Pearson correlation coefficient was calculated for BSCTM and TPACK. The result of the correlation were in Table 9.

Table 9
The Pearson correlation coefficients for BSCTM and TPACK

Level	Variables	N	r	P
Freshman	BSCTM and TPACK	118	.138	.136
Senior	BSCTM and TPACK	81	.554	.000

As seen in the Table 9, there was only positive and a significant difference between BSCTM and TPACK scores for senior pre-service teachers. Thus the simple linear regression was used for only senior pre-service teachers' scores. The simple linear regression findings are presented in Table 10.

Table 10
Regression analysis results related to prediction of senior pre-service teachers' technological pedagogical content knowledge in mathematics instruction

	Unstandardized Coefficients		**Standardized Coefficients**			
	B	**Std. Error**	**Beta**	**t**	**R**	**R^2**
Constant	1.562	.364	.554	4.291	.554	.307
BSCTM	.572	.097		5.921		

F=35.06, p<.05

As a result of the regression analysis it can be said that beliefs about using technology in mathematics instruction had an effect on the senior pre-service teachers' technological pedagogical content knowledge (R=.554, R^2=.307). The BSCTM variable explain 31% of pre-service teachers' TPACK. On examining the significance of the test's regression coefficients, it can be seen that the predictor variable of BSCTM variable, with a level of p<.05, is significant predictor of TPACK.

Discussion and Conclusion

The results of this study showed that both freshman and senior pre-service teachers' TPACK for mathematics instruction and beliefs using computer technology in mathematics instruction were generally high. The reason that the freshman pre-service teachers' high level of technological pedagogical content knowledge and belief using computer technology in mathematics instruction may be due to the FATIH Project. There have been serious investments in Turkey on integrating technology into classroom activities recently. The FATIH Project in Education is one of the most important project supported by the Turkish Ministry of National Education. It has been implemented in both public elementary and high schools since 2012 in Turkey. Most of teachers get an opportunity to use new techniques and technologies in their lessons through the FATIH Project. Moreover, students enter teacher education programs with pre-existing belief based on their experience as students. Research focusing on teachers' beliefs have shown that students' beliefs are associated with teachers' instruction (Karatas, 2014). Thus, it can be said that freshman pre-service teachers' pre-existing belief using computer technology in mathematics may be connected with their teachers' beliefs and instruction about using computer technology in mathematics education. The further researches should investigate the effects of such projects on teachers' and students' beliefs and TPACK for mathematics teaching and learning.

Furthermore, it is determined that there was an increase in both the total TPACK scores and its sub-dimensions as well as the total BSCTM scores and its sub-dimensions from freshman to senior pre-service teachers. This demonstrates that the teacher education program has a positive effect on pre-service teachers' TPACK for mathematics teaching and beliefs using computer technology in mathematics instruction. This result supported the result of the studies such as Çetin-Berber and Erdem (2015), Gök and Yıldırım (2015) and Karakaya and Yazıcı (2017).

The findings of the study showed that there was a significant difference in the total scores of TPACK and sub-dimensions of CKM and TPCKM in favor of senior pre-service teachers. Similarly, there was also a significant difference in the total scores of BSCTM and sub-dimension of learning in favor of senior pre-service teachers. Shulman (1986) describes content knowledge as the amount and organization of knowledge in the mind of a teacher. In this sense, a teacher must not only know the facts or concepts of a domain, but also have the ability to explain the structure of the concepts within that domain. Pre-service teachers attend to various content courses such as calculus, algebra and geometry in order to develop their content knowledge. The reason for the senior pre-service teachers' high level of CKM might be these content courses. Hill (2010) reported that teachers who took additional mathematical courses had higher levels of mathematical knowledge for teaching. She found a significant correlation between mathematics content courses and mathematical content knowledge of teachers. At the same time, pre-service teachers take various method courses such as teaching technologies and material design, special methods in mathematics teaching, and application of computers in mathematics in order to developed their pedagogical content knowledge and technological pedagogical content knowledge. Admiraal, Vugt, Kranenburg, Koster, Smit, Weijers and Lockhorst (2017) expressed that teacher education programs should not focus only on how to use technology but also how technology intersects with pedagogical and content knowledge. They also emphasized that stand-alone technology courses (e.g. introduction to computer) are found to be ineffective in providing pre-service teachers with appropriate preparation to successfully integrate computer technology into their instruction. On the other hand, integrating technology into methods and content courses is more effective in developing pre-service teachers' TPACK and beliefs. Keser, Yılmaz and Yılmaz (2015) expressed that technology-related courses can improve pre-service teachers' technology knowledge, but it is not guaranteed that they will know how to integrate these technologies into their learning environments. In this study, pre-service teachers take more technology-infused method courses towards their senior year. This can be the reason for the difference. In future research, the process of change in TPACK and beliefs of pre-service teachers in these courses can be examined in depth. Thus, the situations that occur during the change process can be determined. Teachers use technology, but they do not know how to integrate technology into their instruction effectively (Keser, et.al, 2015). Research findings also show that negative teacher beliefs about using computer technology inhibits its use (Crompton, 2015). One of the aims of the teacher education programs is to improve pre-service teachers' knowledge of how to effectively integrate technology into instruction. The program should also create positive beliefs and attitudes towards the integration of technology into instruction. The results of this study showed that there is a positive correlation between pre-service teachers' belief scores and TPACK scores. The regression analysis indicated that beliefs explained 31% of pre-service teachers' TPACK. It can be seen that the beliefs using computer technology in instruction is a significant predictor for TPACK. TPACK cannot be considered as a separate knowledge independent of teachers' beliefs. Research showed the connection between beliefs and TPACK knowledge of teachers. For example, Hardy (2010) focused on the effect of technology-infused method courses on the development of pre-service teachers' TPACK. The results of this study showed that the instruction during the method course had a positive effect on participants' perceptions of using technology in their teaching practice. In addition, Keser et.al. (2015) compared the TPACK of pre-service teachers with their self-efficacy perception towards technology integration based on grade level. They found a statistically significant difference among pre-service teachers' TPACK and self-efficacy perception level towards technology integration in favor of senior pre-service teachers. The results the study by Keser et.al. (2015) support this study that the teacher education program improved pre-service teachers' perceptions towards technology integration.

The present study investigated the effects of teacher education programs on pre-service teachers' TPACK and beliefs using computer technology in mathematics instruction and whether belief using computer technology in mathematics instruction can be a predictor of TPACK for mathematics instruction. To explore this matter further, additional studies may be carried out with respect to other factors that may influence pre-service teachers' TPACK and belief in mathematics instruction. In addition, the results of the study were limited with quantitative analyses of data. Therefore, qualitative analyses might also be used in order to investigate the context more deeply.

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