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International Journal of Curriculum and Instruction 13(1) Special Issue (2021) 712–742

IJCI
International Journal of Curriculum and Instruction

Technological pedagogical content knowledge self-confidence of prospective pre-school teachers for Science Education during the COVID-19 period: A Structural Equational Modelling

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Abstract

In the age of the COVID-19 pandemic, the use of technology and competencies of educators to support the education of early childhood children drew attention to the education that teachers need to receive in the pre-service period. In this context, it could be significant to examine the relationship between technology, pedagogy, and content knowledge that teachers acquire in the pre-service period. The study aimed to identify the relationship between prospective pre-school teachers' Technological Pedagogical Content Knowledge (TPACK) self-confidence for Science Education and TPACK sub-scales. The study utilized the relational screening method based on the quantitative research paradigm. Path analysis was conducted for structural equational modeling. The study group of the research consisted of 280 pre-school teacher candidates who study at the faculties of education in two different state universities located in the eastern region of Turkey. The data were collected via the "Technological Pedagogical Content Knowledge Self-Confidence Scale" developed by Graham, Burgoyne, Cantrell, Smith and Harris (2009) and adapted to Turkish by Timur and Taşar (2011). The theoretical validity of the data collection tool was tested through the validity and reliability performed on the data set obtained from the prospective pre-school teachers. The results showed that the TPACK variable was affected by the TPK and TCK variables directly and positively. TPK and TCK variables were affected by the TK variable directly and positively.

Keywords: Prospective pre-school teachers, TPACK, early childhood education, teacher education

1. Introduction

During the Covid-19 pandemic period, it seems that both students and educators do not adequately possess digital skills and competencies in the distance education process as a result of the school closure (Alipio, 2020; Ali, 2020; Bozkurt et al., 2020; Desmukh, 2020). In the age of Covid-19 pandemic, the problems faced by educators in the pandemic process such as accessing correct information by using digital tools (Siemens, 2005), developing the critical perspective of learners and teachers by organizing educational activities in digital environments (Bozkurt, 2020), controlling and organizing

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wrong or biased information (Depoux et al.,2020), conducting activities in the digital media, preparing activities, and assigning appear more prominently. It can be said that the problems encountered differ according to both the age category of the students and the fields of the educators. However, considering that the learners using technology are preschoolers, there are discussions and criticisms about online risks and dangers, addiction to videos, social isolation and physical health problems as the teaching process is technology-based. (Jiang & Monk, 2015, Radesky et al., 2016). While these criticisms and discussions continue, the speed of technology to reach the educational environment and children has been increasing in the last 10 years (Silverman, 2020; Zalaznick, 2019). In addition, many online programs are being developed to provide flexibility in learning and to support the learning of young children with disadvantages or disabilities (Zalaznick, 2019). Today, in the 21st century, when the current Covid-19 pandemic is taking place, it has become a necessity to support children's learning by using digital technologies. Indeed, Covid-19 pandemic has also affected Turkey as it affects all countries in the world. As a result of the Covid-19 pandemic, the number of preschoolers affected by the disruption of education in Turkey is 1,326,123 (UNESCO, 2020). In this context, teachers have important responsibilities in the use of technology in early childhood education in terms of both the early age of children and the development of pedagogical content. Teachers' technological and pedagogical knowledge should be developed in the pre-service process, not in the service process. In this context, the importance of preschool teachers' knowledge and competencies according to the technology, pedagogy, and content knowledge (TPACK) model appears (Koehler, & Mishra, 2009). The need to examine the relationship between the elements in the TPACK model has emerged in order to provide the necessary pre-service training for Pre-School Teacher candidates. The need to examine the relationship between the elements in the TPACK model has emerged to provide the necessary pre-service training for Pre-School Teacher candidates. In this context, technology and TPACK model in early childhood period has been examined under the title of Literature Review in the light of related researches.

2.Literature Review

2.1. Educational Technology in Early Childhood Education

With the important developments in the 21st century, technology has been placed in the center of daily life and social structures (Prensky, 2001). Today's children in the early childhood period, who are also referred as digital natives (Prensky, 2001) and netizens (Hauben & Hauben, 1996), are defined as the millennial generation that is born in the technology, uses, interprets, and also internalizes technology as an ordinary part of daily life. According to Ng (2012), the new generation growing up with technology could have differences in their learning styles in comparison to previous generations. In this regard, digital technology producers who take the differences in children's learning styles into consideration, have increased the number of education applications that can be used with technological devices. These applications particularly target children in the early childhood period. For instance, almost all of the 100 top-selling education applications of Apple are for children in the early childhood period (Shuler, 2012). At this age, children use touch-operated tools and applications very well through the use of information and communication technologies (Bredekamp, 2014).

Children's use of educational technology applications has a significant effect on their learning. Educational technology applications have been found to support children's mathematics (Clements and Sarama, 2007; Namukasa, Gadanidis, Sarina, Scucuglia and Aryee, 2016), science (Yelland, Drake and Sadler, 2017), literacy (Guernsey et al., 2012), and concept learning through smart mobile devices and tablets. However, it is a matter of debate whether all the educational technology applications developed for children have educational value. As a matter of fact, Papadakis and Kalogiannakis (2020) examined the researches about the educational value of digital applications from 2011 to 2019. As a result of the research, they found that very few of the digital applications that are tagged educationally support children's development of learning and intelligence. According to Papadakis et al. (2017), most of the mobile applications produced with educational content for children are noneducational and designed to entertain them. According to the results of the research, suggestions were made to parents and teachers about educational mobile applications used by children. In this context, it gains importance for parents and teachers to evaluate the educational mobile applications used by children. However, since parents cannot make expert evaluations on many subjects such as technology, pedagogy, and field knowledge, it is not very easy for them to make this assessment. Besides, it has been determined that not only parents but also professional teachers who support children's development in early childhood have difficulty in choosing digital applications with educational content (Hirsh-Pasek et al. 2015; Papadakis and Kalogiannakis 2017). However, including technology in children’s education considering their age, development levels, individual interests and desires, and the social environment and culture they are in is among the realities of today’s world. Moreover, it has become an obligation for children to meet with technology after the Covid-19 pandemic. Parents, teachers, and technology experts have substantial responsibilities to bring them together with the educational contents of technology.

