



Effects of Geogebra supported micro teaching applications and technological pedagogical content knowledge (TPACK) game practices on the TPACK levels of prospective teachers

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Received: 14 September 2019 / Accepted: 16 October 2019 / Published online: 5 December 2019
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Abstract

The aim of this study is to investigate the effects of GeoGebra Supported Micro Teaching Applications and TPACK Game Practices on the TPACK efficacy and self-efficacy perception levels of the prospective math teachers on polygons. The study was carried out using 2×2 factorial design. The study group comprised 88 prospective math teachers. The prospective teachers were separated into 4 groups (G1, G2, G3, G4) randomly. Prospective teachers in G1 were participated in Micro Teaching Applications and Game- Based TPACK Activities, G2 participated in GeoGebra Supported Micro Teaching Applications, G3 group participated in Micro Teaching Applications and finally G4 group was participated in GeoGebra Supported Micro Teaching Applications and Game-Based TPACK Activities. The prospective teachers' efficacy levels were determined by using lesson plan and participant form; TPACK self-efficacy perception levels were determined by using TPACK Scale for Geometry. It was determined all application processes increased prospective teachers' TPACK efficacy and self-efficacy scores. The result of study showed that in terms of group variable there is a statistically significant difference between prospective teachers' TCK and TPACK efficacy levels. The results for self-efficacy scores rejected the statistically significant difference for post-test scores in terms of group variable for CK, PCK, TCK and TPACK.

Keywords TPACK · Prospective mathematics teacher · TPACK game · GeoGebra materials · Micro teaching

This study includes a part of PhD Thesis by Kübra AÇIKGÜL

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1 Introduction

In the recent years technological developments have also affected mathematics education, in many fields of mathematics the interest for and the emphasis put on the use of technology have increased (Doğan 2012; Erfjord 2011; Habre and Grundmeier 2007; Tabach 2011). Looking at the use of technology in math classes, the responsibility of using the technology effectively is given to the teachers. They are expected to use the technological tools in ways that enable students to benefit from the tools and that enrich the learning process in the class (National Council of Teachers of Mathematics 2000; Tabach 2011). During technology integration it is also considered important that pre-service and in-service math teachers have some efficacies. Focusing on teacher efficacy, researchers stated that math teachers and prospective math teachers are expected to have the Technological Pedagogical and Content Knowledge (TPACK) (Niess 2005; Niess et al. 2009). TPACK is a term that is used for explaining what teachers should know for integrating technology into the teaching process effectively (Schmidt et al. 2009).

Contrary to the expectations of mathematics teachers, it was stated in the researches that mathematics teachers could not use technology in their courses with the required efficacy (Gueudet and Trouche 2011; Ivy 2011; Laborde 2001; McBroom 2012; Stols and Kriek 2011; Urban-Woldron 2013). To overcome this problem many researchers claimed that teachers should have rich experiences that enable their TPACK development in teacher education programs (Agyei and Voogt 2012; Doğan 2012; Habre and Grundmeier 2007; Hacıömeroğlu et al. 2011; Kafyulilo 2010; Kafyulilo et al. 2015; Niess 2005). Even though the responsibility of integration technology to math classes was put on the teacher education programs, the fact that use of technology have not become widespread in math classes shows that teacher education programs are helpless to change the situation (Gueudet and Trouche 2011). In this case, it is considered important to understand the basic theories, principles, opportunities and challenges in improving the TPACK of prospective math teachers during the teacher education (Kafyulilo 2010).

Hardy (2010) showed activities within which prospects can explore various problems and subjects, plan technology enhanced lessons and be reviewed by using technological sources, as applicable methods to improve prospective math teachers' TPACK. Kafyulilo et al. (2015) claimed that attending vocational development programs including course design, teaching, evaluation and re-design might be effective for improving prospective math teachers' knowledge and abilities regarding technology integration in mathematics education. Within this context micro teaching method, which is a common practice where prospective teachers plan a lesson and teach their peers to gain experience as a part of teaching methods course (Bell 2007), is considered a useful method that improves prospective math teachers' TPACK (Cavin 2007; Kafyulilo 2010; Kafyulilo et al. 2015; Suharwoto 2006; Zhang and Wang 2016). Zhang and Wang (2016) stated that during micro teaching method prospective math teachers can experience the stages of teaching design, application and reflection, where they integrate teaching content, teaching methods and technology and reflect this integration to their teaching. Since micro teaching has created a suitable learning environment for TPACK development, we used micro teaching as the teaching method in our study.

On the other hand during micro teaching applications, prospective teachers are expected to develop technology-supported materials to be used in their teachings. But researches (Erdemir et al. 2009; Zengin et al. 2013) show that prospective math teachers can prepare simple technology enhanced materials, but they cannot prepare complicated and versatile materials and they find preparing material by using technology time consuming. The fact that prospective math teachers cannot develop effective technology enhanced materials during their teaching makes it difficult for them to integrate technology into their courses and establish effective technology supported mathematics teaching. To solve this problem researchers addressed material support and mentioned the necessity and the importance of developing and presenting technology enhanced materials that helps the teachers to use technology more efficiently in their math teaching (Bozkurt et al. 2011; Delice and Karaaslan 2015; Kutluca and Birgin 2007; Kutluca and Baki 2013). It is considered that micro teaching method will be more effective in providing TPACK development of prospective teachers if technology material support is provided to prospective mathematics teachers during their teaching. So in this study, it was provided technology support to prospective teachers during micro teaching applications and the effect of technology supported micro teaching method on prospective teachers' TPACK development was investigated. Technology support has been provided with the materials developed using GeoGebra software. The GeoGebra software was developed in 2002 by Markus Hohenwarter in his master's thesis project at the University of Salzburg in Austria. The software was used in this study because it is free and has Turkish language option (Hohenwarter 2002; Hohenwarter and Lavicza 2007). This process was named as GeoGebra Supported Micro Teaching Application and it was investigated the effect of GeoGebra Supported Micro Teaching Applications on the TPACK levels of prospective math teachers.

