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[1]TPACK Competency Perceptions of Preservice Mathematics Teachers and Their Views on Use of Technology in Education

Matematik Öğretmen Adaylarının TPACK Yeterlilik Düzeyleri Algıları ve Eğitimde Teknoloji kullanımına Yönelik Görüşleri

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Abstract: The purpose of this study was to investigate preservice mathematics teachers' competency perceptions of technological pedagogical and content knowledge (TPACK) and their thoughts on the use of technology in education. To that end, the study utilized a mixed design, combining quantitative and qualitative data collection tools. The participants were 65 second-year students studying middle school mathematics teaching at a public university. Data for the quantitative part of the research was collected using the Technopedagogical Education Competency (TPACK-deep) Scale, while semi-structured interview questions were utilized to collect data for the qualitative part. As a result of the analysis, it was concluded that the preservice teachers had advanced TPACK competency perceptions and had rather positive views on the use of technology in education. The preservice teachers' positive views on the use of technology were associated with their high level of TPACK competency perceptions. While the preservice teachers stated that integrating technology into education would bring advantages such as providing communication between teacher and student, being practical, enriching the course content, and being interesting for students, they also emphasized that this situation would increase the responsibilities of teachers.

Keywords: Mathematics education, preservice mathematics teachers, technological pedagogical content knowledge, TPACK competency

Öz: Bu çalışmanın amacı, matematik öğretmen adaylarının teknolojik pedagojik içerik bilgilerine (TPİB) yönelik yeterlik algılarını ve eğitimde teknoloji kullanımı konusundaki görüşlerini incelemektir. Bu amaçla bu çalışmada nicel ve nitel veri toplama araçlarının birlikte kullanıldığı karma desen benimsenmiştir. Çalışmanın katılımcılarını bir devlet üniversitesinde öğrenim görmekte olan ikinci sınıf 65 ortaokul matematik öğretmen adayı oluşturmaktadır. Araştırmanın nicel boyutu için veriler Teknopedagojik Eğitim Yeterlik (TPACK-deep) Ölçeği kullanılarak ve nitel boyutu için yarı yapılandırılmış görüşme soruları sorularak toplanmıştır. Analizler sonucunda öğretmen adaylarının TPACK yeterlik algılarının ileri düzeyde olduğu ve eğitimde teknoloji kullanımına yönelik olumlu görüşlerinin olduğu sonucuna ulaşılmıştır. Öğretmen adaylarının teknolojinin eğitimde kullanımına ilişkin olumlu görüşleri, teknolojik pedagojik içerik bilgilerine (TPİB) yönelik yeterlik algılarının yüksek olması ile ilişkilendirilmiştir. Öğretmen adayları eğitime teknolojiyi entegre etmenin öğretmen ve öğrenci arasındaki iletişimi sağlaması, pratik olması, öğretmenlerin ders içeriğini zenginleştirmesini sağlaması ve öğrenciler için ilgi çekici olması gibi avantajlar taşıdığını belirtirken bu durumun aynı zamanda öğretmenlerin sorumluluklarını artıracağını da vurgulamışlardır.

Anahtar Kelimeler: Matematik eğitimi, matematik öğretmen adayları, teknolojik pedagojik içerik bilgisi, TPİB yeterliği

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Introduction

Technology has recently been through some important changes and expanded its place in our lives. The ever-advancing technology has played a critical role in directing education and determining the educational tendency (Banaszewski, 2005). It has been claimed that courses integrated with technology would improve students' attention and motivation and it is thought that it would enhance productivity in educational-instructional activities (Şen, 2001; Uslupehlivan et al., 2017). Several models and approaches have accordingly been put into practice to achieve technological integration of education. These methods and approaches are mostly centered around teachers.

Teachers are the main elements that bring meaning and spirit to technological tools and make them functional, effective, and efficient through their roles of managing new information technologies and providing a connection between students and information technologies (Aktepe, 2011). Thus, teachers using technology in education are the main factors that will achieve the integration of technology into education. The quality and quantity of preservice teachers' technological experiences are important factors that affect their adoption of technology (Agyei & Voogt, 2011). University courses that allow teachers to have preservice experience and focus on the improvement of their technological knowledge and skills have been included in teacher training curricula (Polly et al.,2013). Such courses have aimed to ensure that preservice teachers can use technology in their instructions in the future (Tondeur et al., 2013). Koehler and Mishra (2009) emphasize that one should focus on not only how to use technology in education but also on how technology is associated with pedagogical and content knowledge as shown by the concept of Technological Pedagogical Content Knowledge (TPACK).

