

**THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY**

**ADAPTATION OF THE TPACK-21 SCALE TO
TURKISH:
A VALIDITY AND RELIABILITY STUDY**

Master's Thesis

MELTEM SUNMAN

ISTANBUL, 2020

**THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY**

**GRADUATE SCHOOL OF EDUCATIONAL SCIENCES
MASTER’S PROGRAM IN EDUCATIONAL TECHNOLOGY**

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Thesis Supervisor: ASSIST. PROF. GÜRSU AŞIK

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ETHICAL CONDUCT



I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

ADAPTATION OF THE TPACK-21 SCALE TO TURKISH: A VALIDITY AND RELIABILITY STUDY

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The purpose of this study is to adapt TPACK-21 scale developed by Valtonen et al. (2017) to Turkish. The items of this 6-point Likert type scale is grounded on 21st century skills (reflective thinking, critical thinking, creative thinking, problem solving, information and communication technologies, etc.) emphasized by the Ministry of National Education in Turkey. Using this scale, it can be measured whether teachers have technological pedagogical content knowledge to follow 21st century skills and apply such skills into their classroom settings. For the adaptation of the TPACK-21 scale, after obtaining permission, translation processes were carried out by academicians from top universities who have good command of both languages. The adapted version of the scale was administered to 309 science and mathematics teachers in Turkey and the data was recorded. Confirmatory factor analysis (CFA), item-total correlations for upper and lower groups according to 27% segment, and Cronbach's alpha reliability analysis were performed to test the psychometric properties of the scale and to provide evidence of suitability of the adapted scale to teachers in Turkey. According to the results, the adapted version of the scale was found as 6-factors and 37 items. Since the fit indices of CFA were found as acceptable values and Cronbach's alpha coefficient was found as .97, the scale is valid and reliable. In addition, descriptive analysis was conducted according to teachers' demographic information.

Keywords: Technological Pedagogical Content Knowledge (TPACK), 21st century skills, Scale Adaptation

ÖZ

TPACK-21 ÖLÇEĞİNİN TÜRKÇEYE ADAPTASYONU: GEÇERLİK VE GÜVENİRLİK ÇALIŞMASI

Sunman, Meltem

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Bu çalışmanın amacı Valtonen ve diğerleri (2017) tarafından geliştirilen TPACK-21 ölçeğini Türkçeye uyarlamaktır. 6'lı Likert tipindeki bu ölçek, Millî Eğitim Bakanlığı'nın son yıllarda vurguladığı 21. yüzyıl becerilerini (eleştirel düşünme, yaratıcı düşünme, problem çözme, bilgi ve iletişim teknolojileri vb.) içermektedir. Bu ölçek ile, öğretmenlerin 21. yüzyıl becerilerini takip edip sınıf ortamına uygulamaları için gerekli olan teknolojik pedagojik alan bilgileri ölçülebilir. Adaptasyon sürecinde, ölçeğin sahiplerinden izin alındıktan sonra, gerekli olan çeviri ve uzman görüşü aşamaları her iki dile de hâkim olan Türkiye'nin en iyi üniversitelerinden akademisyenler tarafından gerçekleştirilmiştir. Hazırlanan ölçek Türkiye'de 309 fen ve matematik öğretmenine uygulanıp, veriler kaydedilmiştir. Ölçeğin psikometrik özelliklerin test edilmesi için doğrulayıcı faktör analizi (DFA), %27'lik dilimlerden oluşan alt ve üst gruplar için madde toplam korelasyonları ve Cronbach alfa güvenirlik analizi yapılmıştır. Yapılan analizler sonucunda adapte edilen ölçek 6 faktörden ve 37 maddeden oluşmaktadır. Kabul edilebilir uyum indekslerine ve .97 olan Cronbach alfa katsayısına göre ölçeğin geçerli ve güvenilir olduğu ve Türkiye'deki öğretmenlere uygun olduğu sonucuna ulaşılmıştır. Ek olarak, öğretmenlerin belirli demografik özelliklerine göre betimsel analiz yapılmıştır.

Anahtar Kelimeler: Teknolojik Pedagojik Alan Bilgisi (TPAB), 21. yüzyıl becerileri, Ölçek adaptasyonu



To My Mother

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LIST OF ABBREVIATIONS

PK	Pedagogical Knowledge
CK	Content Knowledge
TK	Technological Knowledge
PCK	Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge
TCK	Technological Content Knowledge
TPACK	Technological Pedagogical Content Knowledge
ICT	Information and Communication Technologies
CFA	Confirmatory Factor Analysis
MoNE	Ministry of National Education
KPSS	Public Personnel Selection Examination
TALIS	Teaching and Learning International Survey
OECD	Organisation for Economic Co-operation and Development
STEM	Science, Technology, Engineering and Mathematics

Chapter 1

Introduction

In this chapter, the statement of the problem is explained first by mentioning the general idea and the requirements of the current age. Then, the purpose of the study, research question, significance of the study and definitions of important terms are respectively explained under the separate sections.

1.1 Statement of the Problem

Technological pedagogical content knowledge (TPACK) is a concept studied by Mishra and Koehler (2006) based on Shulman's (1986) pedagogical content knowledge (PCK) construct. Basically, it is the intersection of teachers' knowledge of technology, pedagogy and a specific content area. It is crucial to have technology knowledge for teachers to effectively integrate it in teaching as well as having pedagogical knowledge and content knowledge because of the fact that 21st century, the rapidly changing era, have increased the need for new skills for students. And experiencing such technologically developed learning environments is inevitable for teachers. At this point, it is important for them to design appropriate instructions serving the purpose of 21st century needs (Akaygun & Aslan-Tutak, 2016). Moreover, according to the Ministry of National Education in Turkey (2011), teachers should be a role model with their own personalities as well as training students appropriately for the necessities and understanding of the 21st century. One of the most important issues is how 21st century skills can be acquired and developed by students. It is possible to gain 21st century skills by integrating them into classroom. In this context, especially teachers have a crucial role situating these skills in education systems. Teachers can help students to acquire these skills with the activities in and outside the school, and the methods and strategies they use (Cansoy, 2018). For increasing their success in and outside the classroom, it is important for students to master 21st century skills. Teachers should combine web tools and 21st century skills by using the internet in order to bring the world into the classroom and guide students to study collaboratively. Therefore, it is important for teachers to know how to integrate 21st century skills and technology