Experts state that starting from the age of 3-4, children could be introduced computers with the guidance of an adult, and computers could be utilized within the scope of *“teaching while entertaining*” principle (Funk et al.,2009). Reflections on the use of technology in real-life levels have also changed the ways children access information as well as their learning habits. Therefore, the education system and methods need to be revised in line with the needs and habits of the new generation (Prensky, 2001). In this regard, learners’ using contemporary technologies in an appropriate way and by taking responsibility have been one of the issues in the center of the education agenda in the new period. In other words, the primary goal of today's education systems is to raise children who are responsible, sensitive and conscious technology users and to enable them to learn by using technology (Ribble, 2011). Like in all education stages, many technological materials are used in the early childhood period as well. Technology in education has huge impacts on both teachers' practices and children's home and school experiences (Bredekamp, 2014). However, teachers' and prospective teachers' skills in integrating technology in children's learning according to their proficiency is of critical importance (Mishra and Koehler, 2006). Technology integration in education has a complicated process that encompasses many factors (Britten & Cassady, 2005). The most important components of this complicated process are pedagogical content knowledge, content knowledge, and technological knowledge (Mishra & Kohler, 2006). In this regard, knowledge and skills required for integrating technology to the instruction process are identified with the concept of *"Technological Pedagogical Content Knowledge" (*TPACK) developed by Mishra & Koehler (2006). The Technological Pedagogical Content Knowledge (TPACK) framework proposed by Mishra and Kohler (2006), who explain technology with the integration of instructional processes, is expected to shed light on the pre-service education to be received by early childhood period prospective teachers. In this regard, the goal is to explain the theoretical framework of the "*Technological Pedagogical Content Knowledge"* (TPACK).

2.2. TPACK Theoretical Framework

The theoretical framework of the *"Technological Pedagogical Content Knowledge"* (TPACK) developed by Shulman (1986) was formed by adding the technology dimension to the Pedagogical Content Knowledge (PCK). TPCK was defined as *"dynamic, transactional relationship between content, pedagogy, and technology"* by Koehler, Mishra and Yahya (2007, p.741). TPACK is composed of 7 components. These are Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006; Cox, 2008; Shin et al., 2009). The components of TPACK are demonstrated in Figure 1. The meanings of the 7 components in the TPACK framework are explained by Mishra & Koehler (2006) as follows:

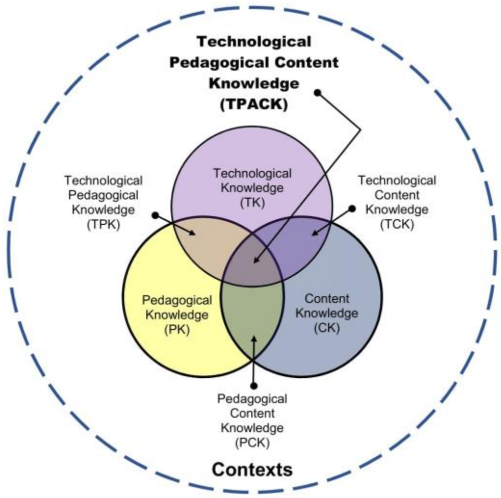


Figure 1. TPACK model proposed by Koehler & Mishra (2009).

- *Technological Knowledge (TK):* Knowledge about various technologies ranging from low technologies such as pencil and blackboard to advanced technologies such as internet, digital video, smart board, and software programs (Mishra & Koehler, 2006).

- *Content Knowledge (CK):* The know-how that is needed for improving the required concepts, facts, theories, and field-specific knowledge for the specific field that is learned and taught (Mishra & Koehler 2006).

- *Pedagogical Knowledge (PK):* General knowledge about how students learn, teaching methods and strategies that could be used in instruction, classroom management, and assessment and evaluation strategies.

- *Pedagogical Content Knowledge (PCK):* The combination of a special content and pedagogy component for teachers' unique professional understanding (Shulman, 1986, p.8). It is a knowledge type that involves information about which instructional methods are appropriate to the content and what kind of an organization is needed for the instruction of field-specific components (Mishra & Koehler, 2006). PCK includes cases that support learning such as instructions, measurement, content, evaluation, and reporting; it also makes connections between pedagogy, program, and assessment. Establishing connections between different content-based ideas, alternative teaching strategies, students' prior knowledge and awareness about developing different points of view to the same problem is highly important for effective instruction in PCK (Mishra & Koehler, 2006).

- *Technological Content Knowledge (TCK):*Teachers need to understand which specific technologies are the most appropriate to learn a topic in their field and how the content dictates technology and even changes it, or vice versa; content learning in their field (Koehler &Mishra, 2009, p.65).According to Graham, Burgoyne, Cantrell, Smith, St Clair, &Harris (2009), TCK is the teacher's knowledge about technological tools and presentations (data collection and analysis tools such as tables) used in the discipline. In addition, TCK requires teachers to be experts in the content they will teach and know-how this content could be taught with the help of the technology (Koehler, Mishra, & Yahya, 2007).

- *Technological Pedagogical Knowledge (TPK):* Knowledge about the use of various technologies in instruction without considering specific content. It is knowledge about how learning and teaching can change when specific technologies are used in specific ways (Koehler & Mishra, 2009). In addition, Schmidt, Baran, Thompson, Mishra, Koehler and Shin (2009) view TPK as the knowledge about the ways of benefitting from technology in the process of instruction stages.

- *Technological Pedagogical Content Knowledge (TPACK)*: It emphasizes that teachers should have the institutional understanding of the complicated interaction between the three fundamental information components (CK, PK, TK) while teaching by using the appropriate pedagogical methods and technologies (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009). It is *"an understanding originated from the interaction among content, pedagogy, and technological knowledge*" (Koehler and Mishra, 2009, p.66). TPACK is a useful theoretical framework that is used in the integration of technology with instruction for enhancing meaningful and sufficient learning. In this regard, TPACK is the knowledge that should be possessed by teachers about how to include technology in the instruction process (Schmidt et al., 2009). In such a process, TPACK is the knowledge of teaching any topics using the most appropriate pedagogical method and technological tools, eliminating the difficulties faced by students in the learning phase by using technology, and being able to support students' learning with technology (Mishra & Koehler, 2006).In such a process, Koehler & Mishra (2009) view TPACK as a whole of knowledge about a) demonstrating concepts with technology, b) positive use of technology to teach information in the field of pedagogical techniques, c) what concepts make things difficult or easy in learning and how technology can help students solve the problems they face, d) students' previous knowledge and knowledge theories; how technology can be used for developing new information theories or strengthening previous knowledge. Hence, prospective teachers at every stage of education who have this knowledge structure increase the quality of the guided learning support that they provide to their students. Technological pedagogical content knowledge also encompasses topics such as the relationship of the field with other fields, latest developments in the field, fundamental concepts, tools and structures of the field, and being knowledgeable about the integration of the content with technology (TED, 2009). Therefore, establishing functional connections between different disciplines would have positive contributions to the education process of technological pedagogical content knowledge. However, the integration of the technology presented to children in the early childhood period with content and pedagogy could be different from other fields. Therefore, the TPACK framework was analyzed in the early childhood period (Park and Hargis, 2018). The new point of view brought to the TPACK framework is demonstrated in Figure 2.