Also in addition to using micro teaching method, TPACK game is shown as one of the applications that will enable TPACK development of prospective teachers through cooperation and discussions on lesson designs (Baran and Uygun 2016; Hofer 2015; Richardson 2010; Uygun 2013). Richardson (2010) stated that TPACK Game can be utilized to use TPACK as a base for vocational development and explained the aim of the game as enabling the teachers to think more about intersection of content, pedagogy and technology. Uygun (2013) expressed that, during the game participants find the chance to discuss about possible course designs that can be planned considering the benefits and limitations of the components that are drawn from the content, pedagogy and technology bags. Because of these characteristics, it is thought TPACK Game Practices support the lesson planning, teaching and discussion stages in micro teaching process and provide the development of TPACK. Thus in this study the effect of participation in both of GeoGebra Supported Micro Teaching Applications and TPACK Game practices on TPACK development of prospective teachers was investigated.

2 Theoretical framework

2.1 Technological pedagogical content knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is one of the technology integration models, which theoretical framework addresses the teacher efficacies

regarding integrating technology into the teaching process effectively (Yurdakul Kabakçı et al. 2012). The concept of Technological Pedagogical Content Knowledge (TPACK) shaped as a result of an initiative to propose a knowledge theory that is required for a teacher to have for technology integration (Tabach 2011). This theoretical framework added technology as the third component to two main components of Pedagogical Content Knowledge (PCK), content and pedagogical knowledge (Pringle et al. 2015). With such a construct, it was aimed to explain how teachers' perception of PCK and educational technology interact with each other (Koehler and Mishra 2005, 2009).

TPACK framework allows teachers, researchers and teacher educators to move beyond the basic approaches (Koehler and Mishra 2009). The content that accepts the premise of TPACK as that the knowledge of the teacher is multifaceted, created a balanced combination of content, pedagogy and technology fields (Cox 2008). Interaction of these components of knowledge (content, pedagogy, technology) produces flexible knowledge types that are necessary to integrate technology into teaching both in theory and practice (Koehler and Mishra 2009). TPACK does not only accentuate teacher knowledge about understanding the content, pedagogy and use of technology, it also addresses these three knowledge fields (content, pedagogy and technology) together and blankets intersection and combination of these knowledge fields (Abbitt 2011; Ivy 2011; Yurdakul Kabakçı et al. 2012). TPACK consists of seven knowledge fields in total: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPCK) (Mishra and Koehler 2006).

On the other hand, Voogt et al. (2013) indicated that meaning of TPACK is better understood in specific subject fields. Niess (2005) remarked that the effect of the structure of their field on the TPACK development of prospective math teachers is important. Accordingly in this study, applications related to technology supported teaching of polygons were realized. There are two reasons for preferring polygons in this study. The first is the difficulties (such as determining the properties of the basic elements of polygons, solving problems related to polygons) that prospective teachers experience with regard to polygons (Couto and Vale 2014; Fujita and Jones 2006; Pickreign 2007). The second is the results of the studies showing the benefits of using technology in the learning and teaching of polygons (Erez and Yerushalmy 2006; Jones 2001; Kordaki and Balomenou 2006). As the study focuses on the teaching of a particular content, TPACK scores of the prospective teachers was restricted respect to CK, PCK, TCK, TPACK dimensions. Thus in this study it is aimed to examine the effect of GeoGebra Supported Micro Teaching Applications and TPACK Game Practices on the CK, PCK, TCK, TPACK levels of prospective math teachers on polygons.

CK is the knowledge of the teacher about the subject field that is taught or learned (Koehler and Mishra 2009). PCK is the knowledge that includes which learning methods are suitable for the content and what kind of regulations are supposed to be made during the teaching of field specific elements (Mishra and Koehler 2006). TCK includes the knowledge about how can technology create new representations for a specific content area (Schmidt et al. 2009). TPACK is the knowledge that represents the use of technology to support the field specific pedagogic strategies (Graham et al. 2009).

As mentioned above, TPACK has been put forward as information structure. Accordingly, the development of TPACK means increasing the efficacy in information structure. But Mudzimiri (2012), addressing the complexity of TPACK development that is necessary for technology integration, draw the attention to the effects knowledge as well as the belief regarding technology use in mathematics education on TPACK development. Albion (1999, 2000) stated that teachers' beliefs in their own capacity, especially their perception of self-efficacy in order for them to work efficiently with technology, is considered an important and measurable factor in the process of integrating technology into their courses. This explanation demonstrates the importance of enhancing TPACK self-efficacy beliefs levels for effective technology integration. Self-efficacy, which was introduced by Bandura (1997: 2), was defined as "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations." Scherer, Tondeur, Siddiq, and Baran (2018), defined TPACK self-efficacy belief as prospective teachers' beliefs regarding their TPACK knowledge fields and emphasized the importance of development of TPACK self-efficacy belief by educational approaches during teacher education processes. In this study it is aimed to examine the TPACK development of prospective teachers in terms of TPACK efficacy level and TPACK self-efficacy perception levels.

2.1.1 Micro teaching method and TPACK game on the TPACK development

Since the TPACK was introduced, it is considered important to conduct application and research studies, which examine the TPACK development of prospective teachers during various experiences in technologically rich environments (Abbitt 2011; Baran and Canbazoglu-Bilici 2015). Within this context micro teaching method is considered a useful method that improves prospective math teachers' TPACK (Cavin 2007; Kafyulilo 2010; Kafyulilo et al. 2015; Suharwoto 2006; Zhang and Wang 2016). Micro teaching method, as a tool of teachers' education, is a key technique for the educators, whereby prospective teachers can practice their teaching in a minimal form (Bhatta 2013). It is one of the best and long appreciated methods used for vocational development of the teachers in pre-service and in-service teacher education (Kpanja 2001; Ping 2013). It is a common practice, where prospective teachers prepare a teaching session as a part of teaching methods lecture and teach to their peers in order to gain experience (Bell 2007). The concept of micro teaching was suggested during the correction and revision process of teacher education protocol that is used in Teacher Education Department of Stanford University developed by Allen et al. in 1963 (Canady III 2013).

The aim of micro teaching method is to ensure the prospective teachers to have as many as possible teaching experiences under controlled circumstances, before they start teaching (Goldthwaite 1968). This common method presents itself with many advantages in the field of education, especially in pre-service teacher education (Bhatta 2013). The method allows prospective teachers to acquire information about different teaching procedures that they learned in teaching methods seminar and helps them to project the acquired knowledge to their teaching (Abdulwahed and Ismail 2011). Fernandez (2005) explained micro teaching process as prospective teacher presenting the minimized course to small groups, receiving feedback from his/her peers and supervisors. Benton-Kupper (2001) also stated that in micro teaching method every

student prepares a course of his/her own choice and teach it to his/her peers, at the end of the course they receive feedback in the form of peer review. He also stated that courses are video-taped and students watch their own videos and evaluate themselves. In accordance with the described application processes, in this study, prospective math teacher presented technology supported course, received feedback from his/her peers and supervisors and watched their own videos and evaluate themselves.