into their classroom settings comprehensively (Tucker, 2014). According to the study conducted by Gelen (2018), these skills include reflective thinking, critical thinking, and creative thinking as well as the knowledge, media and technology skills. Teachers roles have been changing in order to adapt to new century. They need to educate students with 21st century skills in addition to teaching subjects (Shafie, Majid & Ismail, 2019). Therefore, in order to improve their twenty-first century skills, students need to be guided and supported by teachers. Teachers should know how to use new approaches related to information and communication technologies pedagogically. Educators and learners from all around the world use educational technology advances in their teaching and learning processes in order to improve the quality of students' learning environment. According to the study conducted by İlhan and Oruç (2016), the use of multimedia tools has a better effect on students' academic performance when compared to the traditional social studies classroom. Moreover, students indicate that use of technology in classes increases their motivation for learning (Francis, 2017). Martínez-Rivera and Duță (2015) focused on the significance of using new technology in higher education. They demonstrated how technology encourages the collaboration of students during their learning process. In this sense, teachers have an important role to adapt technology into their classes effectively and increase students' achievement, motivation and skills.

In the light of this information, there is a need for TPACK of teachers to be examined in further studies. Especially, in recent years it should be emphasized that TPACK of teachers should be examined in terms of their competency on improving students' 21st century skills. Although there are many TPACK scales in the literature, this study mainly focuses on teachers' TPACK for 21st century skills. Baran and Canbazoglu Bilici (2015) conducted a systematic literature review on TPACK in Turkey. Among the thirty studies they examined, eleven of them adapted the TPACK scale developed by Schmidt et al. (2009). It is very important to investigate teachers' technological, pedagogical and content knowledge to improve students' 21st century skills. From this perspective, measuring whether teachers integrate 21st century skills into their classrooms or not provides some insight for the gained competencies that MoNE (2017) of Turkey suggests teachers to have. Valtonen et al. (2015) emphasize the importance of the TPACK scales for being based on some pedagogical approaches, such as 21st century skills. Therefore, the TPACK-21 scale that they developed can be

used to measure the technological pedagogical content knowledge that teachers have in order to improve students' 21st century skills.

The TPACK-21 scale was adapted to Turkish and administered to science and mathematics teachers. Science and mathematics have become prominent areas for students to prepare for the future life and to adapt to the 21st century. (National Research Council, 2011). It is possible for students to be successful in these areas with new learning environments. According to Akgündüz et al. (2015), the new generation should be able to integrate technology and engineering practices into pure mathematics and science knowledge in order to make innovations adding value to life. STEM (Science, technology, engineering and mathematics) is a good example as an important teaching approach emerging for this need. This approach suggests that science, mathematics and information technologies classes should be taught within content and methods which are compatible with the requirements of the 21st century. (Aşık, Doğança Küçük, Helvacı & Çorlu, 2017). Especially teachers in these areas should use pedagogical knowledge and technology to plan and design instructions considering 21st century skills. Therefore, mathematics and science teachers were chosen as participants in this study and the aim of providing evidence to the suitability of the scale to the teachers in Turkey was strongly considered.

1.2 Purpose of the Study

The main purpose of this study is to adapt the “Technological Pedagogical Content Knowledge for Twenty-First Century Skills (TPACK-21) Scale” developed by Valtonen et al. (2017) to Turkish language and to test the psychometric properties of the scale. Overall, the study aimed to contribute to research about the TPACK in Turkey by adapting the TPACK- 21 scale and providing evidence to the appropriateness of the scale to science and mathematics teachers in Turkey.

1.3 Research Question

The research question of this study is:

- Is the TPACK-21 scale adapted to Turkish valid and reliable?

1.4 Significance of the Study

The need for technology in the field of education is increasing day by day. In Turkey, the Ministry of National Education has made great technological progress in education in recent years. Many technology-related objectives have been added to the curriculum followed by elementary and secondary schools (MoNE, 2017). Students and teachers have been encouraged to use technological tools and applications. Teaching in the 21st century requires technological knowledge as well as content and pedagogical knowledge. Especially in recent months, global pandemic and curfews have revealed the importance of teachers' ability to use technology in their teaching. According to Daniel (2020), there has been a huge development in education in the world for fifty years; however, Covid-19 is the most difficult issue that national education systems have faced. Most of the educational institutions have suddenly switched to online education. Conducting research studies about how developments in information and communication technologies (ICT) enhance the efficiency of education is essential. It is also a need to examine how educators are good at educational technology because they are the ones who give the meaning and spirit to education and make it functional and efficient (Keleş, Öksüz & Bahçekapılı, 2013). In this sense, TPACK of teachers represents their competence in using and preparing proper instructional design and guiding students learning with appropriate ICT (Niess, 2011). TPACK scales can be used for measuring teachers' technological adaptation to rapidly changing the education system as well as their technological pedagogical content knowledge. It is important to make research about this issue and design in-service training for teachers' professional development. However, there is a research gap about measuring the TPACK of teachers in terms of twenty-first century skills in Turkey.

There are several pedagogical approaches that teachers should know how to use for the development of students' 21st century skills. Teachers may have difficulties in developing these skills, especially alongwith the use of ICT. In order to improve 21st century skills of students, the need of creating learning environments by adapting technology into classroom revealed the importance of making research about the TPACK (Emara, 2020). Valtonen et al. (2015) emphasize that teachers' pedagogical

knowledge is a key factor to integrate ICT successfully into the classroom. It is important to compile 21st century skills in different ways rather than developing new skills. Thus, teachers need to have the knowledge of how to support students' 21st century skills by utilizing pedagogical approaches and ICT. Similarly, Goradia (2018) indicates that these approaches help 21st century students to develop their “higher-order thinking skills, metacognitive skills and support deeper learning through collaboration” (p.48). Brown, Neal and Fine (2011) support the idea of using technology based on 21st century skills in classroom by considering the connections between these skills and TPACK. Cherner and Smith (2017) also emphasize that the TPACK framework should focus on the students' adoption of the 21st century skills.

