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Research on the Development of Middle School Mathematics Pre-service Teachers' Perceptions Regarding the Use of Technology in Teaching Mathematics

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This study aimed to investigate the changes in teacher perceptions regarding the use of technology subsequent to the training about technology integration in mathematics teaching. A training program that included combined technology, pedagogy and content knowledge was prepared and implemented on pre-service teachers with this aim. Exploratory sequential mixed method, one of the mixed method designs that include qualitative and quantitative research techniques, was utilized in the study. While pretest-posttest experimental design with no control groups was used in the quantitative dimension of research, pre-service teachers' written views were collected during the qualitative part of the study. Study participants were 34 pre-service teachers attending Middle School Mathematics Teaching Department of a state university during the spring semester of 2013-2014 academic year. Perception Scale for Technology Use and interview forms were used as data collection tools. Descriptive statistical methods and t-test were utilized for analyzing quantitative data whereas content analysis was preferred for qualitative data. Research results presented that significant differences were identified in middle school mathematics pre-service teachers' perceptions regarding the use of technology as a result of the training related to technology integration in mathematics teaching. Based on the findings, it was concluded that trainings that incorporate technological, pedagogical and content knowledge that are provided during teacher training process develop pre-service teachers' perceptions related to the use of technology in mathematics teaching.

Keywords: mathematics teaching, middle school mathematics pre-service teachers, technological-pedagogical-content knowledge, perceptions regarding technology use

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INTRODUCTION

Effectiveness of technology use in the field of education has become one of the significant research topics along with the widespread use of technology in daily life. Mathematics teaching is one of the leading fields affected by technology when training and education activities are considered. Use of technology in mathematics instruction contributes to concept teaching and development of skills such as problem solving, connections and reasoning (Kimmins & Bouldin, 1996). Also, utilizing technology in mathematics instruction increases the quality and permanence of teaching by positively affecting student achievement and attitudes towards mathematics (Aktümen & Kaçar, 2008; Baki & Özpınar, 2007; Diković, 2009; Güven & Karataş, 2004; Önal & Demir, 2013; Tutak & Birgin, 2008).

Using technology in teaching mathematics is not a new approach. The process that started with the use of calculators in the 1980's has acquired different dimensions with the rapid changes of the day (Karaarslan, Boz & Yıldırım, 2013). Computer algebra systems, dynamic geometry software, virtual learning objects, interactive boards and graphing calculators are often in use in mathematics teaching along with technological advances. Use of these technological tools is important in making sense of mathematical concepts. Dynamic geometry software have provided opportunities, especially in teaching geometry, in visualization, dynamic drawing of geometric shapes and exploring various geometric relationships (Akkoç, Özmantar, Bingölbali, Demir, Baştürk & Yavuz, 2011; Gürbüz & Gülburnu, 2013; Kağızmanlı, Tatar & Zengin, 2013; Kokol-Voljic, 2007; Selçik & Bilgici, 2011; Tutkun, Öztürk & Demirtaş, 2011). On the other hand, graphic calculators have enabled the rapid creation of multiple representations of mathematical concepts. Virtual learning objects are stated to improve comprehension of, reasoning regarding mathematical concepts and use of concepts in problem solving (Durmuş & Karakirik, 2006; Karakırık, 2008; Yaman & Şahin, 2014). The means provided by these technological tools have made technology integration in learning and teaching process a current issue.

Integrating technology into teaching-learning process is a hard and complicated matter (Demir & Özmantar, 2013; Harris, Mishra & Koehler, 2007; İşman & Canan, 2008; Usluel & Demiraslan, 2005). Technology integration includes several variables such as teacher and student competences, technological infrastructure and educational policies. This study focused on teacher competences. Teacher perceptions regarding technology, their self-competences, technological knowledge and pedagogical approaches are important factors in integrating technology (İşman & Canan, 2008). Teacher perception towards technology is a factor that determines

State of the literature

- Recent technological advances have necessitated the integration of technology in instructional processes. Therefore, it is crucial to identify and develop technological perceptions of teachers and pre-service teachers who are the planners and implementers of the teaching process.
- It is necessary to address teachers' and pre-service teachers' technological, pedagogical and content knowledge together for technology use in mathematics teaching. Desired level and quality technology integration will be possible only in this way. Current study addresses all these three types of knowledge in combination.
- Instruction provided during teacher training includes some deficiencies in providing pre-service teachers with technological pedagogical content knowledge. In this respect, teachers should be provided with trainings focusing on pedagogical content knowledge.

Contribution of this paper to the literature

- This study aimed to ensure quality technology integration by developing pre-service teachers' perceptions regarding technology use.
- Teachers' perceptions regarding technology use can be developed via trainings similar to the ones used in the current study.
- Training provided in the framework of this study can be used as a road map in providing teachers and pre-service teachers with technological pedagogical knowledge.

technology use. Previous studies have shown that mathematics teachers and pre-service teachers have negative beliefs regarding technology use and a significant part of them are unsure about using technology in the teaching process (Çakıroğlu, Güven & Akkan, 2008; Umay, 2004). One of the important reasons for these findings is related to lack of knowledge and skills on the part of the teachers about using technological tools (Hew & Brush, 2007). When teachers are informed of the uses of the technological tools they will utilize, they integrate them more easily and present positive attitudes towards technology use (Bingölbali, Özmantar, Sağlam, Demir & Bozkurt, 2012). Teachers' self-confidence perceptions related to technology use also affect perceptions related to the use of technology. A high level technological self confidence perception positively affects in-class technology use (Albion, 1999; Koh & Frick, 2009). Also, it has been identified that teachers who use technology outside the school in daily life are more comfortable using technology in the classroom (Ramos, 2005).

