The Factors Affecting Techno-Pedagogical Competencies and Critical Thinking Skills of Preservice Mathematics Teachers

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ABSTRACT

Students' high-level thinking skills, like critical thinking, have been developed thanks to the use of technology. When the previous researches in the literature are analyzed, it will be understood that this research is original by providing significant contributions to the literature. This research aims to investigate whether techno-pedagogical competencies and critical thinking skills show statistically significant difference in terms of some variables and whether there is statistically significant relationship between critical thinking skills and techno-pedagogical competencies of pre-service elementary mathematics teachers. At that point, this research is remarkable for presenting an idea in terms of educating more qualified mathematics teachers. This study was designed as a descriptive study. The sample of the research consists of 552 pre-service elementary mathematics teachers. Two types of data collection tools were used in this study: "TPACK Self-Efficacy Scale" and "Critical Thinking Scale". The data of the study were analyzed by using the Statistical Package for Social Science (SPSS) 21.0. The results of the study reveal that the techno-pedagogical competencies and critical thinking skills of pre-service mathematics teachers are midlevel. On the other hand, there is a significant relation between the pre-service mathematics teachers' critical thinking skills and techno-pedagogical competencies.

Keywords: *Techno-pedagogical competencies, critical thinking skills, pre-service elementary mathematics teachers.*

INTRODUCTION

In some cases, it is enough to know just for thinking, yet it may not provide qualified thinking as high-level thinking is prerequisite for certain situations (Erbaş, Kertil, Çetinkaya, Çakıroğlu, Alacacı & Baş, 2014). Learning to think is very important than transferring knowledge (Patrick, 1986; Yıldız & Baltacı, 2016). Therefore, teachers and pre-service teachers are required to have the knowledge and skills related to the use of technology in teaching (Hofer & Swan, 2008). Related literature has demonstrated that students' high-level skills such as critical thinking have been developed thanks to the use of technology in education (Baltacı, 2014; Hofer & Swan, 2008; Koehler, Mishra & Yahya, 2007). Even if schools have sufficient technological equipment, teachers are the core figures who will carry their education programs into effect through educational technologies (Kumar, Rose & D'Silva, 2008). Thus, the teachers, putting technologies into practice, must have the ability to think about using and designing new teaching techniques along with technology (Doruk, Aktümen & Aytekin, 2013; Koh, Chai & Tsai, 2013).

Training new generations who will guide our future as individuals with critical thinking skills is considered as an important goal in all levels of education starting from primary to higher education (Aytekin & Toluk Uçar, 2014, Huitt, 1998). Teachers are those who will provide a learning setting in which contemporary teaching approaches are used, memorization is abandoned, students can express themselves

and discuss their thoughts freely, fear and authority are not available (Özçakır, Aytekin, Altunkaya & Doruk, 2015; Patrick, 1986). It should also be remembered that a teacher who thinks critically can ensure that the individuals will gain critical thinking skills (Brahler, Quitadamo & Johnson, 2002). Critical thinking is defined as a process by which individuals decide what to do and what to believe (Ennis, 1993) as well as logical, purposeful and reflective thinking in this decision-making process (Rudd, 2007). Epstein (1999) describes critical thinking as a defense against the world with full of knowledge and too many people who are trying to persuade us. Actually, it is inappropriate to explain critical thinking with a single factor when examining numerous definitions of critical thinking. Considering the definitions mentioned above, critical thinking may be regarded as a complex and comprehensive process requiring high levels of cognitive competencies. According to the study of Ennis (1990), the students can get the ability of critical thinking when the components of the critical thinking are defined properly and taught step by step. The critical thinking skills are; deducing, interpreting, explaining, assessing, and reaching to the end (Büyükkantarcıoğlu, 2006). Thus, the individuals, having critical thinking skills, are those who dominate their behaviors in the correct way, trigger the social developments through requirements of the century, and are open-minded, objective and creative (Rudinow & Barry, 2004).