TPACK Model

TPACK model was constituted by the integration of technology and full learning (Mishra & Koehler, 2006). In the literature, TPACK is defined as the knowledge required for

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associating pedagogical knowledge with technological knowledge in the instruction of a given content (Koehler & Mishra, 2005; Schmidt et al. 2009). The TPACK model addresses knowledge to be possessed by teachers in the integration of technology into education in three disciplines which are pedagogy, technology, and content knowledge (Yurdakul, 2011). Professional knowledge of teaching, which is described as pedagogical content knowledge by Shulman in 1986, underlies this model (Koehler & Mishra, 2006). Later, the TPACK model was finalized with the addition of technological knowledge and content knowledge to pedagogical content knowledge. Other components of the model include the overlap and combination of these three knowledge types (Koehler & Mishra, 2005, 2008, 2009; Mishra & Koehler, 2006). Figure 1 shows the structure of the TPACK model.

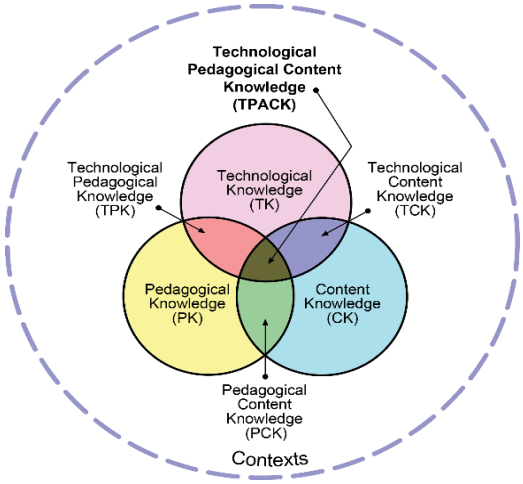

Figure 1. TPACK model

Knowledge types in the TPACK model are described as presented in Table 1 (Chai et al.; Mishra & Koehler, 2005).

Table 1. Descriptions of knowledge types in the TPACK model

Technological Knowledge (TK)	Knowledge of features, capacities, and applications of technology
Pedagogical Knowledge (PK)	Knowledge of teaching and learning, and respective methods, applications, and processes
Content Knowledge (CK)	Subject-matter knowledge
Pedagogical Content Knowledge (PCK)	Knowledge regarding how to teach the subject matter
Technological Content Knowledge (PCK)	Knowledge regarding how to represent the content in different ways using technology
Technological Pedagogical Knowledge (TPK)	Knowledge of the presence and features of various technologies in allowing for instructional approaches
Technological Pedagogical Content Knowledge (TPACK)	Knowledge of using various technologies for teaching and representing a given subject matter

The Use of Technology in Mathematics Education

Mathematics education aims to help students acquire important skills such as prediction, mental calculation, representing mathematical information in various ways, and problem-solving (Baykul, 2004). However, passive roles taken up by students in mathematics courses cause them to have difficulty in making sense of mathematical information and asking questions during the course (Kır, 2011). A method that ensures that students become active in mathematics courses is the utilization of technology. The use of technological tools in mathematics education plays an important role in increasing students' attention and making it easier for them to understand mathematics (Alakoç, 2003). The utilization of technology in mathematics education enables students to learn conceptual and procedural knowledge and insert it into their minds more easily (Tatar et al., 2014). This represents an advantage for students. There are several studies concluding that the utilization of technology in mathematics education has a positive effect on student achievement (Benning et al., 2018; Dikovic, 2009; Kaleli Yılmaz et al., 2010; Kebritchi et al., 2010; Serin & Öz, 2017).

Mathematics education is an appropriate field that allows for using technological sources (Öksüz & Ak, 2009). Yet, the way in which one benefits from technological sources is important both for pedagogical and content knowledge. Hence, the competencies of mathematics teachers and preservice mathematics teachers in the integration of technology into mathematics education play a key role in the effective use of technology in this field. For effective teaching in mathematics education, it is quite important to build a dynamic connection between technology, pedagogy, and content knowledge (Doukakis, et al., 2010). The factor that facilitates this dynamic connection is the concept of TPACK. High TPACK competencies of mathematics teachers bring about the effective use of technology in mathematics education and teaching. Teachers with technological pedagogical content knowledge are competent in using technological instruments. Moreover, they become aware of the effects of using technological tools and demonstrations on how students understand the subject (Graham et al. 2009). As argued by Grandgenett (2008), a mathematics teacher with good technological pedagogical content knowledge possesses the following attributes:

1- S/he can use new technological tools effectively and is open to using them while teaching.
2- S/he does not stray away from the focus of the topic in a technologically integrated course and is methodical.
3- S/he can explain the importance of using technology to students.
4- S/he can use technology in classroom management during the process of mathematics education.
5- S/he has a relaxed and positive attitude toward technological changes.