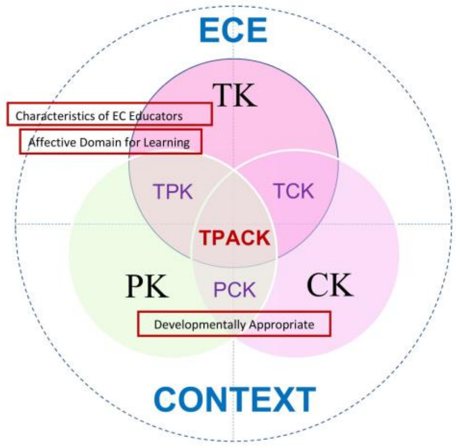


Figure 2. TPACK framework in early childhood education (ECE) context proposed by Park & Hargis (2018).

A study conducted by Park & Hargis (2018) brought a new point of view to the TPACK model childhood education content and recommended that the TPACK framework should be revised according to the TK, TPK, TCK and TPACK components. Hence, the study conducted by Graham, Burgoyne, Cantrell, Smith, & Harris (2009) reported that the sample of TPACK where early childhood educators were also involved was reported to be composed of the same sub-scales. As this study investigated TPACK within the scope of science teaching in early childhood period, it was decided that it should be conducted according to the dimensions defined (TK, TPK, TCK, TPACK) in light of the related studies (Park and Hargis, 2018; Graham et al., 2009; Hammond, & Manfra, 2009; Niess, 2005).

Several studies on the technological pedagogical content knowledge were performed according to the different disciplinary fields and content.

An analysis of the studies on science instruction showed that Cirit & Canpolat (2019) investigated the TPACK levels of prospective science teachers in the instruction of renewable energy sources. The results showed that prospective teachers' knowledge about the integration of technology to the topics in the instruction process and assessment was not sufficient. The study conducted by Canbazoğlu Bilici (2012) investigated prospective science teachers' TPACK and self-efficacy levels. While the prospective teachers' knowledge about the science and technology curriculum component was sufficient, their knowledge about the aims and goals of the instruction of science with technology was partly sufficient. The study conducted by Kılıç (2015) investigated the effects of TPACK of prospective science teachers about fundamental astronomy topics on their classroom practices. The prospective teachers' TPACK about all fundamental astronomy topics had significant differences in classroom practices in favor of the post-test. Kaya (2014) investigated the effect of blended learning on prospective science teachers' technological pedagogical knowledge about global warming and the development of classroom instruction skills. The experimental research results indicated significant differences except for the TCK component of TPACK. There are also scales developed in the TPACK theoretical framework Graham, Burgoyne, Cantrell, Smith, &Harris (2009) and scale adaptation studies (Timur &Taşar, 2011) for prospective science teachers.

An analysis of the studies on Math teaching showed that the study conducted by Kurt (2016) investigated the TPACK development level of prospective teachers within the microinstruction course scope in terms of statistics instruction with virtual manipulatives. The results showed an important increase in prospective teachers' TPACK knowledge dimensions especially in statistical content knowledge, statistical pedagogical knowledge, and technological content knowledge. The study conducted by Mutluoğlu and Erdoğan (2016) found a relationship between mathematics teachers' learning styles and TPACK. The study showed that the learning styles that predicted TPACK the most were the *"facilitator"* and *"authoritative"* learning styles.

An analysis of the studies about Social Studies teaching showed that Bal and Karademir (2013) aimed to identify social studies teachers' TPACK self-assessment levels. The results of the study showed that while social studies teachers perceived themselves as highly proficient about pedagogical knowledge, they thought they were slightly proficient in technological knowledge. A study conducted by Aksin (2014) aimed to detect social studies teachers' proficiency in using technology and instruction methods in teaching the topics in their profession considering the pedagogical characteristics of students. The results showed that the lowest level of TPACK among other sub-scales was Technological Knowledge (TK) while the highest level belonged to the Content Knowledge (CK).

As to the studies on pre-school education, Sancar-Tokmak, Yavuz Konokman, and Yanpar- Yelken, (2013) investigated preschool prospective teachers' self-confidence about their technological pedagogical content knowledge (TPACK) and found that prospective pre-school teachers had high TPACK self-confidence.

In the studies about language learning, Hsu (2016) investigated the use of TPACK in their study about the mobile-assisted language learning approach of 158 Taiwanese in-service EFL teachers. The study revealed that teachers' maintaining the systematic use of mobile-assisted learning approach of TPACK eventually increased positive attitudes and learning. In addition, some scales regarding the use of TPACK were also developed in language teaching. A study conducted by Başer (2015) developed a data collection tool that can be used in assessing prospective English teachers' technological pedagogical content knowledge (TPACK). The data collection tool was composed of 7 sub-scales that had reliability and validity.

The technological pedagogical content knowledge (TPACK) framework proposed by Mishra and Koehler (2006) was based on the proficiency of teachers and prospective teachers about the integration of technology into their instruction process. In this regard, an analysis of the studies showed that the study conducted by Ay (2015) investigated teachers' technological pedagogical content knowledge (TPACK) in the context of practice. Teachers demonstrated technology integration in different categories in terms of TPACK- practice skills, and the teachers' technology integration was found to be affected by their years of experience in the profession, grade level of the schools where they worked, and technology attitudes. Lee and Tsai (2010) found that there was a positive relationship between teachers' TPACK and their real web-based instruction. The study conducted by Hsu, Liang, Chuang, Chai and Tsai, (2020) also investigated the differences between technological and pedagogical content knowledge-games (TPACK-G) in primary school teachers who were grouped according to their age (young and advanced ages), attitudes towards games, and perceptions in real instruction. The results showed that young teachers had a higher tendency of having game knowledge, game content knowledge, game pedagogical content knowledge levels in comparison to older teachers. In their two-stage mixed-method research, Tondeur, Scherer, Siddiq and Baran (2020) investigated the efficiency of the model used for preparing prospective teachers for technological pedagogical content knowledge (TPACK). The model, which was called the SQD model, had a six-stage structure that focused on qualitative evidence. These stages included a) using teacher educators as role models b) reflecting on the role of technology in education c) learning how to use technology by design, d) collaboration with peers, e) scaffolding authentic technology experiences and f) providing continuous feedback. The qualitative aspect of the study showed that the teachers acknowledged the importance of the six strategies. As to the quantitative aspect, when the general attitudes of the sample about technology were controlled, there was a positive relationship between TPACK and SQD. The TPACKEA model developed by Asamoah (2019) included ethics and success variables to the technological pedagogical content knowledge. The study that utilized a qualitative research design included 20 instructors. The results showed that the ethics and success components were appropriate and required practical terms for instruction and learning.