Technological tools enable the discovery of concepts (İsmail & Kasmin, 2007). Therefore, technology integration has become an important requirement in education (Baltacı, 2016; Liao, 2007), but technology integration in education is a multidimensional and complex process (Kabakçı-Yurdakul, 2011). For an effective teaching process via technology, it is essential to create a dynamic balance among all components, to maintain this balance, and to restore this balance when needed (Koehler & Mishra, 2009). The studies conducted so far have determined that technology can not only serve for pedagogical and content knowledge, and in recent years the focus has been mostly upon developing the integration of technology into the learning-teaching process (Compton & Harwood, 2003). In this case, such a question comes to mind that "what is the pre-service elementary mathematics teachers' critical thinking skill and techno-pedagogical competency level?"

Conceptual Framework

Jonassen (2000) has emphasized three basic skills to explain critical thinking; evaluation, analysis and relating. The basic cognitive skills that constitute the core of critical thinking are interpretation, analysis, evaluation, inference, explanation and self-regulation (APA, 1990; Facione, Facione & Winterhalter, 2010). As is seen, critical thinking requires synthesis and evaluation more than practice or analysis (Moore, 2001). This suggests that it is not enough only to develop individuals' thinking skills in order to achieve success in the educational and professional area (Facione, Facione & Giancarlo, 2000); instead, it necessitates preparing learning settings that enable the use of these skills (Tuna & Kaçar, 2016). For this reason, teachers can actually raise individuals with critical thinking skills through using technology effectively in learning settings (Branch, 2000).

It can be said that there are some differences in teaching approaches with the development of technologies in the education life. Although, the computers were, once, thought to be a tool of presentation, it began to take place as the main component of forming the teaching. With the usage of computers in education activities, new terms and concepts go in to the literature such as computer aided education or computer aided teaching. Most researchers underline that students enjoy the learning process more actively with computers and use this technology as a tool for exploring (Anabousy, Daher, Baya'a & Abu-Naja, 2014; Lachmy & Koichu, 2014). The related researches have revealed various technology integration models. These models accept technology, pedagogy, and content knowledge as a whole, and hence teacher competencies have been reassessed and new criteria have been expressed within this context (Niess, 2005). The elements of which teachers' knowledge is composed have been determined so as to provide effective technology integration with the emergence of a concept stated by Mishra and Koehler (2006) as "Technological Pedagogical Content Knowledge" (TPCK) and put forward after the inclusion of Shulman's (1986) "Pedagogical Content Knowledge" (PCK) into instructional technologies. Therefore, TPCK is defined as a model that explains how teachers will incorporate technology into learning-teaching processes and how to use technology more effectively within the framework of technological, pedagogical and content knowledge (Koehler et all, 2007; Mishra & Koehler, 2006). The other components of the model consist of the combination and intersection of these components. These components include; pedagogical content

knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK) (Koehler & Mishra, 2009). Techno-pedagogical competency concept is conducting the planning, applying and assessing processes depending upon technological and pedagogical contents in order to increase the effectiveness of teaching process (Niess, 2005). In recent years, Technological Pedagogical Content Knowledge has become the main concept used in the reshaping process of teacher training programs for many universities in EU countries (Abell, 2008).

Different evaluation instruments were developed by various researchers in order to assess critical thinking skills. Each evaluation instrument differs from the perspective of properties, applying fundamentals, aimed levels, individuals, scores and types of assessment. Ennis (1993) collected these critical thinking skills evaluation instruments under three headings such as; the evaluation instruments prepared to assess from one perspective, more than one perspectives and specific perspectives of the critical thinking skills. The evaluation instrument, used in the current study, was prepared for assessment from specific perspectives of the critical thinking skills as Ennis (1993) stated, because the scale is only used for pre-service teachers.