In the literature, there are many studies that have examined the use of technology in mathematics education and TPACK. Richardson (2009) carried out a project involving activities that would help mathematics students combine their algebraic content knowledge with technology. It was aimed with that project to improve mathematics teachers' technological pedagogical content knowledge. It was concluded that the project was effective in expanding the technological

pedagogical content knowledge of the teachers. It was stated by the researcher that similar projects or activities were needed for improving teachers' technological pedagogical content knowledge. In a study on technological pedagogical content knowledge of preservice mathematics teachers, Akkoç (2011) examined how teachers could use technology to eliminate problems that students encountered during the course. As concluded in the study, an activity performed on a given mathematical subject was effective in improving preservice teachers' technological pedagogical content knowledge. Harris and Hofer (2009) conducted a study addressing the improvement of teachers' technological pedagogical content knowledge. They focused on the types of learning activities in their study. After having examined technology-assisted learning activities of teachers in a program, Harris and Hofer (2009) observed that they chose activities suitable for the given subject more conveniently and gained more experience in how to include technology. Similarly, there are a number of research that focus on the development of TPACK through professional development programs and reveal the positive effects of these programs on TPACK (e.g. Doering et al. 2009; Graham et al., 2009; Jimoyiannis, 2010; Richardson, 2009; Shin et al., 2009). While these research studies reflect the attempts for understanding how to develop TPACK, there are other studies investigating various issues such as measurement of TPACK (e.g. Archambault & Crippen, 2009; Burgoyne et al., 2010), TPACK of teachers and preservice teachers (e.g. Chai, Koh, & Tsai, 2010; Chuang & Ho, 2010; Yurdakul, 2011; Sahin, 2011; Schmidt et al., 2009), and teachers' competencies in integrating technology into instruction (e.g. Lin, et al., 2013; Usluel et al., 2007). Although there has been an increasing interest in TPACK recently, more research is needed to quantify this knowledge and establish the factors to which it may be linked in order to completely comprehend TPACK (Archambault & Crippen, 2009; Cox & Graham, 2009).

Significance of The Study

In this study, TPACK was taken into account because it has been used as an essential model of technology integration in education in a number of recent studies (e.g. Angeli & Valanides, 2009; Cox & Graham, 2009; Niess, 2005; So & Kim, 2009). It is anticipated that investigating what preservice teachers think of using technology in education will reveal their attitudes in their future professional lives. Indeed, preservice teachers' perspectives regarding technology are determinant in how they benefit from technology in education more efficiently and productively (Çelik & Kahyaoğlu, 2007). Moreover, the success of preservice teachers in their future instructional activities depends on their adoption of technology's role in education (Erdemir et al. 2009). Niess (2006) emphasized the important role of improving TPACK in teachers' beliefs and views with respect to technology and mathematics teaching. Therefore, the preservice mathematics teachers were asked for their views on the use of technology in education to compare the views with their TPACK competency perceptions. Accordingly, this study is considered important for exploring the effect of TPACK competency perceptions on their views and ideas of technology and teaching. In addition, preservice teachers' views and ideas about utilizing technology in education and the interplay between their TPACK competency perceptions and views will shed light on the topics of teacher training and technological integration in mathematics education.

This study aimed to investigate preservice mathematics teachers' competency perception levels of technological pedagogical content knowledge and their views on the use of technology in education. To this end, the following questions were answered in an attempt:

1. What are preservice mathematics teachers' levels of technological pedagogical content knowledge (TPACK) competency perception?
2. What are preservice mathematics teachers' views on the use of technology in education?

Method

Research Design

This study utilized the "fully mixed concurrent equal status design" in which the qualitative and quantitative approaches are given equal weight and are mixed in one or more research components at the same time (Johnson & Onwuegbuzie, 2004). The quantitative and qualitative data are collected almost simultaneously, analyzed separately, and interpreted collectively in the end. The quantitative part of this study aimed to determine the preservice teachers were competency perception levels of technological pedagogical content knowledge. In the qualitative part, their views on the use of technology in education were investigated.

Study Group

The participants consisted of 65 second-year students studying middle school mathematics teaching at a public university. In the first two years of the undergraduate program, preservice teachers take courses such as information technologies, computer-assisted mathematics education, algorithm and programming, and approaches to mathematics learning and teaching. These courses played a role in the conduct of this study with preservice teachers at the second-year level. This grade level was considered to be appropriate in terms of determining TPACK competency perceptions since students' foundation for technological and pedagogical content knowledge was established. Participants were chosen using a suitable sampling method from volunteer preservice teachers. In the research, the scale was applied to 65 (48 females, 17 males) preservice teachers, and 13 of them (10 female, 3 male) were interviewed at the end of the spring semester, namely, after the completion of the courses mentioned.