TPACK scales used for measuring teachers' knowledge should be grounded on pedagogical approaches, and 21st century skills have an important place in this context. The technological pedagogical and content knowledge that teachers should have and use in order to make students master 21st century skills can be examined by the TPACK-21 scale. With this framework (TPACK that is pedagogically based on 21st century skills), it was aimed to contribute to literature an extensive measurement for investigating TPACK of teachers in terms of 21st century skills in Turkey. The main aim of this scale is explained in the original study as measuring teachers' knowledge to get benefit from wide range of technologies in order to create 21st century learning environment (Valtonen et al., 2017). Therefore, this study aims to adapt the TPACK-21 scale developed by Valtonen et al. (2017) to Turkish and provide evidence to the appropriateness of it to teachers in Turkey.

1.5 Definitions

PK. Pedagogical knowledge is strategies that teachers use in order to organize and manage the classroom which seems more important than the subject matter knowledge (Shulman, 1987).

TK. “Technological knowledge is a measure of competence with current digital technologies that affords individuals the ability to achieve both personal and professional goals with the available technologies” (Jamieson-Proctor, Finger & Albion, 2010, p.11).

CK. Content knowledge is “the amount and organization of knowledge per se in the mind of the teacher” about their subject area (Shulman, 1986, p.6).

PCK. Pedagogical content knowledge is “for the most regularly taught topics in one’s subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations” (Shulman, 1986, p.6).

TPK. Technological pedagogical knowledge is “an understanding of how teaching and learning can change when particular technologies are used in particular ways” (Koehler & Mishra, 2009, p.65).

TCK. Technological content knowledge is the “knowledge of how technology is used within certain discipline like math or history” (Valtonen et al., 2015, p.89).

TPACK. “Technological pedagogical content knowledge is an understanding that emerges from interactions among content, pedagogy, and technology knowledge” (Koehler and Mishra, 2009, p.66).

21st century skills. Skills that students of 21st century need, including critical thinking, creative thinking, reflective thinking, problem solving and information and communication technologies (Valtonen et al., 2017).

ICT. Information and communication technologies include all devices such as computers, smartphones, tablets as well as software, applications, social media, online learning environments (Valtonen et al., 2017).

Chapter 2

Literature Review

This chapter was covered in four sections examining related literature. The first section focuses on the theoretical framework of TPACK and each subsection under this section includes the subdimensions of it which are TK, CK, PK, PCK, TPK, and TCK. The second section is related to 21st century skills and its place in the curriculum of Turkish national education. The third and fourth sections examine the TPACK scales existing in literature with some sample items.

2.1 Technological Pedagogical Content Knowledge Framework

TPACK model was constructed on Shulman's (1986, 1987) statements on PCK by aiming to explain how teachers' understanding of educational technology and their PCK are affected by each other. Mishra and Koehler (2009) have developed the complete definition of the TPACK framework after some publications (e.g. Mishra & Koehler, 2005, 2006, 2008). Before their definition, in 2001, Pierson (2001) used the term to describe teachers' integration of technology. ICT-related PCK and technology-enhanced PCK are the other terms used before (Angeli & Valanides, 2005; Niess, 2005). The concept, originally called TPCK, was changed to the more useful TPACK (technology, pedagogy and content knowledge) (Thompson & Mishra, 2007). Figure 1 illustrates the framework with three main components as CK, PK, and TK and their intersections consisting PCK, TPK, TCK, and TPACK which have equal importance for the model (Koehler & Mishra, 2009).

According to the model represented in Figure 1, the intersections are more specified than the main components. For example, when pedagogical knowledge is about general knowledge of the teaching process, pedagogical content knowledge includes content-specific teaching knowledge. The technological pedagogical content knowledge, which is the intersection of all three, is the knowledge of how teachers can make their teaching better for specific content by using technology. According to Angeli and Valanides (2009), teachers should be trained on the features of a technological tool, its suitability for students, and how it can be used to teach a specific

content area. Teachers also should be familiar with the interactions of technology, pedagogy and content knowledge.