Koehler and Mishra (2005) are the first ones to attempt to develop a scale about TPCK. The researchers prepared a 7-point Likert Type Scale, comprised 33 items, in order to assess the attitudes of academicians and the master degree students, towards the development of TPCK, group dynamics, online lesson design, learning environment. Another scale, used to assess the teachers' perception levels about seven information sources depending upon TPCK, was developed by MaKinster, Boone and Trautmann (2010). However, among the scales developed in Turkey about TPCK, it is determined that there is only one to assess the techno-pedagogical competencies of the pre-service teachers. Thus, the scale, developed by Kabakçı Yurdakul, Odabaşı, Kılıçer, Çoklar, Birinci and Kurt (2012), was used in the current study.

Significance of the Study

When the related literature on critical thinking has been examined, the researches mostly concentrate on three topics. The first topic is; analyzing the effect of critical thinking skills on various variables (Ennis, 1993; Ferret, 1997; Fisher, 1995; Foxx, 2001), the second one is; the examination of current critical thinking skills (Facione, Giancarlo, Facione & Gainen, 1995; Rudd, Baker & Hoover, 2000) and the last topic is; the development of critical thinking through empirical method (Quitadamo, 2002; Robertson, 2000). On the other hand, during analyzing the studies, carried out with pre-service teachers regarding TPCK, it is obvious that the main purposes of these studies are; pre-service teachers' TPCK levels (Archambault & Crippen, 2009; Tokmak, Konokman & Yelken, 2013) and its development (Niess, 2005). In other words, researches on TPCK mostly seem to focus on theoretical studies (Cox, 2008; Graham, 2011) about the conceptualization of TPCK. In addition to these researches, numerous studies that determine which techno-pedagogical competencies should be experienced, are required (Archambault & Crippen, 2009; Cox & Graham, 2009). Whereas studies on PCK and TPCK have been conducted since 2005 in Turkey, researchers work on the development of teachers' TPCK levels thanks to the use of technology in classrooms. Still, these studies are insufficient in terms of revealing the situation in Turkey.

Being cognizant of how individuals learn, what they think, and what the influencing factors are enables the effective learning process (Biggs, 2001). With this regard, it was aimed to investigate whether techno-pedagogical competencies and critical thinking skills show a statistically significant difference in terms of some variables such as gender, grade, grade point average, and whether there is statistically significant relationship among critical thinking skills, techno-pedagogical competencies and frequency of technology use of pre-service elementary mathematics teachers. Thus, the study is considered to be original and provides significant contributions to the literature. As indicated above, there is no study available in the literature that relates pre-service teachers with critical thinking and techno-pedagogical competencies. At that point, this research is remarkable for presenting an idea in terms of educating more qualified mathematics teachers and what to be done for them. The difficulties that most countries experience in mathematics due to the lack of students' mathematical thinking skills can only be overcome by training mathematics teachers with various thinking styles as well as several competencies.

In accordance with these ideas, the following questions are presented:

1. What is the level of pre-service elementary mathematics teachers' critical thinking skills and techno-

pedagogical competencies?

2. Is there any statistically significant difference in pre-service elementary mathematics teachers' techno-pedagogical competencies according to their gender?

3. Is there any statistically significant difference in pre-service elementary mathematics teachers' critical thinking skills according to their gender?

4. Is there any statistically significant difference in pre-service elementary mathematics teachers' techno-pedagogical competencies according to their grade?

5. Is there any statistically significant difference in pre-service elementary mathematics teachers' critical thinking skills according to their grade?

6. Is there any statistically significant difference in pre-service elementary mathematics teachers' techno-pedagogical competencies according to their grade point average?

7. Is there any statistically significant difference in pre-service elementary mathematics teachers' critical thinking skills according to their grade point average?

8. Is there any statistically significant relationship between technology usage frequency and techno-pedagogical competencies of pre-service elementary mathematics teachers?

9. Is there any statistically significant relationship between technology usage frequency and critical thinking skills of pre-service elementary mathematics teachers?

10. Is there any statistically significant relationship between critical thinking skills and techno-pedagogical competencies of pre-service elementary mathematics teachers?