Data Collection

For the quantitative part of the research, the data was collected with the Technological Pedagogical Education Competency (TPACK-deep) Scale (Kabakçı Yurdakul et al., 2012). The scale consists of 33 items. The lowest possible score on the scale is 33 while the highest possible score is 165. Answers to the 5-point Likert scale items include "completely competent", "fairly competent", "somewhat competent", "slightly competent", and "incompetent". The scale consists of four subtests, which are "design", "exertion", "ethics", and "proficiency". The design factor includes the design competency for enriching the teaching process via technological and pedagogical knowledge. The exertion factor refers to the competency of using technology to conduct

Table 2. Assessment criteria for scores obtained on the TPACK scale

Assessment Range		Assessment Criterion
Total Score	**Mean Score**	
X<95	1.00-2.33	Low
95≤X≤130	2.34-3.67	Moderate
X>130	3.68-5.00	Advanced

the teaching process and assessing and evaluating the effectiveness of the process. The ethics factor is about the competency of conducting the teaching process in accordance with ethical issues. The proficiency factor refers to competencies such as offering solutions to problems regarding the teaching process and technology, choosing the right solution, specializing in the teaching profession through the solution to problems, and combining technology with content and pedagogy. The scale mainly provides to determine how preservice teachers evaluate themselves in terms of TPACK competencies.

The validity-reliability studies conducted by the developers of the scale (Kabakçı Yurdakul et al. 2012) gave a Cronbach's alpha reliability coefficient of 0.95 for the scale. Cronbach's alphas for each factor vary between 0.86 and 0.92. The test-retest reliability coefficient was calculated as 0.80 with Pearson's Product-Moment Correlation Coefficient. The validity-reliability studies show that it showed is a highly valid and reliable scale for measuring the respective attribute. For this study, Cronbach's alpha of the scale was also calculated as 0.95. Besides, Cronbach's alphas were calculated as 0.90 for the design factor, 0.90 for the exertion factor, 0.86 for the ethics factor, and 0.79 for the proficiency factor in this study. As determined by Kabakçı Yurdakul et al. (2012), the score ranges in Table 2 were used for assessing the TPACK scale scores.

The data were collected in semi-structured interviews for the qualitative part of the research. The semi-structured interview form was composed of 10 open-ended questions. Three subject-matter experts reviewed the questions. The required corrections were made to the questions upon their feedback. In the interviews, the preservice teachers were asked to a) share their general views on the use of technology in educational activities, (b) evaluate the use of technology in educational activities in terms of teachers, students, and mathematics education, and (c) tell about their views on using technology when they would become a teacher. Each interview took about 20 minutes. This research was conducted with the permission of the İstanbul University-Cerrahpaşa ethics committee with the decision no. 2020/304 dated 05/01/2021.

Data Analysis

In the quantitative part of the study, SPSS 22.0 statistical software package was used for the data analysis. Descriptive statistical calculations were performed on the scores obtained by the preservice teachers from the TPACK-deep scale and its subscales, and their TPACK competency perception levels were determined based on the criteria set by Kabakçı Yurdakul et al. (2012). The qualitative data were subjected to content analysis. The semi-structured interviews were analyzed with a three-stage qualitative data analysis procedure consisting of "data reduction", "data representation" and "revealing and verification of results" (Miles & Huberman, 1994). The raw data were retrieved considering the aim of the research in the data reduction stage, and then the categories and themes were constructed by encoding the data. Similar codes were grouped as subthemes and themes. In the data representation stage, the data were visualized using a table. The associations between codes, subthemes, and themes were analyzed and contrasted with the literature during the stage of revealing and validating the results. The findings of semi-structured interviews were clustered and detailed under six themes: Preservice teachers' views on the use of technology in educational activities in terms of general viewpoints, students, teachers, and mathematics education as well as preservice teachers' plans on using technology in future mathematics teaching activities. In order to ensure reliability, the data were coded by two researchers separately, and the ratio of agreement between them was calculated to be 92%. The researchers discussed their differently expressed codes and reached a consensus.

Findings

The first research question aimed to explore the preservice mathematics teachers' TPACK competency perception levels. For this purpose, their scores from the TPACK-deep scale were examined. Mean and standard deviation scores that the preservice teachers obtained in the TPACK-deep scale are shown in Table 3 for the total scale and the subscales.

Preservice teachers' views on the use of technology in educational activities

This section includes general viewpoints of the preservice teachers on the use of technology in educational activities and their relevant opinions in terms of students, teachers, and mathematics education. Table 4 presents the codes and themes derived from the analyses.

Table 3. TPACK competency perception levels of preservice teachers

Variables	N	$\overline{X}$	sd	Level
Design	65	3.72	0.51	Advanced
Exertion	65	3.83	0.48	Advanced
Ethics	65	3.91	0.55	Advanced
Proficiency	65	3.41	0.56	Moderate
Overall	65	3.75	0.43	Advanced

Table 4. Preservice teachers' views on the use of technology in educational activities in terms of general viewpoints

Theme	Subtheme	Code	Students
Views on the use of technology in educational activities	Positive Evaluation	Enriches the content of teaching	S6, S13
		Useful	S2, S3, S7, S8, S10
		Facilitating	S4, S5, S8, S13
		Increases participation in the course	S12
		Offers visual materials to achieve retentive learning	S3, S4, S5
		Important	S4, S9, S12
		Necessary	S7
		Supporting	S6, S7
		Extends education	S13
	Recommendations	Should be increased	S1
		Should not be overused to avoid problems	S9, S11