Pedagogical approaches used by teachers are one of the important factors that affect effective use of technology (Vacirca, 2008). Existence of technological infrastructures in classes does not mean technology is used in the teaching and learning process (Mumcu, Haşlaman & Usluel, 2008). Previous studies have identified that technology is used in the palace of traditional tools and therefore teaching is continued by using traditional approaches (Balakrishnan, Rossafri, Soon & Fook, 2007). However, the use of technology in the teaching process requires significant changes in the planning, implementation and evaluation of instruction (Crisan, Lerman & Winbourne, 2007). Another point that needs to be taken into consideration while using technology is related to the content of what is taught and the structure of the activities that will be implemented (Earle, 2002). In this respect, it has become crucial to equip teachers with combined knowledge on technology, content knowledge and pedagogical knowledge (Earle, 2002; Mishra & Koehler, 2006; Niess & Garofalo, 2006; Öksüz, Ak & Uça, 2009; Öksüz & Ak; 2009).

In the last decade, some models have been created that address technology, content and pedagogical knowledge in technology integration. One of these models is the *Technological* Pedagogical Content Knowledge (TPACK) model. TPACK is a teacher information model developed by Mishra and Koehler (2006). TPACK is an extension of "Pedagogical Content Knowledge" proposed by Shulman (1986) and it includes the addition of technology information to pedagogical content knowledge (Cox, 2008). TPACK model consists of three components: Pedagogical Knowledge (PK), Content Knowledge (CK) and Technological Knowledge (TK). There are also three separate knowledge fields obtained by pairing these three components as Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK) and Pedagogical Content Knowledge (PCK). TPACK explains the relationships and interactions among pedagogical, content and technological knowledge (Mishra & Koehler, 2006). TPACK is the type of knowledge which should be acquired by teachers to use technology effectively and efficiently in order to increase quality of teaching in all phases of teaching and learning process (Yurdakul, 2011). Components of TPACK are defined as the knowledge related to teaching techniques and representation to teach by using technology, information on the amount of student knowledge with respect to technology and knowledge about selecting suitable technological tools that are appropriate to the content that is being taught (Mishra & Koehler, 2008). Activities included in the current study aimed to equip teachers with the identified components of TPACK.

Considering the opportunities provided by technology and the fact that modern day needs are based on technology, it can be realized that the use of technology is now more of a necessity than a preference (Demir & Özmantar, 2013). One of the most important factors in realizing the role of technology use in mathematics teaching is teacher training. Studies in the field have presented that teachers are not able to effectively utilize technology in their schools (Bozkurt & Cilavdaroğlu, 2011; Yurdakul, 2011). One of the reasons related to the lack of technology use at schools is based on lack of effective pre-service training for teachers to acquire sufficient knowledge and skills (Jerald & Orlofsky, 1998). During their university education, teachers take classes related to technology but on their own, these classes are not sufficient to ensure technology integration in the future (Ertmer, 1999). These technology classes provided during university education mostly focus on information about using the technology and ignore field specific practices (Öksüz, Ak & Uça, 2009). On the other hand, teacher views on technology use are directly affected by their previous experiences. Therefore, in order for teachers to use technology in class, they need to experience technology use in environments where it is used for teaching and learning purposes (Niess & Garofalo, 2006).

Reviews of other studies show that various studies examining teachers and pre-service teachers' levels and perceptions of using technology (Abbitt, 2011; Agyei & Keengwe, 2014; Agyei & Voogt, 2012; Chai, Koh & Tsai, 2010; Guzey & Roehring, 2009; Özgun-Koca, Meagher & Edwards, 2010). Some of these studies were carried out to determine TPACK levels of teachers and pre-service teachers while others focused on developing TPACK levels within the context of a program (Akkoc et al., 2011; Agyei & Keengwe, 2014; Agyei & Voogt, 2012).

In their study Agyei and Voogt (2012) investigated the effects of technological lesson materials on pre-service teachers' levels of using technology. They reported that technology supported lesson patterns affected pre-service teachers' level of using technology positively. In the study done by Agyei and Keengwe (2014) pre-service mathematics teachers were given a training based on TPACK model. A multifaceted assessment of integration of technology to mathematics teaching was done through lesson plans, pre-service teachers' self-evaluation, and TPACK observation forms. It was stated that at the end of the training TPACK levels of pre-service teachers increased positively. In the study of Akkoc et al., (2011) a program was developed to gain pre-service secondary mathematics teachers Technological Pedagogical Content Knowledge and the contribution of the program to pre-service teachers was examined within the theoretical frame of TPACK. Workshops were organised before and after the trainings provided to assess the program attainments. Pre-service teachers' TPACK levels at the end of the program were evaluated via interviews before and after the workshops, micro teachings and lesson plans prepared by the pre-service teachers. As a result of the study, it was found that the program achieved to gain pre-service teachers TPACK. The results of the studies which embraced technology, pedagogy, and content knowledge together showed that there was a positive effect on pre-service teachers' perceptions of using technology while teaching mathematics. However, these studies were carried out with secondary education pre-service mathematics teachers. The fact that pre-service middle school mathematics teachers in our country are not given such training is a significant issue. For this reason, this study aims to give pre-service middle school mathematics teachers a training that combines technology, pedagogy, and content knowledge and to evaluate the efficiency of the training.