Various researches have been conducted examining TPACK development of prospective math teachers during and after these micro teaching processes. It was found out that these studies aimed to allow prospective math teachers to have experiences about technology enhanced math teaching as a part of a course, training, workshop, project etc., and to determine the effects of these experiences on TPACK development. It was determined that studies are mostly qualitative case studies and the results of these studies do not include statistical development in prospective teachers' TPACK (Agyei and Voogt 2012; Akyüz 2016; Cavin 2007; Hacıömeroğlu et al. 2009; Hardy 2010; Holmes 2009; Meagher et al. 2011; Mudzimiri 2012; Niess 2005; Polly 2014; Suharwoto 2006; Uygun 2013; Zambak 2014). But however there are limited empirical studies examining the effect on development of TPACK components as a result of the experiences of prospective math teachers (Yiğit 2014) and in empirical studies, TPACK development was examined on one group (Agyei and Keengwe 2014; Çetin 2017; Erdoğan 2014; Erdoğan and Ader 2013; Kafyulilo et al. 2015; Meng et al. 2014). Furthermore, there was no study in which provided technology support to prospective teachers during micro teaching applications for determining effect on their TPACK levels. So, it was considered important to investigate the statistical effect of GeoGebra Supported Micro Teaching Applications on prospective math teachers' TPACK level. As result of this, effects of Micro Teaching Applications (G3) and GeoGebra Supported Micro Teaching Applications (G2) on the TPACK scores of prospective math teachers were compared in this study. This way it was projected to acquire statistical evidence regarding the views about the necessity of providing material support to prospective teachers during their teaching.

On the other hand, it is considered important to compare effects of different teaching experiences on the TPACK level of prospective math teachers (Abbitt 2011). Also, it is thought that the participation of prospective math teachers in more than one teaching experiences may improve their TPACK levels more. So in this study in addition to Micro Teaching Application, prospective teachers were planned to participate in TPACK Game Practices. TPACK Game suggested by Judi Harris, Punya Mishra and Matt Koehler (Hofer 2015; Mishra 2010, 2013; Richardson 2010) whose rules and stages were explained by Richardson (2010). In the TPACK Game it was predicted to have three bags with cards in them, that have components content (math etc.), pedagogy (project based learning etc.) and technology (simulations etc.) written on them (Richardson 2010). The ground rule of these activities is that prospective teachers choose components out of the bags and discuss their ideas about the effectiveness of the possible teaching design that was formed by using the components together, while keeping the surpassing features and limitations of the component in mind (Richardson 2010).

TPACK game is shown as one of the applications that will enable TPACK development of prospective teachers through cooperation and discussions on lesson designs (Baran and Uygun 2016; Hofer 2015; Richardson 2010; Uygun 2013). However when

the literature was examined, there were found limited number of studies using TPACK Game as a stage of the application process while investigating the TPACK development (Baran and Uygun 2016; Koştur 2018; Kurt 2016; Uygun 2013). Furthermore, in these studies the statistical effect of TPACK Game on the TPACK levels of prospective math teachers was not investigated. Contrary to the mentioned studies, statistical effects of TPACK Game Practices on prospective teachers' TPACK development was examined in this study. Prospective teachers in G1 participated Micro Teaching Applications and TPACK Game Practices, and prospective teachers in G4 participated GeoGebra Supported Micro Teaching Applications and TPACK Game Practices.

In this study all groups (G1, G2, G3, G4) TPACK efficacy and self-efficacy development were examined and compared. It is thought that the results from this study will contribute to the literature about the effect of involvement in different teaching experiences on TPACK efficacy and self-efficacy levels and which teaching experience is more effective for improving prospective math teachers' TPACKs. It is also believed that the results can direct the teacher education programs.

Aim of the study The aim of this study is to determine the effect of GeoGebra Supported Micro Teaching Applications and TPACK Game Practices on the CK, PCK, TCK, TPACK efficacy and self-efficacy levels of prospective math teachers. In accordance with this aim, answers were sought for the following sub-problems:

1. In terms of CK, PCK, TCK, TPACK efficacy:
 - a. Is there a statistically significant difference in the post-test scores between the experimental groups (G1, G2, G4) and the control group (G3)?
 - b. Is there a statistically significant difference between the pre-tests and post-tests scores of the experimental groups (G1, G2, G4) and the control group (G3)?
2. In terms of CK, PCK, TCK, TPACK self-efficacy:
 - a. Is there a statistically significant difference in the post-test scores between the experimental groups (G1, G2, G4) and the control group (G3)?
 - b. Is there a statistically significant difference between the pre-test and post-test scores of the experimental (G1, G2, G4) groups and the control group (G3)?

3 Methods

3.1 Model of the research

In this study 2×2 factorial design, which is a true experimental design, was used. In experimental designs, researchers are able to examine the effect of one or more independent variables on dependent variable (Cohen et al. 2007; Fraenkel et al. 2012). On the other hand, with factorial design researcher is able to examine not only the independent variables' effects separately, but also how one variable moderates the

other by looking at the common effect (Fraenkel et al. 2012). In this regard factorial design was found suitable for the aim of the study.

In this study participants were randomly assigned into 4 groups (G1, G2, G3, G4) and the type of application for each group was also randomly determined. In this way it was aimed to have equal possible differences among the participants between groups (Coolican 1996; Lodico et al. 2006). At all, G3 was control group and G1, G2, G4 were experimental groups. In G1, Micro Teaching Applications and TPACK Game Practices; in G2, GeoGebra Supported Micro Teaching Applications; in G3, Micro Teaching Applications and in G4, GeoGebra Supported Micro Teaching Applications and TPACK Game Practices were carried out.

3.2 Participants

This study was conducted with 3rd year Elementary School Mathematics Education prospective teachers, who attend Special Teaching Methods II course. Participants were informed about the scope of the research and the study was conducted with 88 voluntary prospective teachers (Female = 72, Male = 16). In the research every group contained 22 prospective teachers. Hinkle, Wiersma, and Jurs (2003: 654) claimed that in experimental studies with 0,75 power value, $1,0\sigma$ influence quantity and 0,05 significance level each group should contain 21 participants. According to that it can be said that prospective teacher number per group is sufficient.