When the preservice teachers were asked about their views on the use of technology in educational activities, they made positive evaluations, and none of them provided negative views. For example, S8 provided the following statement as a positive evaluation: *"I think technology is useful in educational activities. It offers us conveniences. I think it offers benefits when doing our homework or conducting our courses."* How technology offers the chance to work with visual materials in educational activities is a topic that attracted the preservice teachers' attention. As a positive evaluation, S5 stated, *"I think using technology will play a great role. Indeed, because technology offers visual tools, it increases retention in students."* The preservice teachers recommended that the integration of technology into education should be increased but overuse should also be avoided. S9 reported *"Even little children have phones in their hands now. Children start to use it at school, too. They are already using social media too much. It causes disorders. Therefore, I do not recommend the overuse of technology in education."* As observed from these statements, although some of the participants recommended increased use of technology in education, some others mentioned the harms in case of overuse.

The preservice teachers were asked to evaluate the use of technology in education particularly in terms of students. The codes and themes derived from the analyses are shown in Table 5.

The preservice mathematics teachers argued that the use of technology in educational activities would have both positive and negative impacts on students. Those who thought that its effects would be positive focused on how it attracts students' attention and the fact that it is practical. The following statement of S13 indicates how technological integration into education arouses interest among students: *"I reckon we draw students' interest more when we use technology. Because they are more interested in technology, as well. They like the courses with games and videos better than a plain narration in the course."* The preservice teachers reported that the use of technology also has a positive effect on students in terms of achieving retentive learning and bringing three-dimensional thinking skills to students. As for the subtheme of negative effects, they thought that it could cause students to get bored. Accordingly, S2 argued, *"In fact, use of technology should be organized properly. The reason for this is that a child's connection to their course will break due to the environment brought about by technology after a while. I see it with my own sibling. In time, the boredom starts."* In addition, the following statement of S12 shows that technological tools are an important factor in the use of technology in education: *"Financially, some of them can access technological tools, and some of them cannot. There can certainly be financial issues for students."*

The preservice teachers were also asked to evaluate the use of technology in education particularly in terms of teachers. Table 6 summarizes the codes and themes derived from the analyses.

Table 5. Preservice teachers' views on the use of technology in educational activities in terms of students

Theme	Subtheme	Code	Students
Use of technology in educational activities in terms of students	Positive effects for students	Attracts attention	S1, S11, S13
		Practical	S3 S4, S5, S7, S8, S10, S12
		Ensures retentive learning	S4, S9
		Helps students acquire three-dimensional thinking skills	S9
	Negative effects for students	May cause students to get bored	S2
		Insufficient technological tools may affect students negatively	S6, S12

Table 6. Preservice teachers' views on the use of technology in educational activities in terms of teachers

Theme	Subtheme	Code	Students
The use of technology in educational activities in terms of teachers	Positive effects for teachers	Enables the teacher to communicate with the student more easily	S1, S2, S3, S12
		Practical	S2, S4, S10, S11, S12
		Helps teachers to enrich the course	S2
	Negative effects for teachers	Increases the responsibilities of teachers	S4, S5, S6, S8
		Teachers lack the knowledge of using technology in education	S7, S9
	Assessment of teachers	Older teachers are partial to using technology in education	S1, S13
		Beginner teachers are more successful at using technology in education	S1, S13

When stating the positive and negative aspects of using technology in educational activities, the preservice teachers also evaluated teachers with respect to the matter at hand. Whereas positive effects included the facilitation of teacher-student communication, practicality, and helping teachers enrich the course, one of the preservice teachers thought that it would increase the responsibilities of teachers. Based on their own academic life, S3 emphasized the positive effect on teacher-student communication in the following statement: *"Our lecturers reach us very quickly through technology. For example, we could almost never talk to our lecturers face-to-face in the past, but in this way, both our communication and information flow is very easy. I mean, using technology increases student-teacher communication."* To mention the positive effects, S2 reported*, "I think it makes it easier for teachers. That is to say, for preparation, or to reach the student. If the teacher really knows how to use the technology and has mastered it, they are able to coordinate this very well. It is very useful for communicating with the student, managing the course, bringing different things into the course, and preparing materials,"*. In the following statement, S6 argued that the use of technology places extra responsibilities on teachers: *"For teachers, they would normally give the lecture, and that is it. But in this way, it is more challenging. For example, preparing questions at home or monitoring their children for their interactive learning in the third person. Teachers may find it to be more difficult".* The preservice teachers evaluated teachers in relation to the integration of technology into education, and S7 and S9 reported that teachers lacked the knowledge. S7 accordingly explained, *"As for teachers, we, including me, are incompetent in this matter. We are incompetent as the training we receive is not sufficient.".* Comparing the senior and beginner teachers in terms of integrating technology into education, S1 stated, "*I think it may be scary for teachers in the older age group. They keep away, I suppose. But it is easier for younger teachers,"* and S13 affirmed, *"In my high school years, teachers did not use technology much because they were older graduates who did not have courses associated with technology. But I think young teachers use technology better."* As argued by some of the participants, teachers who are at the beginner level in their profession are more open to using technology.