Rapid advances in technology and its effectiveness in the teaching process require identifying and improving pre-service teachers' perceptions regarding technology use. In this sense, improving pre-service teachers' perceptions with regard to the use of technology in teaching mathematics will facilitate future integration of technology in teaching. In this context, the study aimed to develop pre-service teachers' perceptions related to technology use in mathematics instruction. With this aim, a training program that included combined technology, pedagogy and content knowledge was prepared and implemented on pre-service teachers. Problem statement of the study was "Does the training provided to ensure technology integration in mathematics instruction affect pre-service teachers' perceptions related to technology use?". Based on this general problem, answers to these sub problems were sought: (i) Are there significant differences in middle school mathematics pre-service teachers' perceptions regarding technology use prior and subsequent to the training on technology integration in mathematics instruction? (ii) Are there significant differences in middle school mathematics pre-service teachers' perceptions regarding technology use in terms of requirement, advantages and disadvantages sub-dimensions prior and subsequent to the training on technology integration in mathematics instruction? (iii) What are middle school mathematics pre-service teachers' views on use of technology in mathematics instruction following the training on technology integration?

METHOD

The design of the study

Exploratory sequential mixed method, one of the mixed method designs that include quantative and qualitative research techniques, was used in the study. The method was preferred since the aim was completion. The researcher aims to detail, explain and clarify the results obtained in one method with those of others in the studies that focus on completion (Johnson & Christensen, 2010). The first phase of this study included the collection of quantitative data with a pre-experimental design (pretest-posttest data, by a Likert type scale) and the second phase involved collection and analysis of qualitative data (interview forms, micro teaching video recordings, document analysis) in order to enrich and clarify the obtained quantitative data. In the study it was aimed to compare qualitative with quantitative data to observe whether they support quantitative data.

Pretest-posttest experimental design without control groups was used in the quantitative aspect of the study. This model was preferred since the study aimed to investigate the effects of training based on technology integration in mathematics instruction on pre-service teachers' perceptions rather than determine the effectiveness of middle school mathematics pre-service teachers who took the training related to technology integration in mathematics education over other teachers. Independent variable of the study was the training on technology integration and the dependent variable was selected to be middle school mathematics pre-service teacher' perception levels regarding the use of technology in teaching mathematics.

Qualitative part of the study included collecting written views of middle school mathematics pre-service teachers. In this context, pre-service teachers were asked three open-ended questions and the obtained data were analyzed via content analysis method. Additionally, conversations were carried out with middle school mathematics pre-service teachers during the presentations about micro teaching classes in order to ensure data variety. Notes taken during these conversations, lesson plans prepared by pre-service teachers and video recordings were also examined through content analysis method.

Study group

Convenience sampling method was used in the study in selecting the study sample. Convenience sampling is a sampling method that uses the individuals who are in the immediate vicinity, easy to reach and volunteering to participate (Erkuş, 2009: 98). Therefore, instead of sample, the term study group was preferred. Two separate samples were not selected for the quantitative and qualitative aspects of the study and pre-service teachers who participated in the quantitative part were also involved in the qualitative part. The study was carried out with 34 middle school mathematics pre-service teachers enrolled in the third year of Primary Mathematics Teaching Program in a state university in Turkey during the spring semester of 2013-2014 academic year. 24 of the participating mathematics pre-service teachers were females and 10 were males. Pre-service teachers were first given teaching Principles and Methods, Teaching Technologies and Material Design and Special Education Methods I classes. Pre-service teachers were informed of the purpose and scope of the study.

Data collection tools

"*Perception Scale* for *Technology Use* in Mathematics Teaching (PSTU)" developed by Öksüz, Ak & Uça (2009) to identify pre-service teachers' perception levels regarding technology use in teaching mathematics was used in the study. PSTU is a Likert type scale with a total of 73 items, 63 positive, 10 negative. The answers provided to the scale are range from "completely disagree" to "completely agree" and scored from 1 to 5. The highest score that can be obtained from the scale is 365 and the lowest score is 113. The scale has three sub-dimensions: requirement, advantages and disadvantages. It is possible to calculate the total score for the scale as well as the scores for each sub-dimension. High scores in PSTU show positive perceptions on the part of middle school mathematics pre-service teachers related to the use of technology in mathematics instruction. Öksüz, Ak & Uça (2009) found Cronbach alpha coefficient which determined the internal consistency of the scale to be .96. Internal consistency coefficients for sub-dimensions were as follows: Requirement *.95*, advantage *.96* and disadvantage *.84*. According to the data for the current study internal consistency coefficient for the scale was found to be *.89* and internal consistency coefficient for the sub-dimensions (requirement, advantage and disadvantage) were *.82, .85* and *.64* respectively.

Qualitative part of the study included written views of middle school mathematics pre-service teachers. A form containing five open-ended questions was prepared in this respect and expert views were sought from two mathematics instructors. Based on the feedback from the experts, two of these questions were eliminated and the final form contained three open-ended questions to determine middle school mathematics pre-service teachers' views on the place of technology in mathematics teaching following the training provided about technology integration. The form was finalized after piloting the questions with two pre-service teachers. The questions included in the form are as follows:

1. In your opinion, should technology be used in mathematics teaching? Please explain your answer with the rationales that support it.
2. In your opinion what are the superior/strong aspects of using technology in mathematics learning and teaching? Please explain your answer with the rationales that support it.
3. In your opinion what are the weak aspects of using technology in mathematics instruction? Please explain your answer with the rationales that support it.

The finalized form was given to pre-service teachers to be filled in class during the last week following the implementation.