3.3 Implementation process of study

Research stages were execution of pre-test, Micro Teaching Applications, TPACK Game Practices and execution of post-test. Research focused on learning outcomes about polygons, which is a 7th grade subject in Middle School Math Curriculum (Ministry of National Education (MoNE) 2013).

3.3.1 Micro teaching application and GeoGebra supported micro teaching application

In the research Micro Teaching Applications and GeoGebra Supported Micro Teaching Applications for each group had continued for 8 weeks, with a 4 h program per week. The applications had 4 stages. These stages are teaching the subject, watching the video, evaluation and discussion. In all groups, prospective teachers were asked to design a technology supported course by determining the suitable pedagogy and technology for realizing the teaching outcome about 7th grade polygons subject, which they choose themselves, effectively and teach this course. Prospective teachers in groups G1 and G3 who participated Micro Teaching Applications were not given any supporting material. Groups G2 and G4, on the other hand, whereby GeoGebra Supported Micro Teaching Applications were carried out, were provided support with GeoGebra materials for realizing the learning outcome they themselves choose. Prospective teachers in groups G2 and G4 had also right to use technology apart from provided GeoGebra materials.

GeoGebra materials provided for prospective teachers in groups G2 and G4 were prepared by the researchers in accordance with the learning outcomes about 7th grade level polygons subject (MoNE 2013). 43 materials were prepared for this study.

Materials were examined by mathematics education experts experienced with GeoGebra software, math teachers and prospective teachers. Materials were evaluated by using a Material Evaluation Form in terms of appropriateness of learning outcomes, educational appropriateness and programming appropriateness. Scores on the form were set as 2 “enough”, 1 “partially” and 0 “none” and were evaluated as .0–.66 “none”, 0.67–1.33 “partially” and 1.34–2 “enough” by calculating the score means. As a result it was determined that all evaluators evaluated the material appropriateness as “enough” (between the range of 1.92–2).

After the teaching process, micro teaching videos of prospective teachers were viewed, evaluated and the effectiveness of the teaching was discussed. Teachings were evaluated based on TPACK Micro Teaching Evaluation Rubric prepared by the researchers, which is based on TPACK rubric designed by Harris et al. (2010).

3.3.2 TPACK game practices

For groups G1 and G4, TPACK Game Practices were also carried out for a period of 4 weeks. As a part of TPACK Game Practices 4 activities were carried out. The ground rule of these activities is that prospective teachers choose components out of the bags and discuss their ideas about the effectiveness of the possible teaching design that was formed by using the components together, while keeping the surpassing features and limitations of the component in mind (Richardson 2010). TPACK activities consist of 4 stages. These stages are choosing the components, filling out the questionnaire, sharing it on the Facebook group and online discussion.

Prospective teachers in groups G1 and G4 were separated into game groups of 2 within each group. Groups were formed on a voluntary base. As a part of the TPACK Game 1, 2 and 3, groups were asked to click on two bags and choose random components (TPACK Game1 content-pedagogy, TPACK Game2 content-technology, TPACK Game3 pedagogy-technology). All three components content-pedagogy-technology were randomly chosen from the bags in TPACK Game4.

Second stage was filling out the questionnaires. After the components were chosen, every game group was asked to discuss and fill out the questionnaires with the fellow other student in the game group. Questionnaires were prepared based on the studies of Richardson (2010) and Uygun (2013) in line with the contents of the games. Questionnaires 1, 2 and 3 include the characteristics of randomly chosen components, possible opportunities that can be provided and questions regarding the limitations. Questionnaires also include questions regarding the reasoning behind their choice of a third component, which is compatible with the two randomly chosen components, positive features and limitations, compatibility with other components. Questionnaire 4 includes questions about the features of 3 randomly chosen components, positive features, limitations and compatibility with each other. After the groups filled out the questionnaires, they posted their answers on the Facebook group. During the online discussion part, prospective teachers discussed other game groups’ sharings.

3.4 Treatment fidelity

In order to determine whether or not the micro teaching application process had taken place as planned, the process was videotaped, one of the researchers recorded the

observation notes in detail in to a notebook and a second observer was located in the classroom. Second observer made the evaluations with the Micro Teaching Observation Form prepared by the researchers. Prospective teachers also filled the Micro Teaching Observation Form at the end of the micro teaching applications. Arithmetic mean for every given answer was calculated and determined as “No” for values between 1 and 1.66, “Insufficient level” for values between 1.67–2.33 and “Yes” for values between 2.34–3. Results of the calculations showed that all values from second observer and prospective teachers were between 2,34-3,00, which corresponds to “Yes”, This situation might be shown as an evidence that Micro Teaching Applications were carried out as planned.

In order to determine whether or not TPACK Game Practices were carried out as planned, video tapes of the component choosing processes, Facebook group pages were inspected and interviews were made with 4 prospective teachers, who had participated in the activities.

3.5 Data collection tools

In the research prospective teachers’ efficacy levels regarding CK, PCK, TCK and TPACK were determined by using lesson plan and participant form; TPACK self-efficacy perception levels were determined by using Technologic Pedagogic Content Knowledge Scale for Geometry.

3.5.1 Lesson preparation method and participant report

In this study lesson preparation method, which Van Der Valk and Broekman (1999) uses in their studies, were used. At the beginning of the study during pre-test, prospective teachers were asked to prepare a lesson about a learning outcome of their choice about 7th grade polygons subject. They were also asked to use at least one technology, while they were designing their lesson. In this stage prospective teachers were free to choose the learning outcome by themselves. But during the post-test they were asked to prepare a lesson about a different learning outcome that they did not use for the lesson they prepared during pre-test stage and Micro Teaching Applications.

After the lessons were prepared, prospective teachers were asked to fill the participant report, which includes questions about their lesson. Data obtained from participant reports were used to detail and support the data obtained from the analysis of the lessons. Prospective teachers were asked to explain the reasoning behind their choices of content, pedagogy and technology components, the ways they utilized them, positive characteristics and limitations of the chosen content, pedagogy and technologies, the stages they had trouble with while they were preparing the lesson. In order to evaluate the participant report in terms of the scope of the points, fitness for purpose, comprehensibility, language and expression, 2 mathematics education experts were consulted.