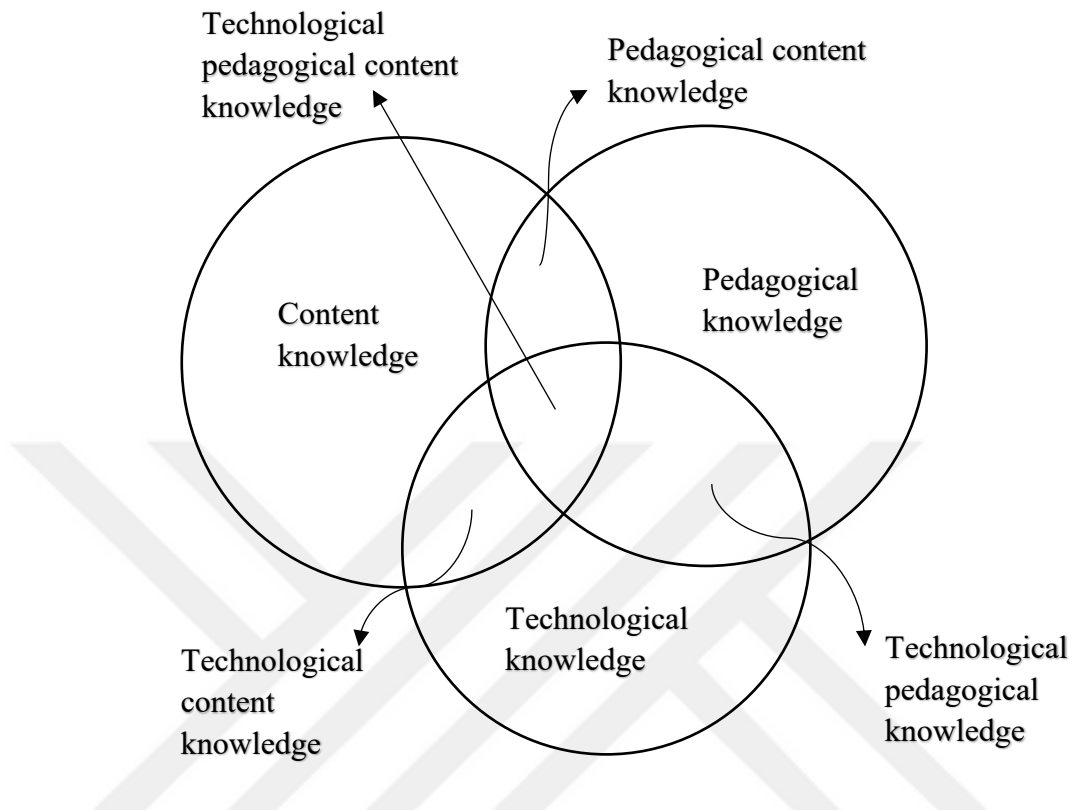


Figure 1. TPACK Model (Mishra & Koehler, 2006, s. 1025)

The sub dimensions of the TPACK framework can be listed as;

i. Technological knowledge (TK)

Using information and communication technologies in teaching contributes to students' understanding of the content, improving problem solving and critical thinking skills, increasing motivation, etc. (Ural, 2015). Therefore, the importance of the technological knowledge of teachers cannot be ignored for their contribution to students. In Kozikoğlu and Babacan's (2019) study, technological knowledge is defined as the knowledge of media tools such as smart boards, software, and applications. It requires some knowledge and skills to use them in teaching. Since TK is the knowledge that reflects individuals' skills to use technology for their self-improvement and professional aims (Jamieson-Proctor, Finger & Albion, 2010), teachers need to follow technological developments and adapt them to their lessons. Teachers' role in integrating technology into education is crucial. Therefore, teachers'

technological knowledge is as important as their content and pedagogical knowledge (Akar, 2019).

According to the study conducted by Voogt, Fisser, Pareja Roblin, Tondeur and van Braak (2013), most studies define TK as knowledge of all kinds of technologies while others as new technologies or ICTs. Such technologies can be used both in personal life and classroom by teachers. According to Rakes, Fields and Cox (2006), the level of personal computer use is a strong predictor for technology use in the classroom. There is a thought among teachers, however, even if they are open to learn and apply new technologies in their classes, they may be obliged to struggle with school administration or some organizational problems (McGrail, 2005). Such reasons may affect the level of teachers' technology knowledge.

ii. Content Knowledge (CK)

Content knowledge is the knowledge of the structures that make up the subject and principles that organize it conceptually (Öner, 2010). Teachers' understanding of a specific subject to teach is represented by their content knowledge. They should know the most important concepts and theories in their field as well. In addition to knowing content, teachers should know that content along with its reasons (Kleickmann et al., 2013). Therefore, it can be obviously said that content knowledge of teachers is more than academical knowledge or daily mathematical knowledge (Kleickmann et al., 2013).

Öner (2010) also supports this idea by stating that knowledge of the content is not sufficient for teaching. In this research, the survey was applied to science and mathematics teachers. Therefore, content knowledge can be identified as science and mathematical knowledge and skills that teachers use in their class (Delaney, 2008). Similarly, it is indicated by Ball, Thames and Phelps (2008) that there is content knowledge specific for the only subject-based teaching purposes. They also mentioned the pedagogical content knowledge which brings content knowledge and teaching methods for the content together. In order to give efficient teaching for a subject, both content and pedagogical strategies should be considered.

iii. Pedagogical Knowledge (PK)

Koehler and Mishra (2009) define pedagogical knowledge as “teachers’ deep knowledge about the processes and practices or methods of teaching and learning.” (p.64). Teachers need to know cognitive, social and developmental theories and how to apply them to children in their class. Pedagogical knowledge is strategies that teachers use in order to organize and manage the classroom which seems more important than the subject matter knowledge (Shulman, 1987).

The term general pedagogical knowledge can be used for pedagogical knowledge in order not to confuse it with pedagogical content knowledge (Mulholland, 2015). König and Rothland (2012) mentioned the dimensions of general pedagogical knowledge. According to them, teachers need to organize their lesson structure in terms of students’ learning objectives, lesson plan and evaluation. Classroom management is another dimension including motivating students, managing time efficiently, preventing and handling students’ conflicts. Using different methods of teaching to adapt the different learning groups in the classroom. Lastly, assessment and evaluation are important part of teaching that teachers should have knowledge about because it takes part in all stages of the teaching process. Guerriero (2017) suggest teachers to have these competencies for effective teaching in addition to having teaching motivation. Pedagogical applications in the class have an undeniable effect on students’ learning.

iv. Pedagogical Content Knowledge (PCK)

PCK is the most emphasized and discussed concept among the others. It indicates that either content knowledge or pedagogical knowledge cannot be sufficient separately for training teachers (Öner, 2010). They should be considered together for a better education. Shulman (1986) indicates that pedagogical content knowledge includes the representations and formulas that make a subject understandable for others. It is parallel with his idea of pedagogical knowledge which includes teachers’ knowledge of methods to teach a subject matter of the content. Krauss et al. (2008) state that there is a theoretical difference between the subject matter content knowledge and pedagogical knowledge, yet they can be considered as connected for effective teaching. In addition to having good knowledge of a content area, teaching strategies,

students' misconceptions and perceptions of the content are crucial (Grossman as cited in Jang, 2009).