Additionally, middle school mathematics pre-service teachers were asked to prepare a technology-supported lesson plan in a topic they selected and present these plans to middle school students via micro teaching method. Micro teaching sessions were recorded via video and evaluated with the participation of pre-service teachers in the last two weeks of implementation. Conversations were carried out with pre-service teachers during the presentation of micro teaching videos (Patton, 2002). Questions (such as What is the reason you prefer this technology? What are the benefits/difficulties of using technology?) that would identify pre-service teachers' views regarding the use of technology in mathematics instruction were asked during interviews and notes were taken which were later evaluated.

Procedures

Implementation phase of the study lasted a total of fourteen weeks, three classes (150 minutes) per week. The study was conducted in the computer lab. The implementation utilized the teaching management system. General information about the implementation, practices about the topic of the week, resources, articles were shared and homework was collected via the system and individual feedback was provided. Implementation as a whole was undertaken by the researcher himself.

During the training, it was targeted to examine the literature on technology integration in mathematics teaching, to present the most commonly used technological tools in mathematics education and to develop skills related to the use of these tools. Therefore the content was prepared on this basis. The subject that will be taught has an important role in the use of technology. The technology that will be used is directly relevant to the selection of technological tools suitable for the subject, the identification of the effectiveness of student learning by using these tools and the content knowledge regarding where and how technology should be used during the teaching process. In this context, it is crucial to address technological pedagogical knowledge based on the subject to be taught (content knowledge) rather than general technological pedagogical knowledge. Technology integration was addressed in this respect in the current study and the activities undertaken in the implementation phase was prepared according to TPACK framework.

Literature review reveals that the leading technological tools in mathematics instruction are virtual learning objects, dynamic geometry software, graphing calculators and smart boards (Akkoç et al., 2011; Gürbüz & Gülburnu, 2013; Kağızmanlı, Tatar & Zengin, 2013; Selçik & Bilgici, 2011; Tutkun, Öztürk & Demirtaş, 2011). A draft program was later prepared and three mathematics instructors were asked to review it after they were briefed on the purpose of the study. New activities were added to the program with the help of graphing calculators to finalize the program following the feedback from the instructors. It is sufficient to have basic computer usage skills to be able to utilize the applications of the program. Computer I and II classes provided to pre-service teachers a year ago were regarded to be sufficient in terms of these skills. The most preferred software among dynamic geometry software are Geogebra, Cabri and Geometer's Sketchpad. Geogebra and Cabri dynamic software were preferred in this study. Geogebra program was selected because software language is Turkish and it is free of charge. Also Geogebra software has several features that are symbolic and let visualization such as direct keying of equations and coordinates and algebraic definitions of functions (Karaarslan, Boz & Yıldırım, 2011). Cabri software is preferred because in addition to offering applications based on Euclidian geometry, it allows concretization of the suitable models of 3-D geometric structures. These geometric software do not require special skills to operate. In the implementation phase, the programs were introduced first. Later, applications were done with these programs to discuss pedagogical content knowledge about geometry subjects and to increase skills in the use of the program. Applications about the program were created before the study and finalized after discussing them with two mathematics experts who have studies on the specific software. Resources about the software were examined to provide pre-service teachers with the skills to use them. The real purpose in the implementation phase was not to provide them with skills related to using them but to have them acquire the knowledge about how to use them in mathematics teaching. The purpose of using TI-Nspire graphing calculators was based on the fact that these graphing calculators were utilized before in the framework of a previous project and the researcher already possessed the software.

Table 1 presents the weekly distribution of the activities undertaken in the framework of the study in detail. Weeks 12 and 13 were spent in observing micro teaching practices of pre-service teachers as groups and providing feedback. Micro teaching groups were composed of 3-4 persons. Each teacher candidate in the groups separately prepared lesson plans for the acquisitions in micro teaching and these plans were discusses to obtain the lesson plans for the groups. Group lesson plans were implemented in the classroom using micro teaching and they were videotaped and made into presentations. Group work aimed to increase peer interactions among pre-service teachers. A total of 12 micro teaching groups were formed and two groups were observed in each lesson to complete observations in a 2-week period and provide the pre-service teachers with the necessary feedback. Appendix-1 provides a sample of the activities implemented in the framework of the study.

Data analysis

Middle school mathematics pre-service teachers' pretest-posttest PSTU scores were analyzed with the help of SPSS. Middle school mathematics pre-service teachers' total scores and pre and post test scores obtained by middle school mathematics pre-service teachers in sub-dimensions were compared by using dependent group t-test. Difference between groups were tested with $p<.05$ level of significance. Effect size was calculated to have information about the size of the difference between groups. During experimental processes, pre-service teachers that took part of the study did not attend to or participate in any classes or study on technology. The classes they had taken on technology previously (Computer I and II) mostly focused on general computer skills. They did not receive any teaching on the technological tools that can be used in teaching mathematics. During the experimental procedures (pretest-posttest) the same assessment tool (PSTU) was used.