The studies on TPACK in the related literature were found to include self-assessment scales (Schmidt et al., 2009), classroom observations (Jin, Wang, Tai and Schmidt-Crawford, 2016), assessment of the products and performance (Koh & Chai 2016), and a combination of various assessment tools (video clips of instruction practices, interviews, and scales) (Yeh, Hsu, Wu, & Chien, 2017). The TPACK framework was utilized for redesigning the teacher development workshops and teacher preparation programs (Chai, Koh, &Tsai, 2010). Some studies utilized TPACK in design projects and micro-teaching activities (Chai et al., 2010). Although TPACK practices are conducted in different subject fields and disciplines, Archimbault and Barnett (2010) reported that although the theoretical structure of TPACK provided benefits, its use in practice is very little because of the complexity of measuring each component in the TPACK model.

A review of the literature showed that studies on TPACK investigated the instruction of different disciplines and topics in various contexts; however, there are few TPACK studies about pre-school teachers and prospective teachers. The increased use of technology in the activities conducted with children in the early childhood period has critical importance (Christakis, 2009; Rideout, Foehr, & Roberts, 2010).

Given that children in the early childhood period learn better through concrete experiences, the reflection of technology to the topics to be taught according to the context to be taught with different activities (Science, Mathematics, Language, Games, etc.) would contribute to children's development (Christakis, 2009; Rideout, Foehr, & Roberts, 2010; O'Rourke & Harrison, 2004). Hence, activities for science teaching include a long process starting from early childhood to high school. Therefore, teachers' use of technology is of great importance so that children can learn the experiences in science instruction in a meaningful and effective way (Marsh et al., 2018; Palaiologou, 2016; OECD, 2006).

While teachers' learning technological developments in professional life is normal, learning many cases that require expertise such as technological knowledge, technological content knowledge, pedagogical content knowledge, technological knowledge in the pre-service period has also critical importance. In this regard, technological pedagogical content knowledge self-confidence of pre-school teachers who will prepare the learning environment for Science, Mathematics, Social Studies, Language and Arts, etc. for activity fields is expected to be high.

Individuals who will teach children in the early childhood period need to maintain their interest in technology in the pre-service period and receive education at the desired level by combining technology, pedagogy, and content knowledge (Haughland,1999).

In addition, pre-school prospective teachers should effectively apply their pedagogical content knowledge and educational technologies in their classrooms and integrate technology appropriately and productively to have quality education. Therefore, an investigation of Pre-school teachers' self-confidence about technological pedagogical content knowledge could shed light on in-service education processes. In this regard, considering the theoretical framework of the technological pedagogical content knowledge, this study aims to explain the theoretical structure through a model to be developed to identify the relationship between TPACK and its components.

3. Method

This study adopted a quantitative research paradigm. It utilized a relational screening model, which is convenient for the nature of quantitative research.

3.1. Research Model

The relational screening model aims to identify the relationship between two or more variables and reveal the cause-effect relationship between the variables (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2008). The study, which was designed in the relational research model, investigated the relationships between pre-school prospective teachers' technological knowledge (TK), Technological Content (TCK), Technological Pedagogical Knowledge (TPK) and Technologic Pedagogical Content Knowledge (TPACK).

In this regard, since the predictive relationships between TK, TCK, TPK, and TPACK variables are investigated, the theoretical model path analysis was performed, and the relationships between the variables were investigated using the Structural Equational Modelling (Fraenkel, Wallen, & Hyun, 2012).

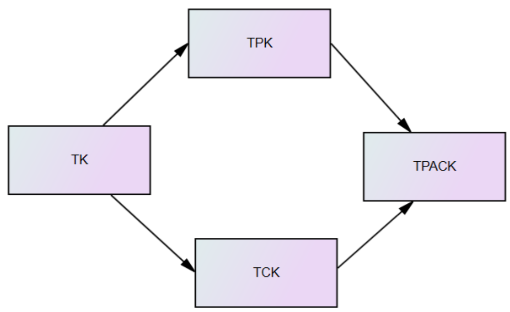


Figure 3. The proposed structural model.

In the research model described in Figure 3, while the TK, TPK and TCK dimensions were defined as the independent latent variables, the TPACK dimension was defined as the dependent latent variable. The main purpose of the study is to develop a model that explains the relationship between pre-school prospective teachers' Technological Pedagogical Content Knowledge Self-confidence Scale for Science Teaching and TPACK total scale and sub-scales and to investigate the fit of this model using statistical fit criteria. In line with this purpose, the study sought answers to the following questions.

1. Which variables affect prospective pre-school teachers' technological pedagogical content knowledge and how much of the technological pedagogical content knowledge is explained by these variables?
2. Which variables affect technological pedagogical knowledge of prospective pre-school teachers and how much of the technological pedagogical content knowledge is explained by these variables?
3. Which variables affect the technological content knowledge of prospective pre-school teachers and how much of the technological pedagogical content knowledge is explained by these variables?

3.2 Study Group

The study group of the research consists of 280 pre-school teacher candidates who study at the education faculties of two different state universities located in the Eastern Anatolia Region of Turkey. The study was conducted with two different study groups that had the same psychometric characteristics. The first is the Exploratory Factor Analysis

(EFA) study group and the second is the Confirmatory Factor Analysis (CFA) study group.

3.2.1 Study Group 1: EFA Study Group

The EFA study group was composed of 120 prospective teachers who study in the preschool teaching program of a state university located in the Eastern Anatolia Region of Turkey. The number of participants in the study group for the Exploratory factor analysis is important for factor analysis (Floyd & Widaman, 1995). The related literature includes different views regarding the number of participants required for EFA. According to Kline (2016), 200 participants are sufficient for the EFA group. According to Stevens (2002), the participants need to be at least 5 times more than the number of items in the scale. Now that the Technological Pedagogical Content Knowledge Self-Confidence Scale is composed of 31 items, 155 prospective teachers are sufficient for EFA. As the EFA study group has 120 pre-school prospective teachers, sub factor-load value was identified according to the criteria in the related literature, efforts were made to complete the missing part in the study group. This case could be considered as a limitation of the study.

3.2.2 Study Group 2: CFA Study Group

The EFA study group was composed of 160 prospective teachers who study in the preschool teaching program of a state university different from EFA, which located in the Eastern Anatolia Region of Turkey. The related literature indicates the number of participants in the CFA study group with the size of the data set. As the data set varies according to the number of items and factors, the number of participants is not indicated specifically (MacCallum, Widaman, Preacher, & Hong, 2001; Wolf, Harrington, Clark, &Miller, 2013).

3.3 Data Collection Tool

The data in this study were collected through the Technological Pedagogical Content Knowledge Confidence Scale (TPACK) developed by Graham, Burgoyne, Cantrell, Smith and Harris (2009). The scale was adapted to Turkish by Timur and Taşar (2011), and this study utilized the Turkish form. The study group in the Turkish adaptation study was composed of prospective Science and Technology teachers. As the study group of the present study was composed of preschool prospective teachers, validity and reliability were needed.