As Shulman (1986) suggested, teachers should use alternative ways to illustrate the topic and adapt them to concepts and students' prior knowledge while they understand it (Koehler & Mishra, 2009). PCK is the knowledge of how teaching can be more understandable to students and is gained and developed by teachers over time (Garritz, 2015). For the subject matter teaching purposes, PCK of teachers is crucial for students' learning. Besides, it is important to perceive PCK because Koehler and Mishra (2009) stated that TPACK was built on Shulman's statement of this component and is crucial for teachers to use technology effectively in their teaching. Due to this reason, PCK is the foundation of the TPACK framework.

v. Technological Pedagogical Knowledge (TPK)

Mishra and Koehler (2008) define TPK as being aware of the change in learning and teaching when using technology. TPK includes the knowledge of the features of technology being used in terms of its' appropriateness and limitations pedagogically. Therefore, teachers need to know how the technology they use affects their instruction and students' understanding. Moreover, Wang Y., Zhang, Wang Y. and He (2017) indicate that they conducted an empirical study on teachers' TPK because this component of TPACK is found as the most efficient part of the TPACK structure.

Harris, Mishra and Koehler (2009) emphasize the flexibility of the technological tools used in the class, i.e., even if it seems to a technological tool can be controlled by only the teacher of the class, different applications and instructional designs should be discussed by anyone in the collaborating team. Effective teaching requires teachers to adapt several applications -created for other areas, such as business- in teaching purposes. Harris et al. (2009) give an example of Excel for the purpose of helping children to observe data clearly. Many such information and communication technology tools continue to be used by teachers for pedagogical purposes. Because teachers' skills of technology use in pedagogical ways help students to improve their abilities (Oktasari, Kuswanto, Ismet & Sardianto, 2018). Didi and Deni (as cited in Oktasari et al., 2012) indicate that teachers having good pedagogical knowledge are able to use appropriate teaching methods and they should be good at integrating

technology into class for efficient teaching. Therefore, the integration of technological and pedagogical knowledge of teachers should be considered.

vi. Technological Content Knowledge (TCK)

In order to develop appropriate educational materials, using technology needs the knowledge of both technology and understanding its effects on a specific content area. Technological content knowledge represents the technological scope and limitations of the field. It is important for teachers to have knowledge about the ways of using technology to improve their instruction. They should know how to change a subject by using technology as well as the content area. For instance, a mathematics teacher can make a geometry topic easier to understand for students by using Geometer's Sketchpad. Students have a chance to see abstract shapes in their devices and understand the proofs of geometrical theorems easily (Koehler & Mishra, 2006, 2009). Such applications can facilitate students in all subject areas if teachers have the necessary technological content knowledge. Schmidt et al. (2009) add teachers' beliefs and ability to change students' knowledge and practice to previous explanations of TCK. Therefore, in order to improve students learning, teachers' TCK plays an important role.

As is seen, each of the subcomponents has an important role in teaching and effective teaching cannot occur without one of them. The intersection of these dimensions constitutes the TPACK framework. Mishra and Koehler (2006) state that TPACK reflects educators' knowledge of technology usage in order to present several concepts and examine their pedagogy knowledge which includes taking advantage of technology in their instruction. Having knowledge of the things making a concept easy or difficult and how technology can help to make a topic easy to learn for students are addressed in this framework as well. Lastly, it is the knowledge about using technology to develop new knowledge by adding previous ones.

2.2 Twenty-First Century Skills

Students in today's world can be called "digital natives" of technological tools, such as computers, video games and the Internet (Prensky, 2001). Most of them have their own devices such as smartphones, laptops, tablets, etc. It's easier to bring

students' 21st century skills in this era than in the past. This section includes studies on 21st century skills. Binkley et al. (2012) indicate that 21st century skills are categorized by some standards, which are ways of thinking, ways of working, tools for working and living in the world. The categories given in Table 1 illustrate the skills that belong to each category. These categories are decided by considering the requirements of being successful in today's work and life, such as being able to communicate effectively, use the knowledge for solving problems, and create innovative ideas to respond to new demands, etc. The skills listed in the table are for everyone without exception among the status of people. Therefore, educational standards are crucial for students to gain 21st century skills (Binkley et al., 2012). Because gaining these skills will help students to solve the problems they faced with in real life and meet rapidly changing requirements of society (Şahin, Ayar & Adıgüzel, 2014).

Table 1

21st Century Skills (Binkley et al., 2012, p.18)

Categories	Skills
Ways of Thinking	Creativity and Innovation
	Critical thinking, Problem solving, Decision making
Ways of Working	Communication
	Collaboration (teamwork)
Tools for Working	Information literacy
	ICT Literacy
Living in the World	Citizenship- local and global
	Life career
	Personal and social responsibility

The Ministry of National Education in Turkey attached great importance to the skills that should be gained by students in recent years. They define curriculum as the basic knowledge and skills framework aiming to acquire by students under the guidance of teachers (MoNE, 2017). According to the studies conducted by MoNE in 2016-2017, they updated the curriculum comprehensively in order to gain new dimensions which are the necessities of 21st century. In the update made in 2017, a very important part was added to the curriculum named "Competencies". In this part, a great emphasis was placed on the need for teachers to transfer 21st century skills to

students which are also matching the model provided by Binkley et al. (2012). This update, which was made in all curricula from the level of primary to secondary school education, started to be implemented at all levels in the academic year 2018-2019 (MoNE, 2017). Some of the competencies that are aimed to be acquired by students in the curriculum presented by MoNE (2017) are:

- Mathematics competence (including problem solving, creative thinking, et.).
- Science and technology competence (critical thinking, perception of properties of scientific inquiry).
- Digital competence (information and communication technologies, using the tools necessary to produce, present and comprehend information.
- Self-directed learning (students' awareness of their own learning strategies, strengths and weaknesses, benefiting from previous experiences).

Furthermore, Voogt and Roblin (2012) conducted a study to analyze different frameworks describing 21st century skills. Selecting from thirty-two documents of their literature review, they included eight important frameworks in their study; P21 (2009), EnGauge (2003), ATCS (2010), NETS/ISTE (2007, 2008, 2009), NAEP (2010), EU (2007, 2008), OECD (2005) and UNESCO (2008). According to the comparison of the skills mentioned in the studies, a list of common skills is given in their study including collaboration, creativity, critical thinking, problem solving, self-direction and ICT skills.