METHOD

This section covers research model, research group, implementation process, data collection and analysis.

Research Model

This study was designed as a descriptive study and conducted by using relational screening model. The main purpose of relational screening is to determine whether a relationship between variables is available during quantitative statistical surveys (Lodico, Spaulding & Voegtle, 2006).

Research Group

This study used maximum diversity which is one of the purposeful sampling methods. Sample of the research consists of 552 pre-service teachers studying in the Elementary Mathematics Teaching undergraduate program at four state universities during the academic year of 2015 and 2016. Table 1 depicts the rest of demographic information concerning the participants. While providing this information, university names were coded.

Table 1. Distribution of the participants in terms of the university, genders and grades

University	Gender	F	Grade	F
A University	Female	72	1	37
	Male	64	2	36
			3	34
			4	29
B University	Female	69	1	39
	Male	79	2	38
			3	38
			4	33
C University	Female	75	1	36
	Male	63	2	35
			3	34
			4	33
D University	Female	62	1	34
	Male	68	2	33
			3	32
			4	31

As can be observed in Table 1, 136 of pre-service elementary mathematics teachers belong to A university, 148 were at B university, 138 were at C university while 130 were at D university. Among the pre-service teachers, 278 were women and 274 were men. Also, 146 of them were freshmen, 142 were at the second grade, 138 were at the third grade and 126 were at the fourth grade.

Data Collection Tool

Two types of data collection tools were used in this study: "TPACK Self-Efficacy Scale" and "Critical Thinking Scale". These measurement tools have been briefly identified below:

TPACK Self-Efficacy Scale was developed by Kabakçı Yurdakul, et all (2012). The researchers determined the valid and reliable competencies and the performance indicators about these competencies for teachers and pre-service teachers from the perspective of techno-pedagogical education approach with this scale. Thus, the scale is addressed to assess the techno-pedagogical competencies. The tool consists of 4 factors and 33 items including design, implementation, ethics and specialization. Being a 5-point Likert type, the scale includes “completely competent”, “fairly competent '', ''somewhat competent '', ''slightly competent'' and ''incompetent”. The researchers stated the evaluation criterions about techno-pedagogical competency depending upon the scores from the highest and the lowest % 27 group as: the lowest level is $\bar{x} \leq 2.87$ (if, n symbolizes the number of people, $\bar{x}$ = the total score of people from the scale / [n.33]), the medium level is $2.87 < \bar{x} \leq 3.93$, and the highest level is $\bar{x} > 3.93$ (Kabakçı Yurdakul et all, 2012). On the other hand, the highest score having been obtained from the scale is 165 and the lowest is 33. As the score gets closer to 165, techno-pedagogical competency increases while it decreases as getting closer to 33. The total scale’s Cronbach’s alpha reliability coefficient was determined to be .95.

The scale, developed by Kabakçı Yurdakul, et all (2012) and detailed above, was applied in the current study. In the present study, Cronbach’s alpha reliability coefficient was found to be .92, which is close to the reliability of the scale and indicates the reliability of the measurement. Moreover, the study has also deployed the "Critical Thinking Scale" which was developed by Özdemir (2005) and whose reliability coefficient of the items was determined as .78 by means of the Cronbach-alpha analysis. The Cronbach Alpha value was identified to be .73 in this study. It is a five-point Likert-type scale composed of 30 items. The options, presented as responses to the items are; "Strongly Agreee (5)", "Agree (4)", "Neither Agree nor Disagree (3)", "Disagree (2)", "Strongly Disagree (1)".

Procedure

The scales were applied to the participants, as mentioned in the Research Group section, from four universities. The researcher has presented requirements to the pre-service teachers. During the application process, both scales were supplied together and pre-service teachers completed the scale in approximately 35 minutes. Afterwards, the obtained data from 552 pre-service mathematics teachers who properly completed both scales were analyzed.