Content analysis method was used in making sense of qualitative data of the study. All middle school mathematics pre-service teachers' answers were taken as a

Table 1. Weekly distribution of activities undertaken in the framework of the study

Week 1	Providing general information about the purpose, content and the implementation of the lesson. Identifying micro teaching groups and the acquisitions related to micro teaching. Implementing PSTU as pretest.
Week 2	Presenting TPACK model.
Week 3	Presenting virtual learning objects and investigating environments related to virtual learning objects that can be used in mathematics teaching. Watching a video of a sample lesson plan that utilizes virtual learning objects and preparing a lesson plan as homework.
Week 4	Presenting Cabri-geometry program, one of the dynamic geometry software, to be used in mathematics teaching and getting involved in practices related to Cabri- geometry program.
Week 5	Applications with Cabri program (Appendix I)
Week 6	Watching a video containing a sample lesson plan prepared by using Cabri program and preparing a lesson plan as homework
Week 7	Presenting Geogebra program and doing practices related to Geogebra program
Week 8	Applications with Geogebra program
Week 9	Watching a video containing a sample lesson plan prepared by using Geogebra program and preparing a lesson plan as homework
Week 10	Presenting TI-Nspire graphing calculators and doing practices related to them
Week 11	Presenting smart boards and doing practices related to them
Week 12	Watching micro teaching videos and providing educational feedback
Week 13	Watching micro teaching videos and providing educational feedback
Week 14	Evaluating the implementation. Giving PSTU as posttest.

whole in the first phase of content analysis and statements and words in these answers were examined. The three questions that provided data for the study requirement, advantage and disadvantage (dimensions of PSTU) generated the three themes in the study at the general level. Later, answers for each question were divided into meaningful parts and sub-themes were formed by trying to pinpoint their conceptual meanings. While identifying the sub-themes, answers were divided into four sub-themes for each general theme. In this way, general themes and sub-themes were identified and codes were organized under these sub-themes. Categories formed in this manner provided the conceptual structure to process all data. Inductive method was followed since the codes were directly generated from the data. Credibility and consistency of the qualitative data were ensured by the researcher by analyzing the data two times at different time periods. Confirmation of qualitative data was provided by quoting the data as much as possible and sufficiently.

The main qualitative data source in the framework of this study was pre-service teachers' written views on technology use in mathematics teaching. The notes taken by the researcher during micro teaching video recordings, lesson plans and conversations were subjected to descriptive analysis based on criteria such as the technological tools used by pre-service teachers, the method of technology use, teaching approaches and the learning domain of the selected subject. Data obtained from the notes taken by the researcher during micro teaching video recordings, lesson plans and conversations were used for confirmation in order to increase the reliability of the study.

FINDINGS

Findings for the first sub-problem

Dependent samples t-test was undertaken in order to test whether the difference between middle school mathematics pre-service teachers' pretest-posttest PSTU mean scores was significant. Before the tests were analyzed, Shapiro-Wilks test was done in order to determine whether the results had normal distribution. Accordingly, Shapiro-Wilks test results for pre and post PSTU are as follows respectively: (*SW=.972, p=514>.05*) and (*SW=.963, p=297>.05*). Since these results pointed to normal distribution it was decided to use t-test in the other analyses.

Dependent samples t-test was undertaken to compare middle school mathematics pre-service teachers' pretest-posttest PSTU scores and the results are presented in Table 2.

Table 2 indicates that pre-service teachers' pretest-posttest PSTU scores based on dependent group t-test presented *.05* level of significance [$t_{(33)}=-7.284$, $p<.05$]. According to this, following the training on technology use, pre-service teachers' perceptions on technology use in mathematics teaching changed positively. The effect size of this identified difference was calculated by using Cohen's d formula and was identified to be *.84*. This value can be interpreted as a large effect size (Cohen, 2013: 25).

Table 2. Comparison of middle school mathematics pre-service teachers' pre-PSTU and post-PSTU scores

	N	$\bar{X}$	S	Sd	t
pre- PSTU	34	276.97	22.13	33	-7.284
post- PSTU	34	295.50	21.85		

Findings for the second sub-problem

Dependent samples t-test was implemented in order to test the significance of the difference between the means of middle school mathematics pre-service teachers' pre- and post-test PSTU sub-dimensions *requirement, advantage* and *disadvantage* scores. Before the tests were analyzed, Shapiro-Wilks test was done in order to determine whether the results had normal distribution. Since these results pointed to normal distribution it was decided to use t-test in the other analyses.

Dependent samples t-test was undertaken to compare middle school mathematics pre-service teachers' pretest-posttest PSTU sub-dimension scores and the results are presented in Table 3.

Table 3. Comparison of middle school mathematics pre-service teachers' pre-PSTU and post-PSTU sub-dimensions scores

Dimensions		N	$\overline{X}$	S	sd	t
Requirement	Pre-PSTU	34	115.47	10.34	33	-2.870
	Post-PSTU	34	122.26	9.81		
Advantage	Pre-PSTU	34	126.23	12.42	33	-2.745
	Post-PSTU	34	134.23	12.6		
Disadvantage	Pre-PSTU	34	35.32	4.84	33	-1.136
	Post-PSTU	34	36.73	4.35		

Table 3 indicates statistically significant differences in mathematics pre-service teachers' *requirement* sub-dimension [$t_{(33)}=-2.870$, $p<.05$] and *advantage* sub-dimension [$t_{(33)}=-2.745$, $p<.05$] based on dependent group t-test results. However, no statistically significant results were obtained in the *disadvantage* sub-dimension [$t_{(33)}=-1.136$, $p<.05$] as a result of dependent group t-test. Based on this finding, training provided on technology integration increased middle school mathematics pre-service teachers' perceptions regarding the *requirement* and *advantage* of technology use in mathematics teaching but it did not affect their perceptions regarding *disadvantage.* On the other hand, effect size for *requirement* sub-dimension was *Cohen's d=.67*, effect size for *advantage* sub-dimension was *Cohen's d=.63* and effect size for *disadvantage* dimension was *Cohen's d=.30*. Based on these results it can be argued that training provided on technology use had medium level positive affect of middle school mathematics pre-service teachers' perceptions on *requirement* and *advantage* sub-dimensions but had a weak effect on their perceptions regarding *disadvantage*.