3.5.2 TPACK scale about geometry

In this study the items regarding CK, PCK, TCK and TPACK dimensions of the scale that was developed by Bulut (2012) for determining the TPACK

development of prospective teachers in geometry was used. In order to determine whether or not the data set obtained from 88 prospective teachers during pre-test provide the 4 dimensional structure (CK, PCK, TCK, TPACK) confirmatory factor analyses was carried out. Calculated values of $\chi^2/df = 1.54$, $p = .000$, $RMSEA = .079$, $CFI = .98$, $NFI = .94$ were determined to be acceptable (Clara et al. 2001; Hooper et al. 2008; MacCallum et al. (1996), Tabachnick and Fidell 2007), only GFI value, which was calculated $GFI = .68$, was determined to be lower than the criteria equals. The reason behind it might be that GFI goodness of fit is strongly affected by sample size (Hooper et al. 2008; Shevlin and Miles 1998). The low value of GFI in this study might be explained by the small sample size ($N = 88$). Within this context examining the other fit indices, it was found out that values obtained from participants confirm the 4 factor structure. Also the calculated Cronbach alpha values ($\alpha_{AB} = .904$, $\alpha_{PAB} = .916$, $\alpha_{TAB} = .892$, $\alpha_{TPAB} = .933$) show that the scale is reliable for participants (Kline 2011).

3.6 Data analysis

3.6.1 Quantification of qualitative data

Lesson plan and participant report were analyzed by TPACK Efficacy Evaluation Rubric, which was developed as a part of this research. Mathematics education and educational science experts were consulted for content and structure validity and reliability study of 16 items TPACK Efficacy Evaluation Rubric. Based on expert views, evaluation criterion were formed into a 4 point scale with points being “Completely (3 points)”, “Highly (2 points)”, “Partially (1 point)” and “None (0 point)”. Examples of items in the rubric can be found below.

CK: Mathematical content introduced by prospective teacher is scientifically adequate.

PCK: Teaching strategy, method-techniques used by prospective teacher for teaching the lesson is adequate for realization of learning outcome.

TCK: Prospective teacher has knowledge about technologies that are appropriate for mathematical content.

TPACK: Prospective teacher used teaching strategy, method-technique and technologies in such ways that learning outcome to realized.

In order to determine the reliability of TPACK Efficacy Evaluation Rubric, first researcher graded lesson plans and participant reports ($N_{pre} = 88$, $N_{post} = 88$) acquired from pre-test and post-test twice with a one month interval. It was determined that correlation coefficients from two gradings vary between .837–1.00. Calculated correlation coefficients show that there is a high relationship between two gradings (Cohen 1988; Cohen et al. 2007; Field 2005). As a result of this relationship it might be claimed that gradings done with TPACK Efficacy Evaluation Rubric are reliable. Answers given to TPACK scale were quantified as Strongly disagree = 1 point, Disagree = 2 points, Somewhat disagree = 3 points, Somewhat agree = 4 points, Agree = 5 points, Strongly agree = 6 points.

3.6.2 Analyses of quantitative data

In the study SPSS program was used for quantitative data analysis. The processes of analysis of quantitative data are presented in detail below.

Examining pre-test and post-test efficacy and self-efficacy perception scores in terms of group variable In the study, the differentiation of participants' efficacy and self-efficacy perception scores obtained from pre-test and post-test in terms of group variable was examined by One Way Manova Test. In the One Way Manova Test the assumptions of sample size, extreme values, collinearity, multiple correlation, the homogeneity of variance covariance matrices were tested (Pallant 2011; Tabachnick and Fidell 2007). Since Tabachnick and Fidell (2007) stated that every cell should have at least 20 participants in order to achieve multiple normality, it can be said the sample groups with 22 participants are sufficient.

Z score for one variable extreme values and Mahalanobis values for multivariable extreme values were examined and found out that there are no extreme values. Collinearity between dependent variables was determined with scatter graph drawn according to group variable (Pallant 2011). Scatter graphs drawn for pre-test efficacy, pre-test self-efficacy perception and post-test self-efficacy perception scores show a linear relationship between dependent variables in terms of group variable. On the other hand scatter graph drawn for post-test efficacy scores show that in some situations there is no linear relationship between dependent variables. It was determined that correlation coefficients calculated between dependent variables vary between .442 and .869. These values show that there is no multiple correlation between variables (Tabachnick and Fidell 2007).

Levene test results show that variances are homogenous ($p > .05$). Also Box test results [Pre-test_{efficacy}: Box's $M = 21.332$, $p = .929 > .001$; Post-test_{efficacy}: Box's $M = 35.707$, $p = .340 > .001$; Pre-test_{self-efficacy}: Box's $M = 39.006$, $p = .221 > .001$; Post-test_{self-efficacy}: Box's $M = 38.574$, $p = .235 > .001$] show that variance covariance matrices are homogenous (Pallant 2011).

For the pre-test efficacy scores, pre-test self-efficacy scores and post-test self-efficacy scores, where all assumptions were met, Wilk's Lambda value was interpreted. On the other hand, Pillai's Trace value was interpreted for post-test efficacy score, where collinearity assumption is not completely met (Pallant 2011). If there is difference, Tukey difference test was performed. Cohen f effect size value was calculated. While interpreting Cohen f values, effect sizes were accepted as 0.10 "small", 0.25 "medium", 0.40 "large" (Cohen 1988). α was set as 0,05.

Examination of the difference between pre-test and post-test scores of groups In case of the assumptions regarding whether or not there is a meaningful difference between prospective teacher's CK, PCK, TCK and TPACK pre-test and post-test scores are met, One Way Repeated Measures Anova Test was decided to be used for examination. Before the test, it was examined whether or not score differences for every level of independent variable have a normal distribution or not. It was determined that for self-efficacy perception scores G1 in CK dimension, G1, G2 in PCK dimension, G1 in TCK dimension, G1, G3 in TPACK dimension do not have a normal distribution ($p < .05$). In these cases Friedman test was carried out. In the

analysis sphericity assumption was not examined, since there were only 2 variables (pre-test and post-test) (Pallant 2011).

For Repeated Measures Anova test r effect sizes were calculated and acquired r values were interpreted as $r = .10$ small effect size, $r = .30$ medium effect size, $r = .50$ large effect size (Field 2005). Since there are 4 groups and 4 dimensions 16 test in total were carried out for efficacy scores and by applying Bonferroni correction α value was set as $\alpha = 0.003 (=0.05/16)$ (Abdi 2010). Similarly α value was set as $\alpha = 0.003 (=0.05/16)$, while evaluating the test results regarding TPACK self-efficacy perception scores.

