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THE EFFECT OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE GAME ACTIVITIES SUPPORTED MICRO-TEACHING PRACTICES ON PRESERVICE MATHEMATICS TEACHERS' SELF-EFFICACY PERCEPTION LEVELS[1]

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Abstract The purpose of this study is to investigate the effect of Technological Pedagogical Content Knowledge (TPACK) Game activities supported micro-teaching practices on middle school preservice mathematics teachers' TPACK self-efficacy perception levels. A single group pretest-posttest experimental design was employed. One hundred middle-school preservice mathematics teachers, attending a mathematics instruction course, participated in the study. The Technological Pedagogical Content Knowledge Survey (Şahin, 2011) was used to determine teachers' level of TPACK-measured self-efficacy. One-way Repeated Measures ANOVA was performed to analyze possible differences between teachers' pre and post self-efficacy scores. The result of this analysis demonstrated a statistically meaningful difference for the overall survey as well as for all dimensions of it. These findings suggest that micro-teaching practices do indeed increase preservice teachers' TPACK self-efficacy perception scores.

Key Words: Micro-Teaching Practices, Preservice Mathematics Teacher, TPACK, TPACK Game

1. Introduction

The improvements in technology have prominently provided the development of technologies that supported learning and teaching of mathematics (Crompton, 2015). Hence, the emergence of such technologies that could be integrated in mathematics courses has offered a spectacular potential for reviving and changing mathematics education (Lavicza, 2010). The potential of such technologies in mathematics education has revealed teachers' needs for developing technologic tools and innovative learning experiences in order them for ensuring their students to involve in tasks that require higher order thinking skills (Agyei & Voogt, 2014). However, studies noted that mathematics teachers are not fully prepared to integrate new digital technologies into the mathematics curriculum and are not able to use those technology in their courses in relation to the required proficiency, level, and purpose (Agyei & Voogt, 2011a, and 2011b; Alagic & Pelenz, 2006; Crompton, 2015; Dockendorff & Solar, 2017; Gueudet v& Trouche, 2011; Koh, 2018; Stols & Kriek, 2011; Urban-Woldron, 2013). To eliminate this negative situation, Stoilescu (2015) emphasized the need for training mathematics teachers about using technological tools effectively in their mathematics lessons. Similarly, many researchers have indicated the need for providing mathematics teachers with experience on integrating technology into their courses and pointed out that teacher education programs should had responsibility for this process (Agyei & Voogt, 2012; Erdoğan & Şahin, 2010; Hacıömeroğlu, Bu, Schoen, & Hohenwarter, 2011; Kafyulilo, 2010; Niess, 2005). With regards to this responsibility, it is necessary to understand how teacher education programs should be planned and implemented (Erdoğan & Şahin, 2010).

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As a result of the necessity and efforts spent for training teachers who can effectively use technology in an interesting and innovative way in their classrooms have enabled the integration of various technology related models into the teacher education programs (Abbitt, 2011). One of the best known and widely used of these models is the Technological Pedagogical Content Knowledge (TPACK) that is presented by Mishra and Koehler (2006) as a theoretical framework for explaining the teacher knowledge required for technology integration (Baran, Canbazoğlu Bilici, Albayrak Sari, & Tondeur, 2017; Stoilescu, 2011). TPACK is a theoretical framework that makes it necessary to understand content, pedagogy, and technology knowledge areas and the relationships among these areas to create an effective technology-supported instruction in teacher education (Erdoğan & Şahin, 2010; Harris, Mishra & Koehler, 2009; Koehler, Mishra, & Yahya, 2007; Koehler & Mishra, 2009).

Sintema (2018) pointed out mathematics as one of the main topics in which the TPACK framework, which is widely used for technology integration in education, has an extensive field for applications. Crompton (2015) highlighted the TPACK framework can contribute to the development of teacher education programs in mathematics education on the use of technology.

1.1. The Development of Preservice Mathematics Teachers' TPACKs in Teacher Education Programs

The use of the TPACK framework in teacher education programs has brought the question how to provide learning experiences for preservice mathematics teachers (PSMTs) to adequately develop their TPACK (Hacıömeroğlu et al., 2011; Niess, 2005). In order to develop TPACK of PSMTs, researchers (e.g., Hardy, 2010; Kafyulilo, Fisser, Pieters, & Voogt, 2015) suggested that in the professional development programs, preservice teachers should be provided with experiences in which they can plan technology-supported lessons, teach those lessons, and evaluate and redesign those lessons according to feedbacks that they received. Moreover, it is indicated that during their experiences of using technology, working in cooperation and discussions with each other may contribute to the development of PSMTs' TPACK. In this respect, micro-teaching, a method in which after planning their lessons, in-service and PSMTs teach lessons and evaluate their peers (Benton-Kupper, 2001), has been regarded as an effective technique in the development of PSMTs' TPACK (Cavin, 2007; Durdu & Dag, 2017; Hähkiöniemi & Leppäaho, 2012; Kafyulilo, 2010; Kafyulilo et al., 2015; Koştur, 2018; Kurt, 2016; Suharwoto, 2006; Zhang & Wang, 2016). During the micro-teaching practices, besides collaborative reflection, instant feedback, and learning from peers, PSMTs have opportunity to practice how to teach their lessons by integrating the technology (Zhou, Xu, & Martinovic, 2017).