Data Analysis

The data of the study were analyzed by using the Statistical Package for Social Science (SPSS) 21.0. First, the current study was checked whether data provided the general requirements of the parametric tests. Thus, skewness and kurtosis values were calculated for normality. The variance's homogeneity was tested by performing Levene's test on the analysis of the data obtained in the study following the normal distribution (p>.05). It can be emphasized that the assumptions required for the use of parametric tests have been met. Thus, independent samples-t test, ANOVA (one way variance), and correlation were used during the data analysis. The "average" has been calculated in order to determine the critical thinking skills and techno-pedagogical competencies of pre-service teachers.

FINDINGS

The levels of critical thinking skills and techno-pedagogical competencies of pre-service elementary mathematics teachers are presented on the Table 2.

Table 2. The mean levels of critical thinking skills and techno-pedagogical competencies

	$\overline{X}$
techno-pedagogical competencies	3.727
critical thinking skills	3.345

(x stands for mean average. The formula, mentioned in the data collection tool section, was used to calculate the mean average of techno-pedagogical competencies)

As can be seen from the Table 2, it was determined that the techno-pedagogical competencies ($\overline{X} = 3.727$) and critical thinking skills ($\overline{X} = 3.345$) are midlevel. The result of t-test, whether any difference exists between pre-service mathematics teachers' techno-pedagogical competencies according to their genders, is presented in Table 3.

Table 3. T-Test results about the differences in techno-pedagogical competencies according to genders

Gender	N	$\overline{X}$	Sd	T	P
Female	278	3.76	0.44	1.689	.072
Male	274	3.69	0.41		

In the light of the result presented in table 3, there is no statistically significant difference between female pre-service teachers' techno-pedagogical competencies ($\overline{X}$=3.76, sd=0.44), and male pre-service teachers' techno-pedagogical competencies ($\overline{X}$=3.69, sd=0.41). In addition, the analysis whether pre-service teachers differ in critical thinking skills in terms of genders is presented in Table 4.

Table 4. T-Test result about differences in critical thinking skills according to genders

Gender	N	$\overline{X}$	Sd	T	P
Female	278	3.44	0.49	2.478	.014
Male	274	3.25	0.47		

According to analysis result in Table 4, there is a statistically significant differences (t=2.478, p<.05) between female pre-service teachers' critical thinking skills ($\overline{X}$=3.44, sd=0.49), and male pre-service teachers' critical thinking skills ($\overline{X}$=3.25, sd=0.47). As can be seen this difference is in favor of the female students.

ANOVA was conducted to investigate whether there is any difference between pre-service mathematics teachers' techno-pedagogical competencies according to grade. The results of this analysis are presented in Table 5.

Table 5. ANOVA result about differences in techno-pedagogical competencies according to grade

Grade	N	$\overline{X}$	Sd	ANOVA		Post-Hoc Scheffe
				Welch F	P	
1	146	3.63	0.42	1.18 (df1=6, df2=544)	.024	Between 1-3 (Mean Difference = ,1590*) 1-4 (Mean Difference = ,1810*) 2-3 (Mean Difference = ,1071*) 2-4 (Mean Difference = ,1304*)
2	142	3.68	0,37			
3	138	3.79	0.44			
4	126	3.81	0.47			

According to the results in Table 5, there is statistically significant difference in pre-service mathematics teachers' techno-pedagogical competencies according to grade (Welch F (6, 544)=1.18, p<.05). Additionally, post-hoc analysis revealed that first-grade pre-service teachers' techno-pedagogical competencies, are statistically different from third-grade pre-service teachers, and the fourth graders. Similarly, second-grade pre-service teachers' techno-pedagogical competencies are statistically different from third-grade preservice teachers, and forth graders. Furthermore, in order to investigate whether pre-service mathematics teachers differentiate in critical thinking skills in terms of grades was presented in table 6. Similarly as in the previous ANOVA analysis, post-hoc analysis was used.