3.7 Internal validity and external validity

Fraenkel et al. (2012) stated that he keeps many threats regarding internal validity of factorial groups that are determined by random assignment under control. In this study 2×2 factorial design was used. Within this context it might be claimed that the experimental design used in this study is qualified for eliminating many threats regarding internal validity. In the research pre-test scores were determined as possible covariant variables on post-test scores and it was investigated whether this has an effect on post-test scores of prospective teachers. Manova test results regarding differentiation situation of CK, PCK, TCK, TPACK efficacy scores obtained from lesson plan and participant report during pre-test in terms of group variable show that there is no statistically significant difference between groups (Wilks' Lambda=,787, $F_{(12, 214)} = 1692$, $p = ,070 > ,05$). Similarly Manova test results regarding differentiation situation of CK, PCK, TCK, TPACK self-efficacy perception scores in terms of group variable show that there is no statistically significant difference between groups (Wilks' Lambda=,859, $F_{(12, 214)} = 1060$, $p = ,396 > ,05$).

To what extent the research result can be generalized is determined by external validity (Fraenkel et al. 2012). This research was conducted in accordance with goals, as it was planned by the researcher with prospective teachers. Thus the results of the study cannot be generalized to a bigger population. But keeping the aim of the study in mind, it might be considered that, participants being suitable to achieve this aim increases the generalizability of the study. Within this context results of the study can be generalized to a much bigger population or sub groups from the population with participants with similar characteristics. Also in this study learning outcomes about 7th grade level polygons was addressed. This situation limits the generalization of the results of this study to different subjects.

4 Results

4.1 Results for the first sub-problem

4.1.1 Comparison of prospective teachers' CK, PCK, TCK and TPACK post-test efficacy scores in terms of group variable

Differentiation situation of prospective teachers' CK, PCK, TCK and TPACK post-test efficacy scores obtained from lesson plan and participant report in terms

of group variable was examined by One Way Manova Test. Manova Test results showed that in terms of group variable there is a statistically significant difference between prospective teachers' CK, PCK, TCK and TPACK efficacy scores (Pillai's Trace = .263, $F_{(12, 249)} = 2144$, $p = .025 < .05$). Calculated effect size value Cohen $f = .31$ points out to a medium level effect. Test results regarding differentiation situation of dependent variables in terms of group variable are presented in the Table 1.

Table 1 shows that there is no statistically significant difference between groups' CK and PCK efficacy scores ($p > .05$). Post-test efficacy scores of prospective teachers in TCK dimension differentiates in a statistically significant way in terms of group variable [$F(3,84) = 3.647$, $p < .05$]. According to Tukey test results there is a significant difference in G4 and G3 efficacy scores in TCK dimension in favor of G4. Calculated Cohen f value for the difference (Cohen $f = .36$) shows that there is a medium level effect. In TPACK dimension prospective teachers' post-test efficacy scores differentiate significantly in terms of group variable [$F(3,84) = 4.703$, $p < .05$]. According to Tukey test result there is a significant difference in efficacy scores of G2 and G3 in favor of G2 and also in efficacy scores of G4 and G3 in favor of G4 in TPACK dimension. Calculated Cohen f value for the difference (Cohen $f = .41$) shows that there is a large effect.

4.1.2 Comparison of prospective teachers' CK, PCK, TCK and TPACK pre-test and post-test efficacy scores

In order to determine whether or not there is a statistically significant difference between prospective teachers' CK, PCK, TCK and TPACK pre-test and post-test efficacy scores obtained from prospective teachers' lesson plan and participant report, One Way Repeated Measures Anova Test was performed. Acquired results are shown in Table 2.

Table 2 shows that there is a statistically significant difference between CK, PCK, TCK and TPACK pre-test efficacy scores and post-test efficacy scores of prospective teachers' in groups G1, G2, G3 and G4 ($p < .003$). This situation shows that prospective teachers in all groups made a statistically significant progress in terms of their CK, PCK, TCK and TPACK efficacy scores. Calculated r effect size values point out to a large effect.

Table 1 Findings of differentiation situation of prospective teachers' post-test efficacy scores

	Dependent variable	Sum of Squares	df	Mean Square	F	p	Tukey Test	Power	Cohen f
Group	CK	1.216	3	.405	.363	.780			
	PCK	.318	3	.106	.174	.914			
	TCK	5.727	3	1.909	3.647	.016*	G4 > G3	.781	.36
	TPACK	6.016	3	2.005	4.703	.004*	G2, G4 > G3	.883	.41

* $p < .05$

Table 2 The Difference between Prospective Teachers' Pre-test Efficacy Scores and Post-test Efficacy Scores

	Group	Source	Sum of Squares	df	Mean Square	F	p	Power	r
CK	G1	Time	92.124	1	92,124	80.464	.000*	.999	.89
		Error	24.043	21	1145				
	G2	Time	81.818	1	81,818	89.573	.000*	.999	.90
		Error	19.182	21	,913				
	G3	Time	70.427	1	70,427	62.008	.000*	.999	.86
		Error	23.851	21	1136				
	G4	Time	106.124	1	106,124	90.192	.000*	.999	.90
		Error	24.710	21	1177				
PCK	G1	Time	51.928	1	51,928	166.951	.000*	.999	.94
		Error	6.532	21	,311				
	G2	Time	52.801	1	52,801	98.833	.000*	.999	.91
		Error	11.219	21	,534				
	G3	Time	48.510	1	48,510	93.718	.000*	.999	.90
		Error	10.870	21	,518				
	G4	Time	73.841	1	73,841	133.458	.000*	.999	.93
		Error	11.619	21	,553				
TCK	G1	Time	66.273	1	66,273	123.349	.000*	.999	.92
		Error	11.283	21	,537				
	G2	Time	73.841	1	73,841	181.406	.000*	.999	.95
		Error	8.548	21	,407				
	G3	Time	35.162	1	35,162	128.926	.000*	.999	.93
		Error	5.727	21	,273				
	G4	Time	86.427	1	86,427	264.919	.000*	.999	.96
		Error	6.851	21	,326				
TPACK	G1	Time	61.928	1	61,928	163.959	.000*	.999	.94
		Error	7.932	21	,378				
	G2	Time	72.808	1	72.808	263.080	.000*	.999	.96
		Error	5.812	21	,277				
	G3	Time	36.001	1	36.001	110.221	.000*	.999	.92
		Error	6.859	21	,327				
	G4	Time	83.463	1	83.463	236.941	.000*	.999	.96
		Error	7.397	21	,352				

* $p < .003$

4.2 Results for the second sub-problem

4.2.1 Comparison of prospective teachers' CK, PCK, TCK and TPACK self-efficacy perception post-test self-efficacy perception scores in terms of group variable

Differentiation situation of prospective teachers' CK, PCK, TCK and TPACK post-test self-efficacy perception scores in terms of group variable was examined by One Way Repeated Monava Test. Manova test results show that there is no statistically significant difference between prospective teachers' CK, PCK,

TCK and TPACK self-efficacy perception scores (Wilks' Lambda = .833, $F_{(12, 214)} = 1.282$, $p = .231 > .05$).