In the light of all this important information, it is of great importance to examine the conceptions of teachers about 21st century skills that should be gained by students. In their article, Valtonen et al. (2017) indicate that today's teachers and students should have 21st century skills because of the changes in life caused by major economic developments. In order to meet the expectation of students about gaining these skills, teachers' pedagogical knowledge and ICT usage as a supporting tool for their teaching became very important. Teachers' conceptions about 21st century skills can be measured by their technological pedagogical content knowledge scale introduced as TPACK-21 by Valtonen et al. (2017) corresponding to skills that Voogt and Roblin (2012), Binkley et al. (2012) and MoNE (2017) pointed out. The items of the TPACK-21 scale assess teachers' knowledge about how to guide students' critical thinking,

creative thinking, reflective thinking, group working and self-directed learning by using information and communication technologies (Valtonen et al., 2017). Therefore, this scale is more appropriate to apply teachers giving instruction of national education than the other scales in Turkish, as they do not include the dimensions of 21st century skills. The structure and contents of the TPACK scales available were included in the next sections of the literature review.

2.3 TPACK Scales in the Literature

The first developed scale to measure technological pedagogical content knowledge belongs to Schmidt et al. (2009) named “Survey of Pre-service Teachers’ Knowledge of Teaching and Technology”. They administered the survey to 124 pre-service teachers and analyzed the data using Cronbach’s alpha statistics and factor analysis. After deleting some items based on the results, the survey remained with 47 items all having internal consistency reliability coefficients between .75 and .92. This valid and reliable scale has been very effective for examining the TPACK conceptions of teachers and to start new research on this subject (Schmidt et al., 2009). Koh, Chai and Tsai (2010) also conducted a study using the Schmidt et al.’s TPACK survey with some adaptations. They changed specific content area items as general and deleted some items not related to the study, such as pre-service teachers’ evaluations about their professors. The final version has 29 seven-point Likert-type items with five factors, which are TK, CK, KP (knowledge of pedagogy), KTT (knowledge of teaching with technology) and KCR (knowledge from critical reflection). This scale was adapted to Turkish by Karadeniz and Vatanartiran (2013) in order to apply to secondary school teachers of different subject areas which are mentioned in section 2.4.

Lastly, TPACK-21, one of the most up to date TPACK scales, was developed by Valtonen et al. (2017) aiming to ground on 21st century skills. Collaboration, problem solving, creative thinking, critical thinking, self-directed learning and ICT literacy skills are included in this six-factor scale which has a strong factorial structure. Results showed that participants need information about technology-related knowledge more. This study adapted their scale and examined teachers’ conceptions of TPACK.

2.4 TPACK Scales Administered in Turkey

There are several TPACK scales administered in Turkey which can be categorized into two groups as development studies and adaptation studies. Table 2 shows the TPACK scales developed in Turkish or adapted to Turkish from other cultures. Most of them are valid and reliable for their target group with high Cronbach's alpha values. Nevertheless, there are no twenty-first century skills related items included in those scales. Therefore, TPACK-21 scale developed by Valtonen et al. (2017) will be beneficial for TPACK studies in Turkey.

Table 2

TPACK Scales Administered in Turkey

Authors	Method used	Sample	Analysis	α	Number of Items
Öztürk & Horzum (2011)	Adapted from Schmidt et al. (2009)	291 primary school teachers	EFA, CFA	.96	47
Karadeniz & Vatanartiran (2013)	Adapted from Koh, Chai and Tsai (2010)	285 secondary school teachers	CFA	.94	18
Z. Kaya, O. Kaya, & Emre (2013)	Adapted from Schmidt et al. (2009)	407 pre-service teachers	EFA, CFA	.89	47
Canbazoğlu-Bilici, Yamak, Kavak & Guzey (2013)	Developed by the authors	808 pre-service science teachers	EFA, CFA	.98	52
Kaya & Dağ (2013)	Adapted from Schmidt et al. (2009)	352 elementary pre-service teachers	EFA, CFA	>.7	46
Karataş (2014)	Adapted from Handal et al. (2013)	138 mathematics teachers	EFA	.94	30
Akman & Güven (2015)	Developed by the authors	285 pre-service teachers	CFA	.97	55

Table 2 (cont.d)

Authors	Method used	Sample	Analysis	α	Number of Items
T. Kartal, B. Kartal & Uluay (2016)	Developed by the authors	754 pre-service teachers	EFA, CFA	.92	67
Kiray (2016)	Developed by the author	467 preservice teachers	CFA	.96	55
Balçın & Ergün (2016)	Developed by the authors	659 pre-service science teachers	EFA, CFA	.93	40
Önal (2016)	Developed by the authors	353 pre-service mathematics teachers	EFA, CFA	.97	59
Sarı & Bostancıoğlu (2018)	Adapted from Zelkowski et al. (2013)	372 classroom teachers	EFA, CFA	.97	47

Note. CFA=confirmatory factor analysis, EFA=exploratory factor analysis, α = Cronbach's alpha

Öztürk and Horzum (2011) adapt the TPACK scale developed by Schmidt et al. (2009). They administered the adapted scale to 291 primary education teachers to test the validity and reliability of the study. According to the results of factor and reliability analyses, the scale has formed seven factors and is valid and reliable. The authors explain the different psychometric properties between the original and adapted form of the scale as it may be caused from sample size, culture and language changes. They offer the adapted scale to be used for understanding the effectiveness of teacher training programs in terms of TPACK.

According to Karadeniz and Vatanartıran (2013), the importance of the knowledge about how to manage technology by corresponding its contributions and restrictions to education creates a new necessity of literacy and skills for teachers. TPACK scales measure teachers' conceptions about this necessity (use of information and communication technologies) in their classes (Tondeur et al., 2019). By adapting the TPACK survey developed by Koh, Chai and Tsai (2010) into Turkish, Karadeniz and Vatanartıran (2013) contributes to the enrichment of the Turkish literature with a reliable and valid adapted survey with five factors for secondary school teachers of different subjects.