Table 6. ANOVA result about differences in critical thinking skills according to grade

Grade	N	$\overline{X}$	Sd	ANOVA		Post-Hoc Scheffe
				Welch F	P	
1	146	3.26	0.35	1.83 (df1=6, df2=544)	.016	Between 1-4 (Mean Difference = ,1712*)
2	142	3.34	0.15			
3	138	3.36	0.23			
4	126	3.43	0.38			

In the light of the result presented in table 6, there is a statistically significant differences in pre-service mathematics teachers' critical thinking skills according to grade (Welch F (6, 544)=1.83, p<.05). In addition, post-hoc analysis revealed that first-grade pre-service teachers' critical thinking skills, are statistically different from fourth-grade pre-service teachers.

The result of ANOVA analysis, whether pre-service teachers differentiate in techno-pedagogical competencies in terms of grade point average, is presented in Table 7.

Table 7. ANOVA result about differences in techno-pedagogical competencies according to grade point average

Grade Point Average	N	$\overline{X}$	Sd	ANOVA		Post-Hoc Scheffe
				Welch F	P	
1.00-2.50	154	3.59	0.38			Between
2.50-3.00	228	3.71	0.14	3.26 (df1=8, df2=542)	.004	1.00-2.50 / 2.50-3.00 (Mean Difference = ,1242*)
3.00-4.00	170	3.86	0.36			2.50-3.00 / 3.00-4.00 (Mean Difference = ,1553*)
						1.00-2.50 / 3.00-4.00 (Mean Difference = ,2768*)

According to analysis of results in Table 7, there is a statistical significant differences between pre-service elementary mathematics teachers' techno-pedagogical competencies in terms of grade point average (Welch F (8, 542)=3.26, p<.05). Additionally, post-hoc analysis revealed that pre-service teachers' techno-pedagogical competencies, whose grade point average are 1.00-2.50, are statistically different from pre-service teachers, whose grade point average are 2.50-3.00, and ones, whose grade point average are 3.00-4.00. Similarly, pre-service teachers' techno-pedagogical competencies, whose grade point average are 2.50-3.00, are statistically different from pre-service teachers, whose grade point average are 3.00-4.00.

Moreover, in order to analyze whether there is any difference between pre-service elementary mathematics teachers' critical thinking skills in terms of grade point average, ANOVA was conducted and result of this test is presented in Table 8.

Table 8. ANOVA result about differences in critical thinking skills according to grade point average

Grade Point Average	N	$\overline{X}$	Sd	ANOVA		Post-Hoc Scheffe
				Welch F	P	
1.00-2.50	154	3.23	0.41			Between
2.50-3.00	228	3.32	0.27	2.79 (df1=8, df2=542)	.015	2.50-3.00 / 3.00-4.00 (Mean Difference= ,1636*)
3.00-4.00	170	3.48	0.52			1.00-2.50 / 3.00-4.00 (Mean Difference= ,2522*)

In the light of the results presented in table 8, there is a statistically significant differences in pre-service mathematics teachers' critical thinking skills according to grade point average (Welch F (8, 542)=2.79, p<.05). In addition to this, post-hoc analysis revealed that pre-service teachers' critical thinking skills, whose grade point average are 1.00-2.50, are statistically different from pre-service teachers, whose grade point average are 3.00-4.00. Similarly, pre-service teachers' critical thinking skills, whose grade point average are 2.50-3.00, are statistically different from pre-service teachers, whose grade point average are 3.00-4.00.

Lastly, a correlation analysis was conducted to investigate three questions; firstly; whether there is significant relationship between the pre-service elementary mathematics teachers' critical thinking skills and technology usage frequency, secondly; significant relationship between techno-pedagogical competencies and technology usage frequency, and lastly; significant relationship between critical thinking skills and techno-pedagogical competencies. The results of this analysis are presented in Table 9.