The preservice mathematics teachers were asked to evaluate the use of technology in educational activities in terms of mathematics education. The codes and themes derived from the analyses are given in Table 7.

Table 7. Preservice teachers' views on the use of technology in educational activities in terms of mathematics education

Theme	Subtheme	Code	Students
The use of technology in educational activities in terms of mathematics education	Its advantages in mathematics teaching	Facilitates teaching abstract mathematical concepts	S4, S6, S7, S9, S10
		Developing a positive attitude toward mathematics	S9, S11
		Facilitates mathematics teaching	S3, S12
		Necessary	S5, S7
	Its effect on mathematics teaching	Mathematics can be integrated with technology	S1
		The effect of technology on mathematics teaching depends on teachers	S8

Table 8. Preservice teachers' plans on the use of technology in future mathematics teaching

Theme	Code	Students
Preservice teachers' plan on using technology in future mathematics teaching	Improve themselves for the purpose of integrating technology into education	S1, S2, S7, S9, S10
	Design games	S2, S3, S5, S11
	Prepare technological activities and materials	S4
	Upload educational videos on YouTube	S10
	Benefit from educational software and applications in the courses	S12, S13
	Use Google tools	S6
	Show students educational software and videos that they can utilize off-school	S8

The preservice teachers explained the advantages and general effects of using technology in education in terms of mathematics teaching. The most notable topic was that technology would facilitate teaching abstract concepts in mathematics. On the topic, S7 said, *"Mathematics itself is a very abstract concept, and the subjects of mathematics are very abstract, too. At least, technology is more than helpful to turn these abstract concepts into concrete ones."* Similarly, to state that technology would make mathematics teaching easier, S3 argued, *"Mathematics is already composed of stages. With technology, we are able to see these stages more easily,"*. Regarding technology's overall effect on mathematics teaching, the participants think that it is necessary and applicable. Moreover, S8 added, *"It depends on the ways how lecturers use it. I think it is more efficient with some of them and less efficient with others."*

The preservice teachers were also asked to explain their plans for the use of technology in future mathematics teaching. Table 8 summarizes the codes and themes derived from the analyses.

All of the preservice mathematics teachers reported that they had plans for future mathematics teaching. The most prominent issue was improving themselves. Suggesting that they tend to improve themselves, S1 explained, *"I am trying to learn everything about this matter right now. I have applied for training courses. At the moment, there are many training courses that train teachers and preservice teachers in technological applications. I am trying to learn them. Honestly, I have not mastered much. I know some simple things, and I am trying to learn more and learn how to adapt the subjects to technology. And I think about using it in the future."* Designing games was another goal set by the preservice teachers. S3 stated, *"I really want to perform an activity which we learned in the last term. Designing an effective game that includes questions between videos. This way, I want to make mathematics liked more."* It was inferred from this statement of S3 that mathematics teaching would help students develop positive attitudes toward mathematics via games. Other plans of the preservice teachers included preparing technological activities and materials to enrich the content and sharing educational videos on YouTube. They also planned to utilize educational programs and applications during courses. For instance, S13 said, "*We have seen some programs in the instructional technologies course. I think about using many of them. I think that they will attract students' attention more. To give an example, we have learned about an Internet-based application in the material design course. I would like to use such applications; it would be nice"*. Stating that they would benefit from Google tools, S6 explained, *"I will definitely use Google tools. For example, I will prepare questions on Google forms. To find out students' preliminary knowledge about the subject."*. Considering the use of technology both inside and outside the school, S8 stated, *"I am planning to assign homework to my students or show them programs or videos they can utilize in their free time. I think I can create extra time and also help them by guiding them and using technology in the subjects for which they have incomplete learning."*

Discussion and Conclusion

TPACK competency perceptions of preservice mathematics teachers and their views on the use of technology in education were examined in this study. The research concluded that the preservice mathematics teacher had advanced TPACK competency perceptions. In other words, preservice teachers evaluated themselves as highly competent in terms of this knowledge. These results are similar to the results of a variety of research studies (e.g. Çetin et al., 2012; Çoklar, 2014; Çuhadar et al., 2013; Özgen et al., 2013; Yurdakul, 2011). In the study conducted with 3105 preservice teachers from seven public universities in Turkey, Yurdakul (2011) similarly concluded that the preservice teachers evaluated themselves to be advanced in TPACK competencies. Çetin et al.(2012) conducted a study with preservice science, social studies, and classroom teachers and observed that the preservice teachers found themselves to be technologically competent. Özgen et al. (2013) found that the preservice mathematics teachers had moderate TPACK competencies.