Z. Kaya, O. Kaya and Emre (2013) also adapted a survey (Schmidt et al., 2009) of technology and teaching knowledge created for pre-service primary teachers into Turkish. Their study was conducted in order to test the validity and reliability of the adapted scale and investigate the suitability to the sample in Turkey. However, the results of the factor analysis showed that some factors are separated depending on the subject areas included in the scale. In other words, in addition to the PK, TK, TPK and TPACK factors, items that should belong to CK, PCK and TCK creates four different factors as science related, mathematics related, social studies related and literacy related factors. It was explained as there is a thought of being a good teacher in Turkey depends mostly on their content knowledge instead of TPACK. Therefore, it is indicated that this scale is not suitable to be applied to the teachers in Turkey for research studies.

Canbazoglu-Bilici, Yamak, Kavak and Guzey (2013) also conducted a study to develop a TPACK Self Efficacy Scale (TPACK-SeS) for pre-service science teachers. After the construction, validation and reliability processes, they introduced a new valid and reliable TPACK scale with eight factors to the teachers of Turkey. The differences of this scale from previous ones include the following transformative approach, measuring context knowledge (CxK) and being only for pre-service teachers.

The other TPACK scale adaptation study was conducted by Kaya and Dağ (2013). The main aim was to adapt TPACK scale of Schmidt et al. (2009) to Turkish and investigate elementary school preservice teachers' technological pedagogical content knowledge. According to the exploratory factor analysis, final version of the scale is similar to the original version in terms of factor features (10 factors). The adapted version is found valid and reliable. After adapting the TPACK scale suitable for primary preservice teachers, they suggested that TPACK of teachers in Turkey and other countries should be further examined and there is a need to develop TPACK of teachers. Karataş (2014) adapted TPACK-M scale of Handal et al. (2013) to Turkish in for using it in their study. The five-point Likert type scale with three factors is mainly focused on the mathematics content area and the reliability coefficient of the scale through Cronbach's alpha is .94 in total.

Akman and Güven (2015) developed a TPACK survey for social sciences teachers and pre-service teachers in Turkey. With the opinions of scale development

experts, they created an item pool. After preparing the survey, for the reliability and validity process, they applied it to 285 pre-service teachers. Both the Turkish and English versions of the scale are included in the article. The valid and reliable survey with seven factors can be applied to social sciences teachers and the researchers suggest adapting this scale to other subject fields.

T. Kartal, B. Kartal and Uluay (2016) conducted a study to develop TPACK Self-Assessment Scale for pre-service teachers as well. The survey development process suggested by DeVellis (2003) was followed by authors and they ended up with a seven-factor valid and reliable scale. According to the analysis of the data obtained from the 754 pre-service teachers, Kartal et al. (2016) indicated that providing weak and insufficient technology related courses in the faculties of education or teachers' lack of knowledge about how they can use technological knowledge in their teaching can be counted as reasons for the low correlation between TK and TPACK.

Another TPACK scale development study is conducted by Kiray (2016). The data was collected from pre-service teachers and used in the process of EFA and CFA. According to the results, the scale he developed is valid with seven factors and is reliable because there is a significant difference between the upper and lower groups which means that items have discriminating power. The scale is specific to the science area and includes scientific inquiry skills, process skills, etc. One of the most important features of this survey is that the technology part items are categorized from traditional to brand new technologies which make the scale a long-term scale because of its adaptation to changes. The Turkish and English versions of the scale included in the article.

Balçın and Ergün (2016) investigated pre-service science teachers' TPACK on material development by using the scale they developed. With this valid and reliable scale, the skills of teachers on developing materials can be improved by determining the weak sides of their technological pedagogical content knowledge. The author also suggests that some qualitative researches can be conducted in order to identify the missing dimensions of science teachers. The Turkish form of the TPACK self-efficacy scale developed by Balçın and Ergün (2016) can be noticed in their article.

Önal (2016) developed a nine-factor valid and reliable scale for measuring mathematics teachers' technological pedagogical content knowledge named TPACK-Math. The author suggested that this scale can be applied to teachers both in-service and pre-service. He also mentions that the scale can be adapted to other areas in future studies. The scale is given in both languages in the article published by Önal (2016).

Sarı and Bostancıoğlu (2018) conducted an adaptation study adapting “TPACK Instrument for Secondary Mathematics Pre-service Teachers” (Zelkowski et al., 2013) to Turkish. After translating processes of the sixty-two five-point Likert-type items, they administered it to 372 classroom teachers. EFA analysis suggested four-factor solution as knowledge of teaching mathematics with technology (KTMT), Knowledge of teaching mathematics (KTM), content knowledge for mathematics (CKM) and technology knowledge (TK). The internal consistency value Cronbach’s Alpha of the scale is found .97. It is recommended by the authors that a larger sample should be administered to get a better outcome.

According to Mtebe and Raphael (2018), during their use of ICT in 21st century teaching environment, teachers should need to consider pedagogical approaches. They found it important to measure teachers’ confidence in using ICT in their teaching. Although there are a lot of scales measuring TPACK of teachers as mentioned, there is a need to have a TPACK scale examining 21st century skills in Turkish. Shafie, Majid and Ismail (2019) state that teachers are expected to teach not only subject matter area but also 21st century skills. Unfortunately, not all teachers have a chance to take training for that purpose. It is crucial to examine whether they understand and teach those skills when integrating technology into their classroom settings. TPACK-21 scale measures teachers’ perception about their integration of 21st century skills within technology, pedagogy and content knowledge. For this reason, this study has an important role due to its contribution to future research studies about teachers’ integration of 21st century skills into their classroom by enhancing their technological pedagogical content knowledge and about teacher education or in-service trainings in Turkey.

Comparing the items of the mentioned TPACK scales and of the TPACK-21 scale will be beneficial for showing the difference of TPACK-21 scale. As it can be seen in the TK items from the scales conducted before stated in the Table 3, being able

to use essential programs is a necessity. Besides, TPACK-21 scale includes technological knowledge items examining knowledge of the latest technology, such as “*I am familiar with new technologies and their features*”. N. Bitner and J. Bitner (2002) emphasize the importance of technological training for teachers about new and different hardware and software. This study focuses especially on new technologies for TK related items.