Findings for the third sub-problem

Written views of middle school mathematics pre-service teachers on technology use in mathematics teaching were sought after the training provided on technology use. Based on the answers provided middle school mathematics pre-service teachers to three questions, 3 themes and 12 sub-themes were coded. Pre-service teachers responded to the three questions on the form by using 216 sentences. Table 4 presents the distribution and percentages of these statements according to 3 themes and 12 sub-themes.

Table 4 indicates that pre-service teachers used the highest number of statements while they explained the requirement for technology use in mathematics teaching and its rationales. While the answers in the *requirement* theme had a ratio of 48.61% to total answer, the ratio of *advantage* theme was 38.42% and the ratio of *disadvantage* theme was 12.97%. These ratios can be interpreted in the sense that while there are some disadvantages associated with the requirement for technology use in mathematics teaching, pre-service teachers believe that there are more advantages related to technology use in mathematics teaching.

Pre-service teachers' views on the requirement for technology use in mathematics education were collected under four sub-themes: Teacher (28), Student (36), Teaching Method (41) and Technological Infrastructure (0). Table 5 present distribution and percentanges of codes according to *requirement* theme by sub-themes. Pre-service teachers (P.T.) believe that use of technology in mathematics teaching is mostly required in terms of teaching methods. Pre-service teachers mentioned the requirement for technology use for students to form their own knowledge when especially the constructive approach is the basis.

Some sample statements from pre-service teachers provided below support this view as well:

> I believe that is has to be definitely used especially in transformation geometry (reflection, translation, rotation). Because you can include activities that are not possible to undertake with materials such as wood, paper etc..(P.T.6)
>
> Mathematics lessons can be enjoyable and fun by benefiting students

Table 4. Distribution of middle school pre-service teachers' answers according to three themes

Theme	Sub-Themes	Frequency (f)	Percentage (%)
Requirement	Teacher	28	12.97
	Student	36	16.67
	Teaching Method	41	18.97
	Technological Infrastructure	0	0
	Total	**105**	**48.61**
Advantage	Teacher	27	12.50
	Student	22	10.18
	Teaching Method	24	11.11
	Technological Infrastructure	0	0
	Total	**73**	**33.79**
Disadvantage	Teacher	4	1.85
	Student	2	0.92
	Technological Infrastructure	32	14.83
	Teaching Method	0	0
	Total	**38**	**17.60**
	General Total	**216**	**100.00**

Table 5. The distribution of middle school pre-service mathematics teachers' statements according to requirement theme by sub-themes

Sub-themes	Codes	Frequency (f)	Percentage (%)
Teacher	Teacher should use to draw attention to the lesson.	14	13.34
	Teacher should use to do more practice.	8	7.62
	Teacher should use to make the lesson more simple and smooth.	4	3.81
	Teacher should use to increase her/his motivation.	2	1.90
Student	It should be used because it gives students new opportunities	19	18.09
	It should be used because it helps students construct knowledge.	9	8.57
	It should be used because it encourages active participation of the students.	8	7.62
Teaching Method	It should be used because it provides a constructivist learning environment.	12	11.42
	It should be used because it encourages a student-centred lesson	11	10.48
	It should be used because it easies teaching.	10	9.53
	It should be used because it makes teaching attractive.	8	7.62
Technological Infrastructure		0	0
	Total	105	100.00

> from geometric software or virtual learning objects. And it can be provided by technology (P.T.15)
>
> Dynamic learning environments offer students with new opportunities in learning mathematics and dynamic tools especially support learning by doing and the process of exploration.(P.T.18)
>
> In my opinion, they should definitely be used. The time spent in drawings without taking technological support can be better spent with activities that will let students take part in different activities to understand the subject with the help of technology (P.T..10)

Pre-service teachers assessed the advantages for technology use in mathematics education in terms of Teacher (27), Student (22), Teaching Method (24) and Technological Infrastructure (0). Table 6 present distribution and percentages of codes according to *advantage* theme by sub-themes.

Table 6. The distribution of pre-service middle school mathematics teachers' statements according to advantage theme by sub-themes

Sub-themes	Codes	Frequency (f)	Percentage (%)
Teacher	It enables the teacher to arouse interest and attention.	11	15.06
	It helps the teacher to relate the topic to real life.	7	9.59
	It helps the teacher to have a more planned and organised lesson.	6	8.22
	It encourages self-development.	3	4.11
Student	It boosts students' active participation.	13	17.81
	It enhances students' motivation.	7	9.59
	It facilitates students' understanding of the subject.	2	2.74
Teaching method	It enables to visualize teaching.	12	16.44
	It provides a more effective teaching.	7	9.59
	It enables to use different methods and techniques in teaching.	5	6.85
Technological Infrastructure		0	0
	Total	73	100.00

Pre-service teachers believe that use of technology in mathematics teaching provides advantages to teachers, increases student motivation with the help of technology, makes lessons more fun, provides opportunities for teaching using multiple senses and helps save time. Supportive statements from pre-service teachers are provided below:

> Taking the harmony between the new generation and technology into consideration, it is more effective to get student interest and attention with the help of computer assisted programs since they may get bored by working on drawings with paper and pencil and their attention may waver. (P.T..8)
>
> It helps students visualize by using virtual learning objects and supports better comprehension of the subject. (P.T..6)
>
> We enrich the field of visualization by using technology. We can save time. (P.T.17).
>
> In technology supported mathematics teaching, student concentration on the lesson becomes easier. Because students are very close to technology everywhere outside the school and they will have higher morale when they come across technology at their schools. (P.T..1)