On the other hand, the TPACK Game has been regarded as another application of TPACK that allows PSTs to collaborate on their technology-supported lesson plans and discuss those plans with each other (Açıkgül, 2017; Baran & Uygun, 2016; Hofer, 2015; Koştur, 2018; Richardson, 2010; Uygun, 2013). The TPACK Game was introduced by Judi Harris, Punya Mishra, and Matt Koehler at the annual meeting of the National Technology Leadership Summit in Washington DC in 2007 (Hofer, 2015; Mishra, 2010, 2013; Richardson, 2010). The TPACK Game includes a process in which participants randomly select cards, each describes the components of the content, pedagogy, and technology, from bags and examine the relationships between those components and discuss the suitability of possible courses that can be designed using these components (Richardson, 2010).

In agreement with the above explanations, in this study, it was important for the PSMTs to participate in the TPACK Game activities supported micro-teaching practices for planning lessons, presenting these lessons to their peers, and evaluating their lessons within the TPACK framework. On the other hand, Crompton (2015) emphasized the significance of examining the effects of approaches that support PSMTs' TPACK development in teacher education programs on their beliefs in the integration of technology into mathematics instruction. Albion (1999, 2000) pointed out that teachers' beliefs in their capacity to work effectively using technology, especially self-efficacy perceptions, is considered to be a useful indicator of the possible success of technology integration. On the other hand, Huzzie-Brown (2018) highlighted that self-efficacy perception is a major determinant of whether a teacher can successfully integrate technology into his/her teaching and emphasized the importance of examining teachers' self-efficacy perceptions. Yerdelen-Damar, Boz, and Aydın-Günbatar (2017) stated that self-efficacy perception has a strong effect on teachers' use of technology in their classrooms.

Self-efficacy, as proposed by Bandura (1997), is a prominent concept within the Social Learning Theory and one of the important variables of this theory. The self-efficacy perception concept, 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.” Therefore, Bandura’s self-efficacy theory provides a basis for understanding the effect of teachers’ faith in their ability of successfully integrating technology into their teaching practices (Abbitt, 2011). Therefore, it is important to examine the development of PSTs’ TPACK self-efficacy perceptions, which are defined as beliefs of PSTs about the components of TPACK (Scherer, Tondeur, Siddiq, & Baran, 2018). In conclusion, this current study aims to determine the effects of the TPACK Game activities supported micro-teaching practices on middle school PSMTs’ TPACK self-efficacy perception levels.

1.2. Literature Review and Significance of the Study

In this study, the effect of TPACK Game activities supported micro-teaching practices based on the PSMTs’ TPACK self-efficacy perception levels was investigated. In mathematics education literature, some studies have been conducted to investigate the effect of micro-teaching practices on PSMTs’ TPACK perception development. For example, Kafyulilo et al. (2015) investigated preservice mathematics and science teachers’ TPACK development in a professional development program in which they designed lessons in collaboration with each other and carried out micro-teaching practices in those lessons. Kafyulilo et al. (2015) determined the PSTs’ TPACK perceptions applying TPACK scale before and after the professional development program. As a result of the study, it was stated that the professional development program was effective for the development of PSTs’ TPACK perceptions. In Agyei and Keengwe (2014)’s study, PSTs prepared lesson plans and activities using spreadsheet programs and revised their plans and activities based on feedback that they received. In the study, it was determined that there was a significant increase in TPACK perceptions of prospective teachers. In addition, Çetin (2017) conducted micro-teaching practices with preservice secondary school mathematics teachers in which they were informed about preparing TPACK-based lesson plans and software used in mathematics education programs. As a result, significant increases were determined from the PSTs' scores on TPACK scale.

Mudzimiri (2012) examined the development of the relationship between PSMTs’ content, pedagogy, and technology knowledge. In the study, five PSMTs were observed for a 15-weeks period in which micro-teaching practices were also conducted. The PSMTs’ TPACK self-efficacy perception levels were determined by using TPACK scale. It was determined that there were developments on three PSMTs’ TPACK perception levels. Durdu and Dag (2017) investigated the effect of a computer-aided mathematics course on PSMTs’ TPACK development. In the study, the PSMTs were instructed about using GeoGebra software, and later they prepared GeoGebra materials and conducted micro-teaching practices. In the study the data obtained from a TPACK survey had showed PSMTs’ TPACK developments.

When the studies in mathematics education literature are examined, it is observed that a few studies included the TPACK Game activities in technology-supported courses. Baran and Uygun (2016) examined graduate students’ development of TPACK in a design-based learning environment in which the TPACK Game was used. Koştur (2018) aimed determining preservice secondary mathematics teachers’ development of TPACK in a technology supported mathematics education course. In the first phase of the study, which was designed as a case study, the PSMTs were informed about using technology in mathematics education and the TPACK framework. In the second phase, the PSMTs participated in 10 technology events, including an activity of preparing lesson plans through the TPACK Game. In the third phase, the PSMTs conducted micro-teaching practices by planning technology supported lessons. Kurt (2016), in the context of micro-teaching practices, investigated the effect of teaching statistics using virtual manipulates on the PSMTs’ TPACK development. At the beginning of the study, the TPACK framework was introduced to the PSTs and they played the TPACK Game. Following weeks, workshops and micro-teaching practices were conducted to give information to the PSMTs on the virtual manipulates used in statistics education. However, in these studies (Baran and Uygun, 2016; Koştur, 2018; Kurt, 2016) the effect of TPACK Game on PSMTs’ TPACK perception levels weren’t investigated.