4.2.2 Comparison of prospective teachers' CK, PCK, TCK and TPACK pre-test and post-test self-efficacy perception scores

In order to determine whether or not there is a statistically significant difference between prospective teachers' CK, PCK, TCK and TPACK pre-test perception scores and post-test perception scores, One Way Repeated Measures Anova and Friedman Tests were performed. One Way Repeated Measures Anova Test results are presented in Table 3 and Friedman Test result are presented in Table 4.

Examining the Tables 3 and 4, it is determined that there is a statistically significant difference between pre-test and post-test self-efficacy perception scores of prospective teachers in G1, G2, G3, G4 in PCK, TCK and TPACK dimensions and prospective teachers in G2, G3, G4 in CK dimension ($p < .003$). Calculated r effect size values point out to a large effect. On the other hand no statistically significant difference was found between CK pre-test and post-test self-efficacy perception scores of prospective teachers in group G1 ($p > .003$).

Table 3 One Way Repeated Measures Anova Test Results

	Group	Source	Sum of Squares	df	Mean Square	F	p	Power	r
CK	G2	Time	2.09	1	2.609	19.790	.000*	.989	.70
		Error	2.769	21	.132				
	G3	Time	3.043	1	3.043	15.472	.001*	.963	.65
		Error	4.130	21	.197				
	G4	Time	4.364	1	4.364	16.058	.001*	.968	.66
		Error	5.707	21	0.272				
PCK	G3	Time	5.133	1	5.133	53.026	.000*	.999	.85
		Error	2.033	21	.097				
	G4	Time	6.568	1	6.568	22.256	.000*	.994	.72
		Error	6.197	21	.295				
TCK	G2	Time	8.690	1	8.690	60.509	.000*	.999	.86
		Error	3.016	21	.144				
	G3	Time	5.637	1	5.637	18.286	.000*	.983	.68
		Error	6.474	21	.308				
	G4	Time	11.556	1	11.556	43.532	.000*	.999	.82
		Error	5.574	21	.265				
TPACK	G2	Time	11.712	1	11.712	39.048	.000*	.999	.81
		Error	6.299	21	.300				
	G4	Time	18.872	1	18.872	106.933	.000*	.999	.91
		Error	3.706	21	.176				

* $p < .003$

Table 4 Friedman Test Results

	Group	Mean Rank	df	χ^2	p	r
CK	G1	1.30	1	4.263	.039	
		1.70				
PCK	G1	1.16	1	11.842	.001*	.66
		1.84				
	G2	1.05	1	18.182	.000*	
		1.95				
TCK	G1	1.05	1	20.00	.000*	.84
		1.95				
TPACK	G1	1.07	1	17.109	.000*	.84
		1.93				
	G3	1.02	1	21.00	.000*	
		1.98				

* $p < .003$

5 Discussion

In this research the differences between CK, PCK, TCK and TPACK efficacy and self-efficacy perception scores of prospective teachers participating in different teaching experiences were examined. Also, the development of CK, PCK, TCK and TPACK efficacy and self-efficacy perception levels of the groups were examined. Results regarding the post-test efficacy scores obtained from lesson plans and participant reports show that there is no statistically significant difference between efficacy scores of prospective teachers participated in GeoGebra Supported Micro Teaching Applications (G2) and efficacy scores of prospective teachers participated in Micro Teaching Applications (G3) in CK, PCK and TCK dimensions. However it was determined that there is a statistically significant difference between TPACK post-test efficacy scores of prospective teachers, who participated in GeoGebra Supported Micro Teaching Applications and provided with material (G2) and TPACK post-test efficacy scores of prospective teachers, who participated in Micro Teaching Applications (G3). This result might be interpreted as providing technology supported teaching materials to prospective teachers increases the efficacy of effectively integrating technology into the teaching of polygons subject on a statistically significant level.

Another result obtained from lesson plans and participant reports was that there was no significant difference between G1 and G2, G2 and G4. This result shows that TPACK Game Practices did not create significant differences on prospective teachers' CK, PCK, TCK, TPACK efficacy levels. During TPACK Game Practices prospective teachers discussed possible lesson designs, which were formed using randomly chosen content, pedagogy and technology components. TPACK Game Practices, having no significant contribution to post-test efficacy scores of prospective teachers, showed that having discussions about possible lesson designs by using components that they choose from a bag without perceptively planning and executing the lesson do not contribute to

their efficacy of planning a lesson. On the other hand randomly chosen components being incompatible for designing a technology supported lesson might have hindered prospective teachers' development. And on the other it was found out that TCK and TPACK efficacy scores of prospective teachers, who attended both GeoGebra Supported Micro Teaching Applications and TPACK Game Practices (G4) are significantly higher from scores of prospective teachers, who only participated in Micro Teaching Applications (G3). In line with this result it might be claimed that, being informed about various technologies that used in lessons during TPACK Game Practices and planning the ways they use the materials by working on GeoGebra materials during GeoGebra Supported Micro Teaching Applications and practising these plans increase prospects TCK and TPACK efficacy in a significant way. This results support the views about the necessity of prospective teachers having experiences in technologically rich environments that would improve their TPACK during their education, in order for them to integrate technology to their teaching implementations efficiently (Agyei and Voogt 2012; Clarke 2009; Doğan 2012; Erdoğan and Şahin 2010; Habre and Grundmeier 2007; Hacıömeroğlu et al. 2009, 2011; Kafyulilo 2010; Kafyulilo et al. 2015; Niess 2005). This result might also be interpreted as participating in various activities that are technologically enhanced during their education might contribute to prospective teachers TPACK on different levels and participating in more than one activity cause even more development in prospects TPACK levels. Similarly in her study Akyüz (2016), who investigated the effect of different teaching methods (design based, problem-solving, activity-based approach,) on TPACK development of prospective math teachers, stated that TPACK levels of prospective math teachers goes up to around 60% with design based teaching methods, are around 35%–40% with activity based approach and decrease to 18% with the method based on problem solving. Based on this finding the researcher concluded that the different methods used for improving prospective teachers' TPACK during their education have different role on their TPACK levels.