3.4 Data Collection

The data collection tool used in the study was sent to the participants belonging to the EFA and CFA groups via Google Forms. Before filling out the data collection tool in the Google Forms, participants filled in the consent form expressing that they voluntarily participated in the research. In addition, it was stated in the form that the personal information of the participants would not be shared with third parties and the research data would be used for scientific purposes. In order to answer the questions of the participants about the items in the research or data collection tool, the e-mail addresses of the researchers were shared on the form. All questions asked by the participants during the data collection process were answered by e-mail.

3.5 Data Analysis

The analysis of the research data was explained in two items. The first item is the data analysis performed for testing the research questions. The second item includes the reliability and validity of the data collection tool.

1. Path analysis was performed with the CFA group to answer the research questions. AMOS program was utilized for Path analysis.
2. Analyses performed for the reliability and validity of the data collection tool was done in three phases. In the first phase, exploratory factor analysis was performed in the EFA study group. In the second phase, item statistics and internal consistency coefficients of the data collection tool was calculated. In the first two phases, SPSS 21 program was utilized for the analyses. In the third phase, the construct validity of the data collection tool was tested by administering the data collection tool to the CFA study group. AMOS program was performed for CFA analysis. Analysis of the reliability and validity of the data collection tool was performed in three phases.

3.5.1 First Phase: Exploratory Factor Analysis

Kaiser-Meyer-Olkin (KMO) was performed to test the fit of the data set to the exploratory factor analysis. Normality distribution of the data set was analyzed according to the Barlett Sphericity values. Table 1 demonstrates the KMO and Barlett Sphericity values.

Table 1.KMO and Bartlett's test values

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,752
Bartlett's Test of Sphericity	Approx. Chi-Square	3616,412
	df	465
	p	,000

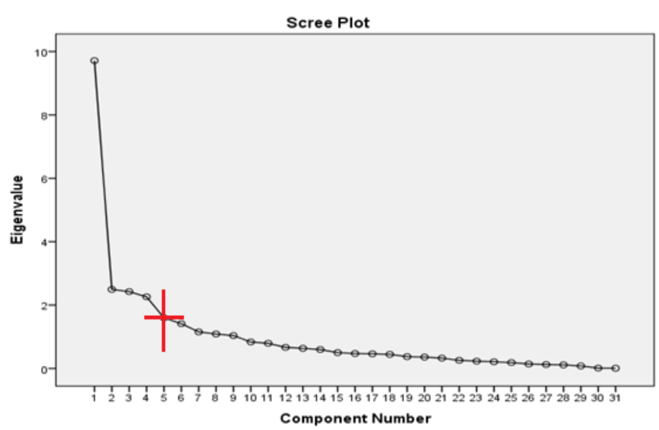
It was found that the 120 pre-school prospective teachers in the EFA group were fit for the data set factor formation (KMO=,752; KMO>, 60; Barlett Test Approx. Chi-Square Value; 3616,412; df=465; p= ,000). According to Kaiser (1974), the KMO value of (,70 to ,80) is a medium-level value for factor analysis. Normality analysis of the data set showed that the z score was in the range of -3 <z <+3. The skewness value was -,245 and the kurtosis value was -,215. The data set is considered to meet the identified normality assumptions (McKillup, 2012; Tabachnick & Fidell, 2013). Kaiser criterion (eigenvalue ≥

1), scree plot test, and total variance explained are the most important criteria in the identification of the data set (Hair et al., 1995). Table 2 demonstrates the eigenvalue coefficient of the data set. Graph 1 demonstrates the scree plot.

Table 2. The eigenvalue of the explained total variance and its components

Components	Eigenvalues	% of Variance	Cumulative %
1	9,712	31,330	31,330
2	2,494	8,046	39,376
3	2,425	7,821	47,197
4	2,261	7,292	54,489
5	1,598	5,155	59,644
6	1,412	4,556	64,200
7	1,154	3,722	67,921
8	1,087	3,508	71,429
9	1,037	3,345	74,774

TPACK scale developed by Graham et al. (2009) was composed of a four-factor structure. An analysis of Table 2 shows that the data set had 9 components with eigenvalues of more than 1. However, the number of factors that fit the theoretical structure of the original scale was detected as 4. The total variance explained by the four components was 54,48%. The explained total variance of over 40% shows that the four-factor structure fits the explained total variance (Kline, 2016).



Graph 1. Scree plot

The Scree plot graph was analyzed to determine if the number of factors was four. According to Büyüköztürk (2010), Rapid decreases with high acceleration give the number of important factors. In this regard, the four-factor structure of the scale developed by Graham, Burgoyne, Cantrell, Smith, & Harris (2009) fit the number of factors obtained in this study.

Rotation techniques are utilized to collect the observed behaviors under latent variables. When the studies on the theoretical dimensions of the TPACK scales in the related literature are considered (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009; Dikkartın-Övez, & Akyüz, 2013), the varimax rotation technique, one of the orthogonal rotational techniques, was preferred. In this regard, the data set was applied the varimax rotation technique. According to Kim-Yin (2004), the lowest limit of the factor load value is related to the sample size (Kim-Yin, 2004, as cited in Şencan, 2005). As the sample size gets smaller, factor load value should increase. When the sample size is around 120, the factor load value is recommended to be 0.5 (Hair et al., 1995). The factor load value limit is 0.5 of this study.

Table 3. Factor load values and item analysis of the scale items after the varimax rotation

	Factor Load Values				Item Statistics				
No	TPACK/F1	TK/F4	TPK/F2	TCK/F3	r	$\bar{x}$	$\bar{x}_1$	$\bar{x}_2$	t
M1	,615	,218	,216	-,088	,569	3,1000	2,4848	3,6364	4,610***
M2	,614	,274	,217	-,194	,610	3,3500	2,6364	3,9697	6,347***
M3	,658	,328	,095	,148	,653	3,5667	2,5758	4,0606	6,828***
M4	,686	,280	,160	,185	,679	3,6167	2,6667	4,0909	7,136***
M5	,598	,125	,183	,091	,571	3,5667	2,7273	4,1818	6,862***
M6	,812	-,016	,039	,213	,659	3,5583	2,7273	4,1515	6,766***
M7	,746	,090	,183	,161	,666	3,4000	2,7879	4,0606	6,278***
M8	,821	-,003	,075	,243	,678	3,3417	2,6667	3,8788	5,755***
M9	,312	,038	,808	-,018	,778	3,5000	2,7576	4,2121	7,711***
M10	,386	,262	,523	-,040	,501	3,4250	2,8485	4,1515	6,826***
M11	,321	,247	,689	,054	,748	3,3333	2,5152	4,2121	9,222***
M12	,243	,065	,836	,067	,814	3,4250	2,6364	4,1212	7,181***
M13	,103	,207	,665	,119	,599	3,5000	2,7273	4,2424	7,543***
M14	,047	,111	,639	,302	,597	3,3750	2,6061	4,1212	7,474***
M15	-,016	,181	,696	,161	,591	3,3333	2,6970	4,0909	7,015***
M16	-,112	-,027	,277	,678	,778	3,4333	2,8788	3,9394	4,808***
M17	,137	-,153	,315	,632	,501	3,5167	2,8485	3,9697	4,657***
M18	,276	,251	,127	,633	,748	3,1083	2,2424	3,9697	8,763***
M19	,241	,258	-,026	,731	,817	3,3417	2,4242	4,0303	6,911***
M20	,162	,282	-,061	,744	,599	3,3917	2,6667	4,0000	5,533***
M21	,264	,520	,184	,189	,515	3,5167	2,7879	4,1515	5,091***
M22	-,065	,587	-,187	,031	,345	3,8250	3,2121	4,1515	3,418***
M23	,223	,593	,243	,107	,599	3,6250	2,8485	4,2727	5,663***
M24	,126	,703	,061	-,045	,497	3,8417	3,1212	4,4848	5,550***
M25	-,074	,728	,048	,161	,485	3,6500	2,9697	4,2121	4,617***
M26	,288	,559	,249	,108	,571	3,4000	2,7879	4,3333	6,142***
M27	,262	,582	,414	-,030	,658	3,4000	2,7879	4,3030	6,229***
M28	,334	,565	,267	,151	,615	3,6583	2,8485	4,3939	6,827***
M29	,231	,589	,312	,063	,650	3,5250	2,6364	4,3333	8,834***
M30	,122	,513	,143	,072	,451	2,9000	2,2121	3,5758	5,031***
M31	,241	,517	,386	,090	,500	3,3917	2,5455	4,3030	7,187***
(α)	,874	,850	,878	,750					