Table 9. Results of the relationships among technology usage frequency, critical thinking skills and techno-pedagogical competencies

		Technology Usage Frequency	Critical Thinking Skills	Techno-pedagogical Competencies
Technology Usage Frequency	Pearson Correlation	1	.171**	.253**
	Sig. (2-tailed)		.028	.000
	N	552	552	552
Critical Thinking Skills	Pearson Correlation	.171**	1	.471**
	Sig. (2-tailed)	.028		.000
	N	552	552	552
Techno-pedagogical Competencies	Pearson Correlation	.253**	.471**	1
	Sig. (2-tailed)	.000	.000	
	N	552	552	552

**. Correlation is significant at the 0.01 level (2-tailed).

As can be seen from the Table 9, there is a significant relationship between elementary pre-service mathematical teachers' technology usage frequency and techno-pedagogical competencies ($p<.05$). Moreover, in the current study, technology usage frequency constitutes %6 of the techno-pedagogical competencies. There is a significant relationship between the pre-service teachers' technology usage frequency and critical thinking skills ($p<.05$). On the other hand, there is a significant relationship between the pre-service mathematics teachers' critical thinking skills and techno-pedagogical competencies ($p<.05$). The calculated r^2 (0.471^2) value is 0,221, so it showed that %22 of techno-pedagogical competency can be explained with critical thinking skills. Thus it can be easily inferred that there is a midlevel relationship between the two variables according to the study of Pallant (2010).

DISCUSSION

The current study has determined that pre-service elementary mathematics teachers have midlevel of critical thinking skills. Considering studies from the literature related to this finding, several of them conclude that university students have a medium level of critical thinking dispositions (Korkmaz & Yeşil, 2009; Özdemir, 2015; Şen, 2009). However, such studies exist in the literature which indicates that students studying higher education have low levels of critical thinking dispositions (Dutoğlu & Tuncel, 2008; Rudd, Baker & Hoover, 2000). This is likely due to the fact that pre-service teachers in Turkey have not been exposed to the activities related to the use of thinking skills. However, many educators who mostly conduct studies on critical thinking emphasize the significance of analyticity, curiosity, self-confidence and search for truth (Ennis, 1993; Ferret, 1997; Fisher, 1995). A study carried out by Ip, Lee, Lee, Chau, Wotton and Chang (2000) determined that the courses in undergraduate programs should be promptly reviewed with the aim of improving students' critical thinking skills. If we can include the above features that researchers strongly emphasize in the undergraduate courses, then we can develop critical thinking skills of pre-service mathematics teachers. By this way, a major step is taken for raising students who think critically.

Techno-pedagogical competencies have been determined to be midlevel for pre-service elementary mathematics teachers. Lee and Kim (2014) conclude that pre-service teachers were at the lowest level in terms of understanding technology integration. Demir and Bozkurt (2011) conducted such a study and determined the effect of students' beliefs about technology integration on teachers' thoughts related to competency. Researchers have determined that there are negative beliefs that affect teachers' or pre-service teachers' effective implementation of technology integration in terms of techno-pedagogical competencies, and that they are at the beginner level in practice. Thus, sample applications and activities on how to achieve the technology integration and how this can be effective on students' learning processes should be presented to pre-service teachers. Pre-service teachers should be guided by the faculty members in order that they can

observe this emphasis during internship, and opportunities should be created for discussing their experience. Thus, it may be wise to emphasize that we will be able to train mathematics teachers at a desired level.

Considering differences in gender, techno-pedagogical competency has been found to be free from a difference, on the other hand, a significant difference has been identified in favor of female students in terms of their critical thinking skills. There are also studies in literature that show gender is effective on critical thinking and differs in favor of female students (Facione, Giancarlo, Facione & Gainen, 1995; Rudd, Baker & Hoover, 2000). Also, several researches show that gender is not an effective variable regarding critical thinking (Ekinci & Aybek, 2010; Özdemir, 2005; Şen, 2009; Walsh & Hardy, 1999). On the other hand in parallel to the research findings, North and Noyes (2002) and Jamieson, Finger and Albion (2010) conclude that techno-pedagogical competencies do not differ depending upon gender. In their study, North and Noyes (2002) have clarified these findings with the equalization of differences in the use of computers as men and women have equal opportunities because of the prevalence of computers in schools. Nevertheless, the study conducted by Erdoğan and Şahin (2010) determined that pre-service elementary mathematics teachers' techno-pedagogical competencies have a significant difference in favor of male teachers. Upon analyzing literature, different results have been achieved.