In the literature it is observed that only two studies which investigated effect of TPACK Game on PSMTs' TPACK perception levels. Açıkgül (2017) investigated the effects of the TPACK Game activities on PSMTs' perception levels on their self-efficacy of the content knowledge (CK), pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). In the study, TPACK game activities consisted of two stages: choose technology, pedagogy, content cards from the bags and preparing lesson plans. Uygun (2013) examined the TPACK development of the graduate students who participated in a learning module that included TPACK Game activities. The study consisted of 10 master's students, including graduates of mathematics education.

Among the studies mentioned in previous paragraphs, there was no such study in which PSMTs planned, taught and evaluate their lessons via playing the TPACK Game within the scope of micro teaching practices. Therefore, it is important to investigate the effect of PSMTs' participation in the TPACK Game activities supported micro-teaching practices in which they prepare lessons by taking into account the benefits and limitations of the components they chose randomly from the content, pedagogy and technology bags during the TPACK Game, lecture these lessons to their peers, discuss and evaluate these lessons on the development of their TPACK self-efficacy perceptions. Thus, the results of this study are expected to contribute to the mathematics education literature about how teacher education programs should be planned and which methods should be used in order to provide the in the development of PSMTs' TPACK self-efficacy perceptions.

The purpose of this study is to investigate the effect of Technological Pedagogical Content Knowledge (TPACK) Game activities supported micro-teaching practices on middle school preservice mathematics teachers' TPACK self-efficacy perception levels. In accordance with this aim, answer was sought for the following question: Is there a statistically significant difference between the pre-test and post-test TPACK self-efficacy perception scores of middle school preservice mathematics teachers who participate in Technological Pedagogical Content Knowledge (TPACK) Game activities?

1.3. Conceptual Framework

In this study, the TPACK Game activities supported micro-teaching practices were designed within the TPACK framework and the PSMTs' self-efficacy perceptions were evaluated in terms of TPACK dimensions. The micro-teaching method and TPACK theoretical framework are explained in below.

1.3.1. Technological Pedagogical Content Knowledge. TPACK, which puts forward the necessary knowledge areas for the effective integration of technology into instruction, was first introduced by Koehler and Mishra (2005) and was published as a theoretical framework in 2006 (Mishra & Koehler, 2006). TPACK was theoretically structured on the Shulman's (1986) PCK framework (Koehler & Mishra, 2005, 2009; Koehler, Mishra, & Cain, 2013¸Valtonen et al., 2017) and included technology knowledge as a new component that is compatible with the content and pedagogical knowledge (Voogt & Mckenney, 2017). Hence, the core of the TPACK framework was based on content, pedagogy, and technology knowledge (Koehler et al., 2013). On the other hand, the TPACK framework emphasized the complex interaction of content, pedagogy and technology knowledge, and how teachers would practice this knowledge in their classrooms rather than treating these three knowledge areas being independent of each other (Willermark, 2018). Consequently, the TPACK theoretical framework addressed the intersections of the three main knowledge areas, resulting in a total of seven knowledge domains: content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK (Koehler & Mishra, 2005, 2009; Koehler et al., 2013; Mishra & Koehler, 2006).

In the TPACK framework, CK expresses teachers' knowledge about teaching and learning (Chen & Jang, 2014; Koehler & Mishra, 2009). PK is the teacher's deep knowledge of the processes, practices, or methods in teaching and learning (Harris et al., 2009; Koehler & Mishra, 2009). TK covers knowledge and skills related to various traditional, current, and emerging technologies (Chen & Jang, 2014). Moreover, in accordance with Shulman's (1986) conceptualization, PCK is considered as the practicable teaching knowledge in a specific content area (Harris et al., 2009). Furthermore, TCK refers to teachers' knowledge about which specific technologies are most relevant for subjects in their fields and to understand how content and technology affect each other (Koehler et al., 2013). In addition, TPK is a type of knowledge that requires understanding how technology supports pedagogical goals and integrating these technologies in pedagogical strategies (Koehler et al., 2007). Finally, TPACK is a new form of knowledge that emerges from the interactions between content, pedagogy, and technology knowledge and goes beyond these three "basic" components (Koehler et al., 2013). Therefore, it necessitates not only understanding content, pedagogy, and technology knowledge, but also interactions of these knowledge areas with each other (Koehler & Mishra, 2009).

1.3.2. Micro-teaching Method. Micro-teaching, which is an effective teaching method in teacher education programs, enables PSTs to develop and implement their teaching skills (Abdulwahed & Ismail, 2011; Benton-Kupper, 2001; Bhatta, 2013). By eliminating the complexity of a real teaching process, it provides presevice teachers with the opportunity to practice their teaching activities under controlled and simulated conditions (Mahmud & Rawshon, 2013). The purpose of the micro-teaching method is to guide PSTs to increase their competence by allowing them to practice their teaching in front of a small group (Ping, 2013).

Fernandez (2005) explained a micro-teaching method as a process in which PSTs teach their lessons in front of a reduced group of individuals (i.e., peers) and receive feedback from their peers and advisors about their performance. Moreover, Bhatta (2013) described a micro-teaching process as follows: The process starts with PSTs choosing a skill, and then continues with observing a model lesson, planning a lesson, teaching a sample lesson, reviewing the sample lesson, receiving feedback from peers and advisors, re-planning the lesson, re-teaching the lesson, and receiving feedback again. Subramaniam (2006) stated that the micro-teaching method has changed from a traditional model to a regulated model in time and noted that following the theory micro-teaching practices includes a phase of revision of the teaching experience rather than including re-teaching cycle. In this current study, the PSTs' micro-teaching performance was reviewed in terms of the PSTs' self-evaluations, peer and instructor evaluations, and the TPACK theoretical framework.