In the present study, the preservice mathematics teachers found themselves to be highly competent in the subscales of design, exertion, and ethics whereas they found themselves to be moderately competent in the proficiency subscale. These results show that the preservice teachers perceived they were more competent in terms of enriching the teaching process with technological and pedagogical knowledge, using technology to conduct and evaluate the teaching process, and considering ethical issues when using technology in the teaching process. However, they did not see themselves as fully competent in some areas such as offering solutions to the problems regarding the teaching process and technology as well as linking technology with content and pedagogy. The findings revealed that, while preservice teachers' TPACK competency perceptions were advanced in general, they also believed they have some shortcomings in terms of being fully expert. This finding is in line with the research conducted by Yurdakul (2011), et al. (2016). These researchers also

concluded that preservice teachers' perceptions of their TPACK competencies were at an advanced level in the design, exertion, and ethics sub-dimension, and at a moderate level in the proficiency sub-dimension. However, in the studies conducted by Çoklar (2014) with preservice teachers and by Albayrak et al. (2016) with teachers, the participants evaluated themselves to be advanced in all of the subscales.

In the present study, the reason why the preservice mathematics teachers found themselves to have advanced TPACK competencies could be the fact that they had taken classes about content, pedagogy, and technology and had performed activities in those classes for two years of education. In the first two years of the program, preservice teachers take classes such as information technologies, computer-aided mathematics education, mathematics learning, and teaching. It is thought that their attainments in those classes had a positive impact on their TPACK competency perceptions. Furthermore, many people, including young age groups, use technology actively and intensively in every moment and aspect of their lives. According to studies, children are greatly intertwined with technology at a young age and the new generation born in the digital age has the experiences brought by this era (Palaiologou, 2014). These experiences, which are naturally gained in daily life, may also have an impact on the new generation of preservice teachers' perceptions of themselves as advanced in terms of TPACK competencies.

According to the results of the present study, it is thought that preservice teachers' TPACK competency perceptions are effective in their positive views on the use of technology in education. Abbitt (2011) states that teachers' beliefs in their ability to effectively integrate technology into education provide a crucial basis for assessing the impact of future teaching practices. On the other hand, Tschannen-Moran and Hoy (2001) argue that teachers' self-efficacy beliefs are highly effective on the goals they set for teaching and willingness levels. As a consequence of the interviews with the preservice teachers who evaluated themselves as advanced in terms of TPACK competencies regarding their views on the use of technology in education, it was found that they had rather positive views about this issue. It was also noteworthy that none of the preservice teachers had a negative opinion regarding the integration of technology into educational activities. This situation strengthens the idea that preservice teachers' positive perspectives toward the use of technology in education are associated with their advanced TPACK competency perceptions.

The interview results show that the preservice teachers who perceive themselves as competent in terms of TPACK support the use of technology in education. The preservice teachers described the use of technology in education as useful, facilitating, and necessary. They also stated that it increases participation in the course and ensures retentive learning. Parallel to this study, in the literature, there are several studies in which preservice teachers have a positive perspective of technology (Başarıcı & Ural, 2009; Helvacı, 2008; İpek & Acuner, 2011; Özdamlı, 2017; Usta & Korkmaz, 2010). Glazewski et al. (2002) revealed that the preservice teachers supported using technology in classrooms and considered the use of technology to be effective in learning among students. As concluded by Russell et al. (2003), teacher views on the importance of technology were an important factor that determines how frequently technology is used in education. Ertmer & Hruskocy (1999) state that negative views of teachers and preservice teachers on the necessity of technology present a significant barrier to technological integration. Hence, with the present study, one can infer from the preservice teachers' views on the use of technology in education what their attitudes will be when they become teachers. The findings suggest that their positive attitudes will be effective in using technology actively in the future.

When the preservice teachers evaluated the use of technology in education in terms of students, they suggested positive and negative impacts. Arguing that there would be more positive effects, the participants emphasized the practical and attraction-grabbing aspects of using technology in education the most. Alakoç (2003) also stated that the use of technology in mathematics education is important for increasing students' attention and making it easier for them to understand mathematics. Besides, the participants also shared the idea that the use of technology would bring three-dimensional thinking skills to students. Moreover, in our study, it was found that the preservice teachers thought that overuse of technology would cause students to get bored and students could be affected negatively in case of insufficient technological tools. Similarly, OECD (2009) states that the efficient execution of educational technology depends on access to technology. The study of Yürektürk and Coşkun (2020) also revealed that teachers mostly had difficulties in conducting technology-assisted teaching due to the lack of opportunities.