Pre-service teachers assessed the disadvantages for technology use in mathematics education in terms of Teacher (4), Student (2), Technological Infrastructure (32) and Teaching Method (0). Table 7 present distribution and percentanges of codes according to *disadvantage* theme by sub-themes. Pre-service teachers mostly state that the most important disadvantage related to the use of technology in mathematics teaching is the lack of technological infrastructure. Also, pre-service teachers mention that using technology in mathematics education bring

Table 7. The distribution of pre-service middle school mathematics teachers' statements according to disadvantage theme by sub-themes

Sub-themes	Codes	Frequency (f)	Percentage (%)
Teacher	It increases teacher's workload.	3	7.89
	It weakens teacher's authority.	1	2.64
Student	Student's negative attitudes towards using computer	2	5.26
Technological Infrastructure	Lack of physical infrastructure in schools (computer lab., internet, overhead projector etc.)	26	68.42
	Classroom size	6	15.79
Teaching method		0	0
	Total	38	100.00

extra work load to teachers that and some students may have negative attitudes to technology which will decrease their interest towards the lesson.

Sample statements from pre-service teachers are provided below:

> Since there is the possibility that every student may not have technology use skills they may have focus on the material and miss the subject matter. (P.T.24)
>
> It is necessary that teachers have high level skills in technology use. Teachers should be equipped in terms of technological applications and materials that they are going to use. And that will bring extra work load o teachers. (P.T.14).
>
> The fact that classrooms are crowded affects the lessons. Technology use needs to be planned very carefully and that means more work for the teachers, i.e. us . (P.T..3)
>
> Since we cannot have computer labs and equipment such as projectors in all schools, we may not be able to practice this type of teaching everywhere. (P.T.29)

In the following section, descriptive findings obtained from pre-service teachers' video recordings of micro teachings, lesson plans, and interviews done during micro teaching presentations were presented.

Pre-service teachers that took part in the study practiced micro teaching in groups of 3-4. Groups selected their own subjects/acquisitions themselves and identified the technologies they could use based on the selected subjects/acquisitions. Pre-service teachers mostly selected subjects/acquisitions in geometry learning domain and used dynamic geometry software in their micro teaching. When they were asked why they selected dynamic geometry software, pre-service teachers mentioned that it allows students to form their own knowledge, can undertake more problem solutions and save time in the teaching process. While pre-service teachers preferred Geogebra, a dynamic geometry software, two of the groups preferred to work with Cabri 3D program. As a rationale for selecting Geogebra program, teachers mentioned that its interface is Turkish and it is easy to use. The groups who preferred to work with Cabri 3D program used it on geometric shapes. They stated that they selected this program to present the expansion of objects and increase visualization.

One group composed by participating teachers selected subjects/acquisitions in numbers whereas another in algebra learning domains. These groups used virtual learning objects and office programs as technological tools. These groups presented micro teaching by using the virtual learning objects in EBA and NLVM web sites. Also, they prepared presentations by using office programs in lectures. When they were asked the reason behind their selection, they mentioned the fact that virtual learning objects are interactive and provide opportunities for activities based on exploration. However since Turkish virtual learning objects do not exist and that the learning objects in NLVM web site are English can create some problems. Pre-service teachers mentioned that at first they present students with the virtual learning objects to minimize this problem and that causes a waste of time itself. In general, when the other groups were asked the reasons why they selected virtual learning objects, they mentioned lack of virtual learning objects in Turkish related to subjects/acquisitions.

While 8 of the 12 groups in the study prepared worksheets and followed a student centered approach, 4 followed a teacher centered approach. When the groups were asked the reason behind their choice, they stated that they would not be able to control the class since the classes were too crowded to practice student centered approaches. Pre-service teachers who followed student centered approaches stated that teaching environments were prepared based on students' learning paces with the help of technology and therefore students were able to form their own knowledge.

While 9 groups started their teaching with animations/videos/presentations about the subject in order to attract student attention, all groups actively used technology in the learning and teaching process. Only one group used technology at the beginning, development and assessment phases of the micro teaching process. When the group members were asked why they followed this approach, they stated that they used this type of teaching approach to save time and be able to answer more questions.

CONCLUSION AND DISCUSSION

Teachers have important roles in the use of technology in mathematics teaching. Previous experiences or competences of teachers highly affect their perceptions regarding the use of technology in lessons (Demir & Bozkurt, 2011). When the fact that mathematics teachers prefer to teach their subjects in the same way they learn is taken into consideration, it will be seen that having teaching experiences where technology is used will facilitate technology integration in mathematics teaching. On the other hand, teachers are also expected in the mathematics teaching program to effectively and relevantly use information and communication technologies (dynamic geometry software, virtual learning objects, graphing calculators, smart board etc). Previous studies indicate that although mathematics teachers and pre-service teachers have positive perceptions related to technology, they can partially use technology during class (Bauer & Kenton, 2005; Bozkurt & Cilavadroğlu, 2011; Demiraslan & Usluel, 2005). Findings of the current study, conducted with this perspective in mind, present significant differences in middle school mathematics pre-service teachers' perceptions regarding technology use in mathematics teaching before and after the training on technology integration. Effect size of this difference declares high and positive effect of the training about technology integration on pre-service teachers' perceptions on technology use. Also it was identified that while training on technology integration increased middle school mathematics pre-service teachers' perceptions on the requirement and advantages of technology use in mathematics lessons, it did not affect their perceptions in terms of disadvantages of technology use in mathematics teaching. Similarly, pre-service teachers' written views on technology use subsequent to the training on technology integration support quantitative findings.