(α)= Cronbach's Alpha, r= Item total correlation, $\bar{x}_1$=Lower 27% Group, $\bar{x}_2$=Upper 27% Group, *** p<,001

An analysis of Table 3 shows that the factor structure of the data set shows the same distribution with the factors of the items in the original scale developed by Graham et al. (2009). The items in the data set were found to be under the related factor. In addition, theoretically, the original form of the data collection tool and the Turkish form were found to fit with each other. Therefore, the construct validity of the data set that belonged to the pre-school prospective teachers was found fit.

3.5.2 Second Phase: Item Analysis

Item total correlation and reliability values based on internal consistency were analyzed to identify how much the data collection tool, whose construct validity was analyzed with EFA, was associated with the scale. Item discriminant analysis was performed to identify whether the items could discriminate prospective teachers with high and low TPACK confidence.

Item total correlation was calculated using the Pearson moments multiplication correlation coefficient (Pearson r). If the R-value is smaller than .30 in the correlation analysis (r<.30), it means that the items have weak relationships with the scale. The item with low correlation should be eliminated from the scale. If the R-value is between .30 and .70 (.30 ≤ r ≤.70), the items have a medium level relationship with the scale. If the R-value receives values higher than .70, the items have good relationships with the scale (Tavşsancıl, 2005; Büyüköztürk, 2010).

According to Table 5, the total correlation (r) values of the items collected under the TPACK factor were in the (,569 ≤ r ≤ ,679) range. Item total correlation of the items under the TPK factor was in the range of (,597 ≤ r ≤ ,814). An analysis of the TPACK factor showed that the item-total correlation (r) values were in the range of (,501 ≤ r ≤ ,817). An analysis of the TK factor showed that the item-total correlation (r) values were in the range of (,345 ≤ r ≤ ,658). In this regard, all the items in the scale were found to receive values between (.30 ≤ r ≤.70) and had relationships with the scale.

When the internal consistency coefficient is calculated in the reliability analysis, how reliably the conceptual structure formed by the items measures the conceptual structure formed by the items in terms of internal consistency was measured through one administration. Cronbach's Alpha (α) value was utilized in the analysis done for internal consistency reliability. The alpha reliability level of α>.90 indicates the perfect value, values of .80< α <.90 indicates the good value, and values .70< α<.80 indicates the acceptable value (George &Mallery, 2003).

An analysis of Table 3 shows that the internal consistency coefficient of the scale (α= ,91) indicated a perfect level of reliability. TPACK internal consistency coefficient was (α= ,87), TPK internal consistency coefficient was (α= ,87) and TK internal consistency coefficient was (α= ,85); these values indicate that the scale had a good level of reliability. TCK internal consistency coefficient had an acceptable level (α= ,75).

Item discriminant analysis is the power of distinguishing between the individuals who had a high and low level of psychometric features (Kalaycı, 2008, p.170). Item discriminant analysis was performed by applying independent t-test to the 27% upper or lower groups. As it is shown in Table 5, all of the items in the data collection tool was significant at a level of p< ,001.

3.5.3 Third Stage: Confirmatory Factor Analysis

Confirmatory factor analysis aims to investigate how much an identified or theoretical structure is confirmed with the collected data. Validity was performed with the EFA study group that was composed of prospective pre-school teachers. Reliability was performed with the CFA study group that had similar psychometric features.

This study investigated and compared $\chi 2/df$ Chi-square/Degree of freedom, Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI) and Comparative Fit Index (CFI) values which were identified as criteria in the literature.

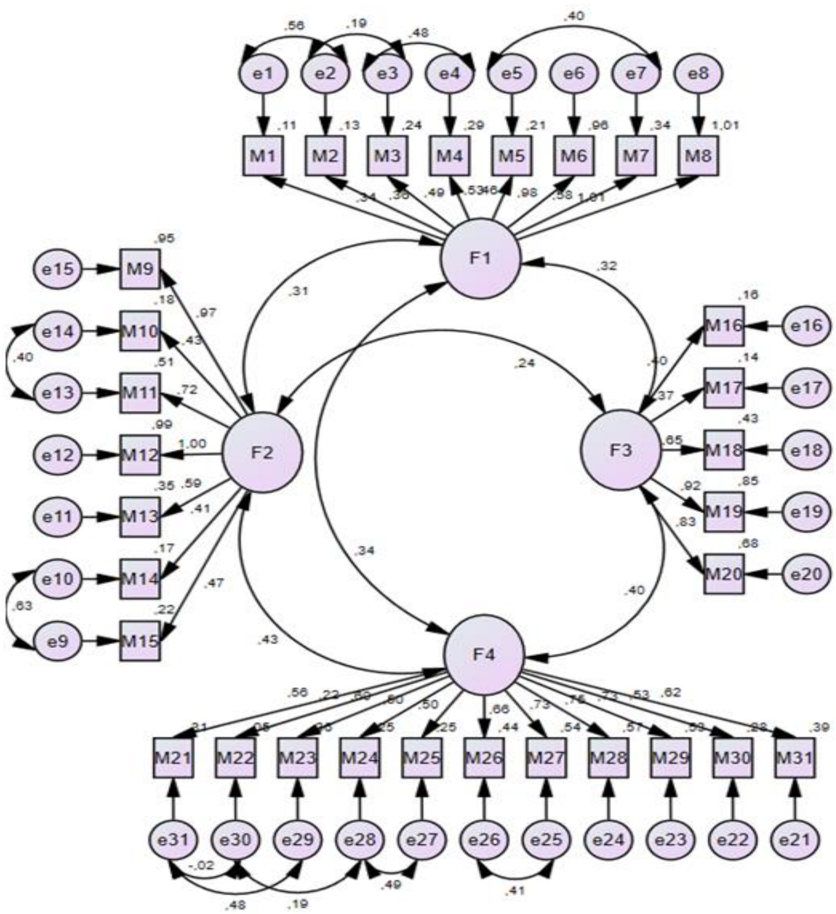


Figure4.Standardized estimates values of the TPACK scale (F_1=TPACK, F_2=TPK, F_3=TCK, F_4=TK)