2. Methods

2.1. The Research Design

A single group pretest-posttest experimental design, was used in developing this study. In a single group pretest-posttest design, a single group is involved in the experimental process and assessments were conducted before and after the application (Fraenkel, Wallen, & Hyun, 2012).

2.2. Participants

The participants of the study consisted of 100 3rd year middle school PSMTs (76 female, 24 male) who were attending to a mathematics instruction course at a state university located in the east of Turkey. The course focused on preparing detailed teaching plans; organizing classroom settings, instruments and course materials; improving teaching skills; and the evaluation of the lessons taught. The content of the course was appropriate for conducting the present study. So, the purposive sampling method was used and the study conducted with PSMTs who attend the mathematics instruction course. Participants were informed about the aim and scope of the research and the study was conducted with voluntary PSMTs.

2.3. Process of Study

In this study, micro-teaching practices have been conducted following the TPACK theoretical framework. The micro-teaching practice process consisted of the following stages: designing a lesson, lecture using lesson plans, watching lesson videos, and evaluation and discussion. The implementation period of the study lasted 13 weeks. While the lessons were designed during the first four weeks of the course, in the following weeks, lecture using lesson plans, watching videos, and evaluation and discussion stages were administered. Within the scope of the TPACK Game activities, the PSMTs played four games, filled question forms, and designed lesson plans. At this stage, the PSMTs worked in groups of four people. The group members were determined on a voluntary basis. The PSTs played four TPACK games during 1st, 2nd, 3rd, and 4th weeks, respectively.

During the TPACK Game activities, first, each group chose cards from the three bags (i.e., content, pedagogy, and technology). The PSMTs will have the opportunity to serve as middle school mathematics teachers (Grade 5-8) after graduation. So, the cards, which were placed in content bag, were taken from middle school mathematics program of the Ministry of National Education (Ministry of National Education (MoNE), 2016). The content bag included 51 cards that had information about contents of the mathematics subjects taught Grade 5 through Grade 8 (e.g., Grade 5: operations with natural numbers; Grade 6: algebraic expressions; Grade 7: views of geometric objects from different directions; and Grade 8: equality and similarity). The pedagogy bag included 53 cards with information on the teaching model, methods, and techniques. The technology bag consisted of 27 cards with information on general technologies (e.g., drawing programs [paint, etc.]) social networks (e.g., Facebook, twitter, etc.), and technologies specific to mathematics (e.g., dynamic geometry software, computer algebra systems).

During TPACK Games 1, 2, and 3, the PSMTs had selected random cardS from two bags, one from each (TPACK Game 1: Content-Pedagogy, TPACK Game 2: Content-Technology, and TPACK Game 3: Pedagogy-Technology). To teach the content in a pedagogically effective way by using technology, in TPACK Games 1, 2, 3, each group had to think and discuss what should be the third component (Mishra, 2010; Richardson, 2010). On the other hand, in the TPACK Game 4, the PSMTs randomly selected one card from all three bags. The TPACK Game 4 was designed to allow groups to think and discuss on the lesson plan, which consisted of a combination of randomly selected content, pedagogy, and technology (Richardson, 2010).

In the TPACK Game activities, after the selection of the components from the bags, each group was asked to fill question forms that allowed them to think and discuss lessons that they would design using the selected components. In this study, the question forms were developed by using the questionnaires of Açıkgül (2017), Richardson (2010) and Uygun (2013) related to TPACK Game. The question form designed for TPACK Games 1, 2, and 3 included 21 items in which there were questions about features, facilities, and limitations of the randomly selected two components. In addition, there were questions about the third component, which was not selected from bags, such as the reasons for selecting this component, facilities and limitations of this component and the compatibility of this component with the two components. The question form designed for TPACK Game 4 included 19 items in which there were questions about features, facilities, limitations, and compatibility of three randomly selected components.

In each TPACK Game, the groups were given a week for conducting research, thinking, and discussing. During this week, the groups provided their written responses to the items in the question form and prepared lesson plans. For example, in the TPACK Game 1, which took place in the first week of the study, during the course, the groups selected random cards from content and pedagogy bags. Next, they determined the technology component in accordance with the selected content and pedagogical components. The groups then answered question form items and prepared a lesson plan by conducting research and discussions together in and out of classroom. In the second week, the documents of the pre-service teachers about TPACK Game 1 activity were gathered and the ideas of the groups were listened by the researcher and TPACK game 2 was started.

Between 5th and 13th weeks, the groups gave a lecture using lesson plans that they prepared. Since each group consisted of four PSMTs and each group prepared four lesson plans in TPACK Games, each PST taught one of these plans. Hence, all the PSTs participated in the study were given opportunity to have teaching experience. The lectures provided by the PSMTs were video recorded and those videos were watched in the classroom. Next, the lectures were evaluated by the PSMT who taught the lesson, the remaining group members, rest of the class, and researcher, respectively according to TPACK theoretical framework. Following the evaluation and discussions, the PSTs were asked to re-plan their lessons by correcting mistakes and completing missing information in those lessons. However, the PSTs prepared reports showing corrections that they made on their lesson plans and submitted it to the researcher. These reports were examined by the researcher within the TPACK theoretical framework and the PSTs were given feedbacks on their lesson plans.