A significant difference has been reported through examining the relation between pre-service elementary mathematics teachers' critical thinking skills according to grade. This difference has been observed to be particularly between the 1st and 4th grade. It is possible to experience various research results similar to this finding (Ekinci & Aybek, 2010; McDonough, 1997). These researchers have indicated a significant difference in favor of the students in upper classes. In fact, this is an inevitable result of the study. Those who are to be trained as teachers are tried to be gained high-level thinking styles such as critical thinking. The only questionable thing is to determine whether this development is at the desired level or not. However, this research has revealed that pre-service elementary mathematics teachers including those at the 4th grade have medium levels of critical thinking skills. On the other, a significant difference has been identified between pre-service elementary mathematics teachers' techno-pedagogical competencies according to grade. In fact, this difference has been observed to be much more evident for the third graders. This may be due to the fact that pre-service mathematics teachers in Turkey take lessons such as computer-assisted mathematics and special teaching methods in the 3rd grade. It is most likely that this can be overcome through taking these lessons earlier; hence the components of TPACK may be realized for pre-service teachers in the early years.

The research findings imply differences in the pre-service elementary mathematics teachers' critical thinking skills according to their grade point average. Related research shows that there is a difference in critical thinking levels from the point of academic achievement (Bowles, 2000; Ferret, 1997; Fisher, 1995; Williams, Wise & West, 2001). Further, the training presented only with technological information lacking field and pedagogical activities has been determined to be ineffective in transferring the technological knowledge and skills that pre-service teachers have into the learning setting (Doering, Hughes & Huffman, 2003; Hew & Brush, 2007). Our country also takes this into account. For that purpose, the findings of the research show a strong relation between the technology usage frequency and techno-pedagogical competency. Technology usage frequency constituted about 6% of the techno-pedagogical competencies of pre-service elementary mathematics teachers. Moreover, a significant relation has been reported between technology usage frequency and critical thinking skills of pre-service teachers. Similar results emerged in the studies conducted by Branch (2000) and Hofer and Swan (2008). Indeed, pre-service teachers who frequently use technology will not have difficulty in integrating thinking processes into active use, and their critical thinking levels will develop as well. Pre-service teachers should be provided such learning settings in which technology is frequently used.

Given the increase in the application of technology integration and the contemporary theoretical transformation in the teaching-learning approaches, it may be reasonable to emphasize that training teachers with techno-pedagogical competencies and critical thinking skills becomes even more significant now than in the past. Upon analyzing the research findings, a significant relationship between pre-service elementary mathematics teachers' critical thinking skills and their techno-pedagogical competencies has been identified. There are such studies available in the literature that reveals the relation between techno-pedagogical competencies and individual innovation (Haelermans & Blank, 2012; Loogma, Kruusvall &

Ümarik, 2012). Taking the results of the research and the studies mentioned above into account, teachers or pre-service teachers with techno-pedagogical competencies can be emphasized to have a critical thinking perspective which is leading the society. Therefore, it is recommendable that learning settings should be prepared as teachers can exhibit techno-pedagogical competencies in the pre-service period, and pre-service teachers are encouraged for effective use of critical thinking in these settings. Demir and Bozkurt (2011) have identified that elementary school mathematics teachers need professional development education in the fields of technology and pedagogy. For this reason, teacher education programs should be promoted in such a way as to enhance pre-service teachers' techno-pedagogical competencies and critical thinking skills.

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