An analysis of Figure 4 shows that the recommended modifications about the items under the same factor were performed to enhance the model fit. As a result of the confirmatory factor analysis for the four-factor structure after modification, the fit index values were [χ2/df=3.05 (p=.000); RMSEA= .07; GFI= .91; AGFI= .86; CFI=.95; NFI= .92; SRMR= .056. According to the fit index values, the degree of freedom value with the chi-square (χ2/sd=3,05< 5) showed that the model had a good fit in small samples with real data (Anderson & Gerbing, 1984). An analysis of the fit index showed that AGFI value was 0,86; the GFI value was 0,91; and NFI value was 0,92. According to Schermelleh-Engel, Moosbrugger and Müller (2003), acceptable values are 0,80 for AGFI and 0,90 for GFI and NFI. According to Tabachnick and Fidell (2013), AGFI value gives more accurate values in big samples. In this regard, based on the sample size of the study group, AGFI value has an acceptable value. While the RMSEA value was 0,070, the SRMR value was 0,056. According to Hu and Bentler (1999), RMSEA values between .060 and .080 are considered good fit. In addition, according to Schermelleh-Engel, Moosbrugger and Mülle (2003), while the SRMR value is an acceptable fit value, according to Hu and Bentler (1999) values of .08 and smaller is considered a good fit. While according to Schermelleh-Engel, Moosbrugger, Müller (2003) CFI value of 0,95is an acceptable fit, it is a good fit value according to Tabachnick and Fidell (2013). An analysis of the values accepted as criteria in the literature, and the model fit values showed that the model fit values were acceptable.

4. Results

Path analysis was performed to identify the relationships between the TK, TCK, TPK and TPACK variables. The structural equitation model proposed in the study was composed of three exogenous variables (TK, TCK, TPK) and three endogenous variables (TPACK). Fit indexes for testing the structural equation model are shown in Table 4.

Table 4. Path Analysis model fit values and fit index good fit measurements

Measure	Good Fit	Model Fit Values	Good Fit Values Source
(χ2/sd)	$\chi 2/sd. \leq 5$	4,771	(Anderson and Gerbing, 1984)
RMSEA	0,06≤ $RMSEA \leq$ 0,08	,064	(Hu and Bentler, 1999)
NFI	0,90≤ $NFI \leq$ 0,94	,937	(Tabachnick and Fidell, 2013)
CFI	0,90≤ CFI	,948	(Tabachnick and Fidell, 2013)
GFI	0,90≤ GFI	,972	(Hooper et al., 2008)
AGFI	0,90≤ $AGFI \leq$ 1	,858	(Schermelleh-Engel et al., 2003)
IFI	0,90≤ IFI	,949	(Marsh and Hau, 1996)

When the model fit indexes in Table 4 is analyzed, the (χ2 =9,543; df=2; p=.000) χ2/sd =4,771 value of under 5 is a good fit indicator according to Anderson and Gerbing (1984). RMSEA value was ,064, which indicates a good fit according to Hu and Bentler (1999). NFI value was ,937, which indicates a good fit (Tabachnick & Fidell, 2013). CFI value was ,948, which indicates a good fit (Tabachnick & Fidell, 2013). GFI value was ,972, which indicates a good fit. (Hooper et al., 2008). AGFI value was ,858, which is below the good fit value. According to Schermelleh-Engel et al. (2003), AGFI value demonstrated an acceptable fit. IFI value was ,949, which indicates a good fit (Marsh & Hau, 1996). Table 4 shows that the fit index values of the model had good fit values.

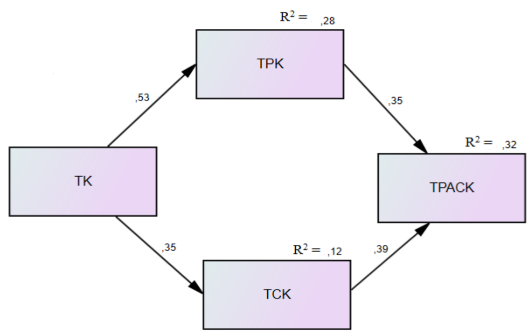


Figure 5**.** Standardized estimates values of the model as a result of the path analysis

Figure 5 demonstrates the path analysis of the model proposed in the study; only the statistically significant paths were included in the model. Each research question was answered under its title.

The path analysis results of the *"Which variables affect prospective pre-school teachers' technological pedagogical content knowledge and how much of the technological pedagogical content knowledge is explained by these variables?"* question showed that the TPK variable (ß=0,35; t= 4.922; $p < .01$) and TCK variable (ß=0,39; t= 5.461; $p < .01$) affected the variable directly and positively. The TPACK variable explains the 32% of the variance ($R^2 = .32$).

The path analysis results of the *"Which variables affect technological pedagogical knowledge of prospective pre-school teachers and how much of the technological pedagogical content knowledge is explained by these variables?"* question in Figure 2 showed that the TK variable (ß=0,53; t= 7816; $p < .01$) affected the TPK variable directly and positively. The TPK variable explains 28% of the variance ($R^2 = .28$)

The results of the path analysis of the *"Which variables affect technological content knowledge of prospective pre-school teachers and how much of the technological pedagogical content knowledge is explained by these variables?"* question according to Figure 2 showed that the TK variable (ß=0,35; t= 4657; $p < .01$) affected the TCK variable directly and positively. The TCK variable explains 12% of the variance ($R^2 = .12$).

4. Discussion

The purpose of this study is to identify the relationship between prospective pre-school teachers' TPACK self-confidence levels and TPACK sub-scales. The path analysis results showed that the proposed model explained TPACK at a level of 32%. An analysis of the models formed with TPACK sub-scales (Kıray, Çelik, & Çolakoğlu, 2018; Günbatar et al., 2017; Çelik et al., 2014) showed that the significant paths between the models were similar. In this regard, TPK, TCK variables that were found to be directly and positively related to TPACK and TK variable that was found to be directly and positively related to TPK and TCK variables were found to indicate similar findings with models that investigated different teaching fields (Kıray, Çelik, &Çolakoğlu, 2018; Günbatar et al., 2017; Çelik et al., 2014)

The model proposed in this study affects TK, TCK, and TPK directly and positively. Hence, prospective teachers who think that they have sufficient technological knowledge are expected to increase their performance while they are applying science activities in the dimensions of technological content knowledge and technological pedagogical knowledge. The study conducted by Graham et al. (2009) found that teachers' self-confidence about integrating technological knowledge with content knowledge was lower in comparison to their confidence in integrating with pedagogical content knowledge. In this regard, the findings of this study indicating that technological knowledge affected pedagogical knowledge more than the technological content knowledge is in line with the results reported by Graham et al. (2009).