Addressing the effects of technology in terms of teachers, the preservice teachers provided positive statements, including that technology ensures teacher-student communication, is practical, and teachers enrich the course content by it. However, with one of the opinions suggesting that technological integration into education would increase teachers' responsibilities, it was stated that technology could have a negative impact. While evaluating teachers about their capability of using technology in education, the preservice teachers concentrated on teachers' lack of technological knowledge and older teachers having a prejudice against using technology. These views of preservice teachers show that they are aware of the importance of having TPACK competencies and positive viewpoints for being able to effectively use technology in education. It has been stated in some studies that preservice teachers do not have sufficient knowledge of using technology in the classroom, therefore having difficulty with technological integration in education (Akkoyunlu, 2002; Çelik & Kahyaoğlu, 2007). On the other hand, because preservice teachers' perceptions of their own TPACK competencies are advanced in our study, they believe that the beginner teachers will also effectively use technology. Preservice teachers' opinions that beginner teachers are more competent in using technology also reflect their positive perceptions of themselves as future teachers in regard to using technology. Similar to the preservice teachers' views in this study, Tondeur et al. (2017) concluded that beginner teachers used technology more competently and successfully. Moreover, while preservice teachers evaluated the use of technology in terms of teachers, they emphasized the necessity of using technology by teachers in education. Hence, it is

anticipated that preservice teachers who evaluated themselves to have advanced TPACK competencies will be more inclined to use technology in their future professional processes.

The preservice teachers did not provide negative views on the use of technology in terms of mathematics education. It shows that the preservice mathematics teachers had positive attitudes toward the use of technology in mathematics. The preservice teachers argued that technology would facilitate mathematics teaching and help students develop positive attitudes toward the course. Likewise, NCTM (2000) states that technological content in mathematics education has an impact on mathematics teaching and improves students' learning. In the literature, there are several studies arguing that the use of technology makes mathematics teaching more effective, and therefore, students have a better understanding of the content (Forgasz, 2006; Gündüz et al., 2008; Harter & Ku, 2007; McCulloch et al. 2018; Özgen et al., 2013). In parallel with the findings of our study, Öksüz and Ak (2009) found that the preservice mathematics teachers had positive views on using technology in mathematics teaching. On the other hand, the statements of the preservice teachers revealed that they evaluated themselves as competent in terms of TPACK, but they also thought that technology would be harmful. TPACK requires using technology by combining content and pedagogical knowledge in accordance with the purpose of the courses. Thus, preservice teachers' highlight also refers to the importance of TPACK for being successful in using technology in education.

It was observed that the preservice teachers aimed to prevent possible problems in their future professional lives by supporting themselves in various ways and improving themselves with respect to the use of technology. The willingness of the preservice teachers with advanced TPACK competency perceptions suggests that they would like to use technology effectively and efficiently in education. Moreover, the results showed that the preservice teachers planned to use technology in the future for a variety of objectives, including teaching lessons, assigning homework, assessing prior knowledge, and developing positive attitudes. These plans of preservice teachers were considered the indicators of their intention to use technology and positive attitudes toward the integration of technology into mathematics education as future teachers. Considering how they would use technology in their teaching, the preservice teachers mentioned designing games, developing materials, using educational programs and applications in their classes, and uploading videos with educational content to YouTube. Given that the most significant tool which enables technological integration into mathematics teaching is the technological materials, the future plans suggested by the preservice teachers are of great importance (McCulloch et all., 2018). It is thought that positive views of the preservice teachers on the use of technology in education would be effective in their plans for using technology in their future teaching activities. Furthermore, the advanced level of TPACK competency perceptions of preservice teachers reveals that preservice teachers consider themselves competent in integrating technology into education. As a result, when the quantitative and qualitative data are considered together, it has been seen that the preservice mathematics teachers who have high TPACK competency perceptions have rather positive views on the use of technology in education.

Limitations and Recommendations of the Study

This study has some limitations in terms of sample size and type of the subject matter since 65 preservice mathematics teachers participated in the study. Thus, a study conducting a larger sample group consisting of participants from different subject matters can be held in the future. TPACK competency perception levels of the preservice teachers were found to be high in this research. However, this information is limited to the data achieved. The relationship between the preservice teachers' perceptions of themselves and their levels of using technology in practice can be examined in a more detailed way through different measures and the consistency between two variables can be investigated. TPACK competency levels of mathematics teachers can be determined, and the relationship with their use of technology can be examined. In addition, the statements of the preservice teachers suggest that the attitudes and skills of younger and older teachers differ in regard to using technology. The accuracy of their statements can be investigated by determining TPACK competencies of mathematics teachers based on age or experience and by examining their skills in using technology. It is anticipated that the findings to be achieved from such studies will be effective in taking steps toward improving mathematics teaching both for teachers and for students.

Author Contribution Rate

The first author carried out the planning, data collection and analysis of the study. Both authors contributed to the writing of the introduction, method, findings, and discussion sections. The authors have read and approved the final version of the study.

Ethical Declaration

The purposes and procedure of the current study were granted approval from the ethical committee of the Istanbul University (Ethics Committee's Decision Date: 18.01.2021, Ethics Committee Approval Issue Numbers: E-74555795-050.01.04-10070).

Conflict of Statement

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

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