2.4. The Data Collection Tool

In this study, TPACK survey developed by Şahin (2011) was used in order to determine the PSTs' TPACK perceptions. The survey contained seven dimensions (TK, PK, CK, TPK, TCK, PCK, and TPACK). The survey included a total of 47 items: six items in CK, six items in PK, fifteen items in TK, four items in TPK, four items in TCK, seven items in PCK, and five items in TPACK. The items were written as likert-type and included five categories: (1) "not at all," (2) "little," (3) "moderate," (4) "quite," and (5) "complete." By collecting the responses of 348 PSTs, Şahin (2011) measured the validity and reliability of the survey. To measure the construct validity, he conducted an independent exploratory factor analyzes for each dimension. According to the factor analysis results, in the dimensions, the factor loadings of the items were ranged between 0.599 and 0.903. Cronbach's alpha values (α_{TB}=0.93, α_{PB}=0.90, α_{AB}=0.86, α_{TPB}= 0.88, α_{TAB}=0.88, α_{PAB}=0.92, α_{TPAB}=0.92), which are calculated as internal consistency coefficients of the dimensions, showed that the measurements were reliable (Şahin, 2011).

A second order confirmatory factor analysis was conducted to examine whether the seven-dimensional structure of the survey has been verified for the participants of this study. The confirmatory factor analysis was conducted over the pre-test data. As a result of the modifications made on between Item 8 and Item 9 in the TK dimension and between Item 16 and Item 17 in the PK dimension, χ^2/df = 1.57, *p* =.00, RMSEA = 0.07, IFI = .95, CFI = 0.95, NNFI = 0.94, values were obtained. In this context, it can be said that TPACK scale which has 7 dimensions as a result of second order confirmatory factor analysis was valid for the participants of the study (Brown, 2006; Hair, Black, Babin, Anderson, & Tatham, 2006; Tabachnick & Fidell, 2007). In addition, the Cronbach's alpha values (α_{TK}=0.91, α_{PK}=0.82, α_{CK}=0.83, α_{TPK}= 0.86, α_{TCK}=0.85, α_{PCK}=0.91, α_{TPACK}=0.87, $\alpha_{Total=}$0.96) indicated that the survey was a reliable source for examining the PSTs' TPACK perceptions (Kline, 2011).

2.5. Internal and External Validity

Internal validity refers to the degree to which the change in the dependent variable originates from experimental manipulation without depending on some external variables (Lodico, Spaulding, & Voegtle, 2006). Unfortunately, the single-group pre-test and post-test design, which is one of the poor experimental designs, is reported to be unprotected against many factors threatening its internal validity (Fraenkel et al., 2012). Therefore, in this study, various precautions were taken to ensure the internal validity.

To eliminate threats that may arise from the place and researcher, the data collection tools were applied by the same researcher in the same place to the PSMTs who were provided with necessary explanations before those applications. Since the data were collected and evaluated by the objective methods, there were no bias from the researcher's side involved in those processes. Moreover, the threats that may arise from the data collection tools were eliminated by applying the same data collection tools in the pre-test and post-test. In addition, there were 13 weeks between the pre-test and post-test, so the test effect that included the threat of higher performance of PSTs in the second test because of being familiar to the test items was tried to get under control.

Statistical regression effect is also considered traits that may threaten internal validity. Fraenkel et al. (2012: 175) suggested that the regression effect may be present when there is a very low or high change in the scores of a group compared to their pre-application scores. Therefore, it was important to investigate whether the regression effect posed a threat to the internal validity of this current study. The regression effect was examined by determining statistical differences between the PSTs' pre-test and post-test scores. For this purpose, the upper 27% and the lower 27% groups were determined by ordering the PSMTs' mean scores in the pre-test. A One-Way Repeated Measures ANOVA test showed significant differences in the self-efficacy scores of both the upper 27% and lower 27% groups in favor of the post-test [27% upper group: F (1,26) = 32.422, *p* = .00, *r* = .75; 27% lower group: F(1,26) = 223.794, *p* = .00, *r* = .95]. Although the calculated *r* effect size values were high for both the lower and upper groups. Thus, the regression effect did not pose threats for the participants of this study.

In order to understand whether the study was implemented as planned, the video recordings taken during the lessons and the PSMTs' responses to the questionnaire items, which were about their views on the study process. In the questionnaire included 16 items in which five of them were about to designing lesson plans using the TPACK Game activities, five were about the lecture using lesson plans, one was about watching video recordings, and five were about evaluation and discussion stages. For instance, regarding the TPACK Game activities, the questionnaire included items such as "During the TPACK Game, the cards were selected randomly from the bags" and "The items in the question forms were answered by the cooperation and discussion of all the group members." Regarding lecture using lesson plans, the questionnaire included items such as "During the course, the lessons planned in the TPACK Games were taught". In terms of monitoring video recordings, the questionnaire included items such as "The video recordings taken during the micro-teaching practices was monitored by all the PSMTs in the class". Finally, regarding the evaluation and discussion stage, the questionnaire included items such as "During the discussion, the facilities and limitations of the technology used by the PSMT who taught the lesson were evaluated". Scores in the questionnaire were determined as Yes = 3 points, Insufficient = 2 points, and No = 1 point. Each PST individually responded to the questionnaire items. Calculating the mean of the PSMTs' scores for each item, the scores between 1 and 1.66 were regarded as "No", the scores between 1.67 and 2.33 were regarded as "Insufficient", and the scores between 2.34 and 3 were regarded as "Yes." The analysis showed that the mean of each item ranged between 2.87-2.99 and was included in the "Yes" category. Based on this finding, it can be concluded that the TPACK Game activities supported micro-teaching practices were implemented as planned.