Canbazoglu-Bilici, Guzey and Yamak (2016) emphasized the critical importance of TPACK for effective teaching with technology and claimed that teacher education programs should offer opportunities for improving TPACK in order for the teachers to effectively integrate technology into their teaching. Statistically significant increase that was determined between CK, PCK, TCK and TPACK pre-test and post-test efficacy scores acquired from prospective teachers' lesson plans and participant reports, reveals the meaningful contribution of all teaching experiences on prospects TPACK efficacy levels. The results regarding the difference of pre-test post-test efficacy scores obtained from this study, show that Micro Teaching Applications, GeoGebra Supported Micro Teaching Applications and TPACK Game Practices increases prospective teachers' TPACK levels in a significant way. Within this context it might be said that teaching experiences in this study can be utilized in teacher education programs in order to improve prospective math teachers' TPACK efficacy.

The statistical results obtained from this study regarding the development levels of prospective teachers' TPACK efficacy, support the qualitative study results that show that activities whereby prospective math teachers being informed about the ways to use technology in math teaching, developing technology supported materials, preparing lesson plans by using technology and presenting it to their peers improve prospects' TPACK (Agyei and Voogt 2012; Balgalmış et al. 2013; Cavin 2007; Hacıömeroğlu

et al. 2009; Hardy 2010; Holmes 2009; Meagher et al. 2011; Niess 2005; Özgün-Koca et al. 2010; Polly 2014; Suharwoto 2006; Uygun 2013; Zambak 2014). Balgalmış (2013), Hacıömeroğlu et al. (2009) found that the process of preparing and presenting technology supported math lessons with GeoGebra program improves prospective teachers' TPACK.

Contrary to the above results it was found that CK, PCK, TCK and TPACK self-efficacy perception post-test scores, which prospective teachers get from TPACK scale, do not differentiate in a statistically significant way in terms of group variable. This result shows that different teaching experiences do not cause meaningful differences on post-test perception scores. Hohenwarter and Lavicza (2007) mentioned that many teachers are eager to integrate technology into their lessons, but without necessary education and additional support it is hard to come by a teacher, who uses technology moderately. In this study it was believed that providing material support to prospective teachers as a part of Micro Teaching Applications would save prospects from a difficult process and create a meaningful increase in their self-efficacy perception on technology use in their lessons. Keeping this in mind, although providing prospective teachers with material support as a part of Micro Teaching Application creates a difference in prospective teachers' TPACK efficacy levels, it does not create a meaningful difference in their self-efficacy perception, which is an attention grabbing result. The reason behind this might be that the self-efficacy perception is that one persons' own belief about his/her efficacy level, rather than the real efficacy level (Albion 2000; Kurbanoglu 2004).

In addition to that meaningful differences between pre-test and post-test perception scores in almost all groups in CK, PCK, TCK and TPACK dimensions were identified. This result show that all teaching experiences performed in this study meaningfully contribute to prospective teachers' CK, PCK, TCK and TPACK self-efficacy perceptions. Obtained results regarding the differences between pre-test and post-test TPACK perception scores have parallels with the results obtained from studies in the literature, whereby prospective teachers get information in technologically rich environments and have experiences (Ageyi and Keengwe 2014; Çetin 2017; Erdoğan 2014; Kafyulilo et al. 2015; Meng et al. 2014). In Çetin's study (2017), where TPACK based lesson planning activities and micro teaching applications were carried out with prospective teachers, it was found out that prospective teachers' scores obtained from TPACK scale increased in all sub-dimensions and throughout the whole scale. Kafyulilo et al. (2015) stated that prospective teachers learn methods used to overcome the difficulties regarding the technology integration into the classroom environment during micro teaching applications and instead of addressing content, pedagogy and technology knowledge separately, they build their confidence about TPACK by merging them.

6 Limitations and future directions

Based on the results of this study, it is suggested to utilize Micro Teaching Applications, GeoGebra Supported Micro Teaching Applications and TPACK Game Practices in prospective teachers' education, in order to improve their TPACK efficacy and self-efficacy perception levels. It is also suggested to provide technological support to

prospective teachers and for the prospective teachers to participate in various teaching experiences to improve their TPACK efficacy levels even more.

This study also has various limitations. Research was carried out with a study group. This situation limits the generalizability of the research. In order to increase the generalizability of the obtained results, it is suggested to test the effect of teaching experiences studied in this research on TPACK levels of prospective math teachers, who has different characteristic features. Another point is that the subject of the research was limited with 7th grade polygons. Future studies can be carried out with different subjects to examine the effect of Micro Teaching Applications, GeoGebra Supported Micro Teaching Applications and TPACK Game Practices on TPACK development of prospective teachers. During Micro Teaching Applications prospective teachers were provided with only materials that are prepared with GeoGebra software. Within this context by using different technologies, the effect of provided support on prospective teachers' TPACK levels might be examined.

7 Conclusion

In the research it was determined that Micro Teaching Applications, GeoGebra Supported Micro Teaching Applications and TPACK Game Practices cause statistically significant increases in prospective teachers' CK, PCK, TCK and TPACK efficacy and self-efficacy perception levels. This result shows the positive effect of different teaching experiences, which were a part of this study, on prospective teachers' TPACK efficacy and self-efficacy perception scores. As a result of this study it was determined that, providing material support during Micro Teaching Applications and TPACK Game Practices especially in the TPACK dimension with the technology component, cause meaningful differences on the efficacy scores of prospective math teachers. Another result of the study shows that efficacy scores of prospective teachers, who participated GeoGebra Supported Micro Teaching Applications and TPACK Game Practices are significantly higher than the scores of prospective teachers, who participated only in Micro Teaching Applications. It was also found that TPACK self-efficacy perception scores of prospective teachers, who participated in different teaching experiences are not different. This finding points to the importance and necessity to examine efficacy levels regarding planning knowledge and skills and self-efficacy perception levels regarding their beliefs separately, while examining their TPACK.

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