According to Donohue (2015), when early childhood period educators integrate technology and digital media into their classroom practices, they should think technology as part of the activities they apply in the scope of the program rather than as a separate activity. However, there are discussions about the use of technology in early childhood classrooms. According to Parette, Quesenberry and Blum (2010), discussions should go beyond the use of technology in classrooms and focus on the ways that could help children's development in the early childhood period science education. In this regard, prospective teachers' education in the pre-service period is of importance.

If prospective teachers are provided with no theoretical information and practices about the use of technology, they might have difficulties in using technological content knowledge and integrating technological pedagogical knowledge with technological knowledge in classrooms. Aldhafeeri, Palaiologou and Folorunsho (2016) reported that teachers who had the competence about digital technology use experienced confidence problems in integrating the education to be given to the children with the early childhood education program by using their technological knowledge in the classrooms that had digital equipment. Since the integration of technology to be given to children in the early childhood period education requires both technological knowledge and practice, preschool teachers should be allowed to practice in the pre-service period. According to Cengiz (2013), for TCK, it is not sufficient to be competent in technological knowledge and content knowledge separately, and there is a need for training to integrate these two knowledge types.

The findings of this study indicate that the increase in technological knowledge directly increases prospective teachers' TPK. This finding of the study showed that the strongest relationship was between TK and TPK in the TPACK modeling, which was in line with the related study results (Chai, Koh, Tsai, &Tan, 2011). However, although the effect of TK is advocated in prospective teachers' TPK increase, it is considered that TPK and TK should be integrated with practice. Hence, special attention should be paid to have practices in the educational environments that have children in the early childhood period. In addition, for TPK, science education should be integrated into the activities and content knowledge should be integrated into practices. The study conducted by Kewalramani and Havu-Nuutinen (2019) reported that TPK should be increased in teachers' science activity practices instead of practices performed solely by teachers. The related study showed that when teachers did research together with students in the science activities, positive contributions were obtained in the views of both teachers and students. The authors stated that teachers' TPK and the related practices are integrated with science content knowledge better.

Another finding of the study was that TPK and TCK of pre-school prospective teachers affect their TPACK directly and positively. Studies related to this finding of the study (Cox & Graham, 2009; Hechter et al., 2012; Young, Young, &Hamilton, 2013) reported similar results. When the TPACK effect power of the prospective teachers' TPK and TCK confidence was investigated, TCK was found to affect more compared to TPK. This finding of the study demonstrated differences with the results of the study conducted by Graham et al., (2009) with teachers, which could be related to the fact that prospective teachers did their pedagogical practices less than the teachers in the pre-service period. In their pedagogical decisions and practices, teachers should demonstrate their planned and purposeful views in their classroom activities (Edwards & Bird, 2017; Early Childhood Australia [ECA], 2018) In this regard, practice opportunities to support prospective teachers' TPK that affects their TPACK should be given in the pre-service period. Prospective teachers should make critical decisions in the practice process, and they should later be allowed to evaluate the decisions they made before. For prospective teachers to make an effective technology integration (TPACK) in the science activities process, their TPK and TCK should be improved. Therefore, researchers recommend the followings in the classrooms where prospective teachers practice for science activities (Harris & Hofer, 2011; Higgins & Spitulnik, 2008). In the classrooms with a curriculum where technology, teaching methods, and content knowledge are integrated, the TPACK framework could be set completely. This case requires prospective teachers who receive early childhood education to construct the education they received in a way to contribute to their TPACK. Hence, prospective pre-school teachers' having opportunities for classroom practices would contribute to a more qualified education they would receive. Similarly, integration of technology to the early childhood education programs to be applied to children would show its effects on learners' personal development. This study investigated dimensions such as classroom practices and programs used in the practice process in the integration of the prospective teachers' pre-service education in the framework of TPACK and technology to be included in the science learning process in the early childhood period with pedagogy. Therefore, not only science activities but also other activities (language, game, music, etc.). provide important contributions to early childhood practices (Mishra & Koehler, 2006; Jen, Yeh, Hsu, Wu, & Chen, 2016).

5. Conclusion

The results of this research are highly significant not only for the mandatory technology imposition of the Covid-19 pandemic, which is a current and big problem today, but also for the integration of post-pandemic technology into education and teacher training. In this context, the relationship between TPACK model elements explains how to integrate technology into education in the future. From this viewpoint, this study shows that TPACK is affected by TPK and TCK directly and positively. TPK and TCK are also affected by the TK variable directly and positively. An analysis of the effect sizes between the variables showed that according to Kline (2016), when the size of the standardized regression coefficients is around .30, it is accepted to have a medium effect size. In this regard, the TPACK variable affects TCK and TPK at a medium level. However, the TPACK variable, compared to the TPK variable, is affected by the TCK variable more. Other results of the study showed that TPK and TCK variables are affected by the TK variable directly and positively. According to Kline (2016), while the TP variable affects the TCK variable at a medium level, the TPK variable affects it at a higher level since it has a standardized regression coefficient of bigger than .50. A significant and positive relationship was found between pre-school prospective teachers' TPACK, TPK, TCK, and TK. In this regard, education programs involving attainments for TPACK, TPK, TCK, and TK should be applied for an effective pre-service education to be provided to prospective teachers. In the light of these research findings and TPACK theoretical framework, TPK, TCK and TK should be evaluated together. Examining only TK or examining TPK and TCK separately, and including them in programs without evaluating them as a whole may cause controversial circumstances.

6. Suggestions

In the updates to be made in pre-school teaching undergraduate education programs, the TPACK model elements can be evaluated as a whole and the knowledge and equipment of the teacher candidates can be updated in the light of the suggested model in the research. In addition, today's Covid-19 pandemic and afterwards, these research results obtained from pre-service teachers can shed light on the programs to be used in in-service trainings for teachers. In addition, projects can be prepared within the framework of TPACK for teachers and teacher candidates, and the research results can be used in practical terms.

7. Limitations and Future Research

This research has some limitations arising from the quantitative research method. Qualitative research methods can be used in future research to elaborate the results obtained from the research. Different model proposals can be developed by testing the research on different study groups. In addition, researchers can test personal variables on the model proposals they will establish according to the TPACK model in their researches during the process of technology integration.

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