External validity is the degree to which results can be generalized to a wider population, cases, and situations (Cohen, Manion, & Morrison, 2007). This study was carried out with the PSTs by whom the researcher could conduct the study as planned. Therefore, the results can be generalized only onto PSTs with similar characteristics of the participants of this study. However, in terms of obtaining findings that are suitable with the purposes, conducting this study with the PSTs who had appropriate characteristics increased the generalizability of these findings.

2.6. Data Analysis

To determine the PSTs' level of TPACK self-efficacy perceptions, descriptive statistics (arithmetic mean, standard deviation) were calculated before and after the application. In the interpretation of mean scores, the range of scores 1.00-1.80 "not at all", 1.81-2.60 "little", 2.61-3.40 "moderate", 3.41-4.20 "quite", and 4.21-5.00 "complete" were used. On the other hand, a One-Way Repeated Measures ANOVA test was conducted to determine the effect of the TPACK Game activities supported micro-teaching practices on the PSTs' TPACK levels. In this study, One-Way Repeated Measures ANOVA test was used instead of Paired Sample t test to calculate the power of the test.

Before the application of the One-Way Repeated Measures ANOVA test, pre-test, post-test, and difference scores (post-test scores - pre-test scores) were analyzed for normality. The results showed that the skewness and kurtosis coefficients of the scores were between -1 and +1, and histogram and Q-Q plots indicated that the scores distributed normally. Within the scope of this study, it has not been necessary to test the assumption of the sphericity since the purpose was to test if there was a significant difference between two dependent variables (pre-test scores and post-test scores). Since the sphericity assumption is not inspected, multivariate test results which are not based on sphericity are examined (Pallant, 2011). In the study, applying a Bonferroni correction (i.e., $\alpha = 0.05/8$), α value was calculated as $\alpha = .006$ (Abdi, 2010). The significance of the study in practice was examined by calculating the effect size values of r. The r values were interpreted as, $r = .10$ small effect size, $r = .30$ medium effect size, and $r = .50$ large effect size (Field, 2009).

2.7. Ethical Issues

At the beginning of the study, the scope of the research was explained to the PSTs and they were provided with a study guide. The PSTs participated in the study in a voluntarily basis and signed a

Volunteer Participant Form. Throughout the application process, the researcher did not interfere in the choices of the PSTs. The information collected from the PSTs was kept confidential. Moreover, while analyzing the data, the PSTs were not referred with their names but referred as PST1, PST2, etc. The results obtained from the study were not used to classify or order the PSTs, and the results were shared in detail with the interested PSTs.

In this study, it was important to have a control group, which should had a regular instruction, to determine the increase in the PSTs' TPACK self-efficacy perception levels caused by the TPACK Game activities supported micro-teaching practices. However, it was considered that all the PSTs who were attending to the course should take the advantage of the possible benefits of the experimental design. In the control group, to prevent any deprivation, the TPACK Game activities supported micro-teaching practices were planned to conduct after the application process of the study. Nevertheless, it was anticipated that due to an overlap with the summer holiday, it was not possible to perform 13-week long micro-teaching practices in the control group. Therefore, it was ensured that all the PSTs who were attending to the course participated in the experimental process. Thus, a single group pre-test and post-test experimental design was used in the development of this study.

3. Results

The descriptive statistics of the PSMTs' pre-test and post-test perception scores are presented in Table 1.

Table 1. *The descriptive statistics of the PSMTs' TPACK self-efficacy perception levels as obtained from the pre-test and post-test*

Dimension	Test	$\overline{X}$	sd	Level
TK	Pre-test	2.80	.64	moderate
	Post-test	3.67	.52	quite
PK	Pre-test	2.82	.64	moderate
	Post-test	3.80	.56	quite
CK	Pre-test	2.62	.64	moderate
	Post-test	3.55	.62	quite
TPK	Pre-test	2.75	.73	moderate
	Post-test	3.90	.60	quite
TCK	Pre-test	2.41	.74	little
	Post-test	3.83	.60	quite
PCK	Pre-test	2.91	.75	moderate
	Post-test	3.90	.55	quite
TPACK	Pre-test	2.60	.72	little
	Post-test	3.89	.60	quite
Total	Pre-test	2.74	.53	moderate
	Post-test	3.76	.46	quite

The PSTs' pre-test mean scores for TK ($\overline{X}$ = 2.80), PK ($\overline{X}$ = 2.82), CK ($\overline{X}$ = 2.62), TPK ($\overline{X}$ = 2.75), and PCK ($\overline{X}$ = 2.91) were determined to be in the "moderate" category, and TCK ($\overline{X}$ = 2.41) and TPACK ($\overline{X}$ = 2.60) pre-test mean scores were determined to be in the "little" category. The PSTs' post-test scores were found to be in the "quite" category for all knowledge dimensions (TK: $\overline{X}$ =3.67; PK: $\overline{X}$ =3.80; CK: $\overline{X}$ = 3.55; TPK: $\overline{X}$ = 3.90; TCK: $\overline{X}$ = 3.83; PCK: $\overline{X}$ = 3.90; and TPACK: $\overline{X}$ = 3.89). Furthermore, the PSMTs' total TPACK average was in the "moderate" category ($\overline{X}$ = 2.74) for the pre-test, and it was in the "quite" category ($\overline{X}$ = 3.76) for the post-test.