It was observed that after the training on technology integration, pre-service teachers were informed of the technological tools that can be used in mathematics teaching and they were able to use those in their micro teaching practices. When the positive relationship between teachers' technological self-competence and in-class technology use is considered (Koh & Frick, 2009) it can be claimed that this finding is an important development for pre-service teachers' technology integration competences. The majority of the pre-service teachers in the study (8 from 12 groups) managed to create learning environments by planning teaching processes that allowed students to form their own knowledge. It was observed that pre-service teachers preferred dynamic geometry software in generating teaching environments. When they were asked why they selected dynamic geometry software, pre-service teachers stated that dynamic geometry allowed answering more questions, were more efficient in visualizing the subjects, allowed students to form their own knowledge through exploration and allowed learning at students' own paces. This finding is consistent with the findings of previous studies (Gürbüz & Gülburnu, 2013; Kağızmanlı, Tatar & Zengin, 2013; Selçik & Bilgici, 2011; Tutkun, Öztürk & Demirtaş, 2011). When this finding is taken into consideration, the necessity to inform teachers and pre-service teachers in the use of technological tools that can be used in mathematics teaching is highly evident.

On the other hand, it was identified that pre-service teachers used less virtual learning objects in micro teaching practices. When the reason for this was inquired, pre-service teachers stated that it resulted from lack of virtual leaning objects in Turkish. Linguistic difficulties are seen as obstacles in teacher and pre-service teachers' use of technology (Akkoç et al., 2011; Baki & Çelik, 2002). However, virtual learning objects ensure concretization of concepts and present many new opportunities for students that increase their level of comprehension (Karakırık, 2010). Virtual learning objects also allow student interaction in the teaching environment and let students learn at their own paces (Tunç, Durmuş & Akkaya, 2012). Studies show that use of virtual learning objects is effective in teaching mathematics (Durmuş & Karakırık, 2006; Karakırık, 2010; Yaman & Şahin, 2014). In this context, it is crucial to develop software in Turkish and assess the efficiency of these software. In this way, it may be possible to ensure selecting virtual learning objects in mathematics teaching.

It was observed that pre-service teachers' perceptions on the disadvantages of technology use in mathematics teaching did not change after the training provided in technology integration. Considering the circumstances of our country, pre-service teachers stated lack of physical equipment at schools and lack of technological infrastructure. They also believe that crowded classrooms would not provide the desired learning environment and therefore may result in some problems in terms of technology use. In this respect, pre-service teachers regarded the lack of technological infrastructure as an important barrier against technology use in mathematics teaching. Work towards developing technological infrastructure at schools that started with FATİH Project is promising. However it should be kept in mind that existence of software and hardware does not necessarily mean that technology will be used in the teaching process (Mumcu, Haşlaman & Usluel, 2008). Therefore, it is highly imperative to develop teachers' and pre-service teachers' technological pedagogical content knowledge.

Based on the findings of the study, several suggestions may be presented. Pre-service teachers should be provided with training on technological pedagogical knowledge during their undergraduate studies. Primary mathematics teaching undergraduate programs should be reviewed in the framework of technological developments and should be assessed in terms of both quality and quantity. Learning needs of teachers and pre-service teachers in terms of technology use should be identified and pre-service and in-service trainings should be planned to have them acquire technological pedagogical content knowledge.

This study is limited to 34 middle school mathematics pre-service teachers enrolled in a state university. Pre-service teachers in other universities can be provided with similar trainings to support the generalization of the results of the current study. Also, a similar training can be provided to teachers to compare results. Pre-service teachers' perceptions regarding the use of technology were taken as the dependent variable in this study. Conducting studies including other variables such as attitudes towards technology use, motivation and self-competence will contribute to the use of technology in mathematics education.

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APPENDIX I

Activity: Geogebra Practice Activity (8. Week)

Purpose: Having pre-service teachers practice Geogebra program and discuss pedagogical content knowledge and geometry subjects. In this process, it is aimed to increase skills related to program use.

Process of Implementation[1]

1- - Draw triangle ABC.

- Select a point P on [BC] side so that perimeters of APC and ABP triangles are equal.
- Prove your selection. (When the corners of the triangle change places, the perimeters should stay the same)

2- Draw an ABC triangle with right angle BAC.

- Name the midpoints of [BC], [AC] and [AB] sides as I, J and K points respectively.
- Draw the circumcircle of triangle IJK.
- Does this circle go through point A? Explain.

3- Construct point A and straight line d on the worksheet. (Point A will not be situated on straight line d). The point B on the straight line. Connect points B and A. Construct the perpendicular bisector of [AB]. Draw an orthogonal from point B to straight line d. Name the point where the perpendicular line meets the perpendicular bisector as P. Allow tracing to P from "trace" option and move point B on the straight line. What do you observe? Explain your opinion by defining the shape that has been generated.

4- Based on your drawing of the parabola, draw a hyperbola and ellipse. Write the stages of your drawing.

5- Draw an ABC triangle. Construct point M which is the midpoint of [BC] side of the triangle. Create the symmetric of the A with respect to point M and call it D. Draw triangle BDC. What geometric shape is the quadrilateral ABDC? Can we use this shape to cover the plane? If your answer is yes, write how you can cover the plane with this shape including the stages.

Draw any triangle and name it as ABC. Paint it generating a decoration by using symmetry translation movements. Write the stages you uses while forming the decorations.

[1] During the creation of these practices, the researcher made use of books titled *Pedagogical principles in technology supported mathematics teaching (*M. Doğan and E. Karakırık (Ed.)