The results of the One-Way Repeated Measures ANOVA test, which was conducted to determine the effect of the TPACK Game activities supported micro-teaching practices on the PSTs' TPACK self-efficacy perception levels, are presented in Table 2.

Table 2. *One-Way repeated measures anova test results regarding the difference between PSMTs' TPACK self-efficacy perception levels in the pre-and post-test*

Group	Source	Sum of Sqıares	df	Mean Square	F	p	Power	r
TK	Time	38.637	1	38.637	172.035	.000*	.999	.80
	Error	22.234	99	.225				
PK	Time	48.221	1	48.221	168.029	.000*	.999	.79
	Error	28.411	99	.287				
CK	Time	43.153	1	43.153	138.490	.000*	.999	.76
	Error	30.848	99	.312				
TPK	Time	65.265	1	65.265	139.467	.000*	.999	.77
	Error	46.328	99	.468				
TCK	Time	100.265	1	100.265	226.182	.000*	.999	.83
	Error	43.886	99	.443				
PCK	Time	49.239	1	49.239	145.533	.000*	.999	.77
	Error	33.495	99	.338				
TPACK	Time	82.934	1	82.934	175.206	.000*	.999	.80
	Error	46.862	99	.473				
Total	Time	52.744	1	52.744	254.129	.000*	.999	.85
	Error	20.547	99	.208				

p<,006

Table 2 showed a statistically significant difference between the PSMTs' pre-test and post-test self-efficacy perception scores [TK: F(1,99) = 172.035, p < .006; PK: F(1,99) = 168.029, p < .006; CK: F(1,99) = 138.490, p < .006; TPK: F(1,99) = 139.467, p < .006; TCK: F(1,99) = 226.18, p < .006; PCK: F(1,99) = 145.533, p < .006; and TPACK: F(1,99) = 175.206, p < .006]. Hence, the calculated r effect size value suggested that the TPACK Game activities supported micro-teaching practices had large effects on the PSMTs' TPACK self-efficacy perception scores (r_{TK} = .80; r_{PK} = .79; r_{CK} = .76; r_{TPK} = .77; r_{TCK} = .83; r_{PCK} = .77; and r_{TPACK} = .80). In addition, there were statistically significant differences between the PSMTs' total TPACK self-efficacy perception scores for the pre-test and post-test [F(1,99) = 254.129, p < .006]. The r effect size value suggests that the TPACK Game activities supported micro-teaching practices had a large effect on the PSMTs' TPACK self-efficacy perception scores [$r_{totalTPACK}$ = .85].

4. Discussion and Conclusion

The present study purposed to investigate the effect of Technological Pedagogical Content Knowledge (TPACK) Game activities supported micro-teaching practices on middle school preservice mathematics teachers' TPACK self-efficacy perception levels. Before the application of the study, the PSMTs' perception scores for the TCK and TPACK dimensions were determined as low; TK, PK, CK, TPK, PCK dimensions were determined as moderate. After the application of this study, the PSTs' self-efficacy perception scores that they obtained from each dimension and from overall survey were all in a good level. There were statistically significant differences between the pre-test and post-test TK, PK, CK, TPK, TCK, PCK, TPACK ans total self-efficacy perception scores of middle school preservice mathematics teachers who participate in Technological Pedagogical Content Knowledge (TPACK) Game activities. During the TPACK Game activities, the PSMTs collaborated on the lesson plans that they prepared using randomly selected components, and their discussions provided the opportunity to understand the relationships among content, pedagogy, and technology knowledge. This process is thought to be effective in the development of PSMTs' TPACK self-efficacy perception. Similarly, Açıkgül (2017) who investigated TPACK Game activities on the PSMTs' TPACK self-efficacy perception levels determined that there were statistically significant differences between the PSTs' pre-test and post-test self-efficacy perception scores for CK, PCK, TCK, and TPACK dimensions on subject of polygons. In addition, Uygun (2013) found that the design-based learning module, which included TPACK game activities, increased graduate students' TPACK perception scores. As a matter of fact, Uygun (2013) stated that when creating a lesson plan with randomly selected content, pedagogy, and technology components, the TPACK Game provides the opportunity to see how these components can be used together, and what are their limitations, possible dilemmas, and relationships among these components. Similarly, in the Baran and Uygun (2016) study, students reported that the TPACK Game contributed to their understanding of the TPACK framework components and relationships among them and was effective on their TPACK development.

The results of this current study support the results obtained in many studies in which PSMTs designed technology-supported courses, taught these courses to their peers, and made evaluations. For example, Agyei and Keengwe (2014) found significant differences between preservice teachers' pre-test and post-test scores for all dimensions of the TPACK survey. Çetin (2017) determined that PSMTs' scores, who participated in the TPACK-based lesson plan development and micro-teaching practices, increased significantly in overall and in all dimensions of the TPACK survey. Similarly, Atasoy, Uzun, and Aygün (2015) examined the effect of a dynamic mathematics software supported learning environment on the development of PSMTs' TPACK self-efficacy perception levels. They found statistically significant differences between the PSTs' pre-test and post-test scores in overall and in all dimensions. Açıkgül (2017) found that micro-teaching practices on subject of polygons improved PSMTs' TPACK self-efficacy perceptions. Furthermore, Meng, Sam, Yew, and Lian (2014) investigated the effect of the lesson study method, in which they used Geometer's Sketchpad software in teaching, on PSTs' learning, and they reported a significant increase in the PSMTs' total TPACK scores.

On the contrary to the previous paragraph, the results of this current study do not correspond completely with results obtained in some studies. For instance, Kafyulilo et al. (2015) only reported significant increases in PSTs' TK, TCK, and TPACK perception scores but observed insignificant increases in their PK, CK, TPK, and PCK perception scores. Similarly, Durdu and Dag (2017) determined that PSTs' knowledge development in the TK, TCK, TPK, and TPACK dimensions was significant; however, there were no significant differences between their pre-test and post-test scores for the CK, PK, and PCK dimensions. In addition, Mudzimiri (2012) observed increment in three PSMTs' TPACK self-assessment scores and a decrement in one PST's TPACK self-assessment score.

The *r* effect size values calculated in this study indicated that there was a large impact on the PSMTs' TPACK perception scores in all dimensions and across the survey. At the same time, these effect size values showed that the maximum effect was in the TCK dimension, followed by the TPACK = TK, PK, PCK = TPK, and CK dimensions, respectively. When the average of the PSTs' pre-test and post-test scores were examined, the maximum increase was in the TCK dimension, followed by the TPACK, TPK, PCK, PK, CK, and TK dimensions. Similar to these results, Durdu and Dag (2017) observed that the difference between PSMTs' pre-application and post-application scores was most significant in terms of the TCK dimension followed by the TPACK dimension. Likewise, Çetin (2017) determined that the application process has more effect on the TCK and TPACK scores. However, Kafyulilo et al. (2015) reported that the most increment in the PSTs' perception scores was in the TPACK=TPK dimensions followed by the TCK, TK, PCK, and CK dimensions, respectively. Moreover, they have determined a decrement in the PSTs' PK perception scores in the post-test.

In the current study, the biggest difference between the PSMTs' mean scores and the biggest effect was in the TCK dimension. This finding suggests that the PSMTs can integrate their content knowledge with their content-specific technology knowledge in the application process and consequently increase their perceptions about TCK competences (Çetin, 2017). The TPACK dimension following the TCK dimension showed that the PSMTs had been developing their TPACK self-efficacy perceptions to integrate technology, pedagogy, and content knowledge during the application process. Furthermore, the high effect on the TK scores can be explained by the fact that during their lectures, the PSTs examined features, advantages, and limitations of the technologies that they use in general and in teaching mathematics. Thus, the application process contributed more to the PSMTs' TPACK self-efficacy perception levels in dimensions with technology knowledge.

In conclusion, this study showed that the participation of the PSMTs in the TPACK Game activities supported micro-teaching practices is a good way to develop their TPACK self-efficacy perceptions. Crompton (2015) stated that mathematics teachers may have to overcome a number of negative beliefs about the integration of technology into mathematics. On the other hand, Huzzie-Brown (2018) pointed out that self-efficacy perception is a major determinant of whether a teacher can successfully integrate technology into his/her teaching. Similarly, Lai and Lin (2018) stated that teachers with high self-efficacy perceptions use technology in more challenging tasks. Based on these explanations, this study has the potential to reduce PSMTs' negative perceptions on the use of technology in mathematics classrooms, to successfully integrate technology into their lessons, and to enable them to use technology in challenging tasks. In addition, the factors affecting PSTs' TPACK also affect their TPACK self-efficacy beliefs (Yerdelen-Damar et al., 2017). In this study, the application process had a significant effect on the PSMTs' TPACK self-efficacy. Thus, this significant effect indicates that the process also had positive effects on their TPACK competencies.

5. Limitations and Future Directions

Based on the results, it is recommended PSMTs to participate in the TPACK Game activities supported micro-teaching practices during their education for the development of TPACK self-efficacy perception levels. There are also various limitations of this study. In this study, the effects of the TPACK Game activities supported micro-teaching practices on the PSMTs' TPACK competence (knowledge, skills, and performance) levels were not investigated, and so future studies should investigate this topic. On the other hand, conducting this study with a single study group limits the generalizability of the findings. In order to increase the generalizability of the findings, it is recommended to examine the effect of TPACK Game activities supported micro-teaching practices on the TPACK self-efficacy perception levels of PSMTs with different characteristics. Furthermore, all PSTs who attended to the mathematics instruction course were included in the experimental process to ensure that they benefit from the possible advantages of the micro-teaching practices. Hence, a control group was not formed, and so the study was conducted with a single group. This condition prevented the determination of whether TPACK Game activities supported micro-teaching practices have a different effect other than usual teaching of the course on the PSMTs' TPACK self-efficacy perception levels. In order to overcome these limitations, it is recommended future studies to conduct true experimental designs with control group included. However, in order for PSMTs in the control group to experience possible benefits of the design, it is necessary that these PSMTs should participate in the TPACK Game activities supported micro-teaching practices after the application period.

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The Effect of Technological Pedagogical Content Knowledge Game Activities Supported Micro-Teaching Practices on Preservice Mathematics Teachers' Self-Efficacy Perception Levels

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