According to the International Society for Technology in Education (ISTE) standards (2017), educators are the facilitators who should “Manage the use of technology and student learning strategies in digital platforms, virtual environments, hands-on makerspaces or in the field” (p.2). There are many criteria for the 21st century teachers which include using technology for better teaching and learning environment. In this sense, the level of technological knowledge of teachers and measuring it is important.

Table 3

Sample TK Items from TPACK Scales in Turkey

-
- I can choose appropriate technological tools (Canbazoğlu- Bilici et al., 2013).
 - I am able to use technology to make calculations on a spreadsheet (Karataş, 2014).
 - Using Office programs (Like Word, Excel, and PowerPoint) (Akman & Güven, 2015).
 - I can use spreadsheets (e.g. Microsoft Excel) (Kartal et al., 2016).
 - Using the essential software programs (Word, Excel, and PowerPoint etc.) (Kiray, 2016).
 - Ability to choose appropriate technologies to be used for instructional purposes (Önal, 2016).
-

The difference of the TPACK-21 scale from other scales is that it has items including 21st century skills. It can be seen in the Table 4 that, for the pedagogical knowledge items, most of them are similar as they measure the essential points of pedagogical knowledge, such as instructional strategies. It is very important to have

the knowledge of pedagogy and applying it in the classroom for students' learning. Most of the PK items in TPACK scales includes teachers' knowledge of classroom management, teaching methods and assessment strategies which are mentioned in Voss, Kunter and Baumert (2011) study. However, beyond the general pedagogical knowledge items, the TPACK-21 scale has PK items as “*Supporting students' critical thinking*” or “*Supporting students' reflective thinking*”. As Valtonen et al. (2017) stated, in order to assess 21st century skills, there are limited scales compared to tools and tasks. Pedagogical approaches as active learning, collaboration and reflective thinking let them develop a new TPACK scale grounded on 21st century skills. 21st century skills as critical and reflective thinking are included in the items of TPACK-21 scale. The main scope of this study is teachers' knowledge but especially grounded on 21st century skills.

According to the report published by the Ministry of National Education (2017) in Turkey, teachers need to have the advanced knowledge of theoretical, methodological and factual knowledge on their content area. Content knowledge is investigating in the test applied by the state Public Personnel Selection Examination (KPSS) in order to start teaching in public schools in Turkey. For most of the teaching branches, the score of the content knowledge has the biggest effect on the total score (H. Karaer, F. Karaer & Kartal, 2018). Measuring CK of teachers is crucial.

Table 4

Sample PK Items from TPACK Scales in Turkey

-
- I can use a variety of instructional strategies effectively (Canbazoglu-Bilici et al., 2013).
 - Implementing the different teaching strategies (Akman & Güven, 2015).
 - I think I can use teaching practices, strategies and methods effectively. (Kartal et al., 2016).
 - Using different teaching strategies (verbal learning, discovery learning, inquiry-based learning, etc.) (Kiray, 2016).
 - Ability to use the best instructional strategy and method for teaching a particular concept (Önal, 2016).
-

In general, teachers' knowledge of the fundamental concepts and ability to use of that knowledge are investigated in CK items. On the other hand, while measuring CK of teachers, some TPACK scales examine it for a specific content area, such as science, mathematics as seen in Table 5. The original version of the TPACK-21 scale is content specific which is "natural sciences" but the developers state that it can be changed for other areas. Therefore, in its Turkish version, it is changed as science and mathematics, such as "*Developing contents in science / mathematics.*" The reason is that the sample consists of science and mathematics teachers in Turkey. Yet, measuring only CK of teachers is not sufficient for efficient teaching, it should be considered with other dimensions of TPACK.

Table 5

Sample CK Items from TPACK Scales in Turkey

-
- I can explain various chemistry concepts. (Canbazoglu-Bilici et al., 2013).
 - Content knowledge related with Individual and Society learning domain (Akman & Güven, 2015).
 - I think I have enough knowledge in my content area. (Kartal et al., 2016).
 - Adequate content knowledge of physics for my profession (Kiray, 2016).
 - Ability to use existing knowledge about mathematical subjects (Önal, 2016).
-

Selecting appropriate teaching techniques and methods for a content area is predominant at measuring PCK of teachers as can be seen in Table 6. MoNE (2017) emphasizes teaching and learning strategies and assessment methods in the report of the "*General Competencies for Teaching Profession*". Since it is important that teachers' ability to use and compare the techniques appropriate for her/his teaching subject, measuring their PCK make sense in studies. Especially, since the TPACK framework constructed on PCK, TPACK scale should include PCK items.

For measuring the pedagogical content knowledge of teachers, TPACK-21 scale focuses again on 21st century skills. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2011), integrating ICT to the classroom effectively depends on some abilities of teachers' including encouraging students to work collaboratively as a group. A PCK item "*In science/ mathematics, guiding students' content-related problem solving in groups*" from TPACK-21 scale

shows again its emphasis on the teachers' role in students' 21st century skills, for instance.

Table 6

Sample PCK Items from TPACK Scales in Turkey

-
- I can teach science and technology courses according to theoretical framework of national curriculum. (Canbazoglu-Bilici et al., 2013).
 - Selecting teaching strategies which are convenient to achievements related with Social Studies (Akman & Güven, 2015).
 - I think I can use teaching methods (e.g. collaborative learning, problem solving, demonstration, inquiry-based learning, discussion, lecturing, case study...) specific to my content area. (Kartal et al., 2016).
 - Deciding on the appropriate teaching technologies for different learning areas of Sciences (physics, chemistry, biology, astronomy) (Kiray, 2016).
 - Ability to determine instructional strategies, methods and techniques suitable for mathematical subjects (Önal, 2016).
-

As for all of the other parts of the TPACK-21 scale, TPACK items are including 21st century skills, such as critical thinking, creative thinking, problem solving, etc. For example, “*In teaching mathematics, I know how to use ICT as a tool for students' creative thinking*” is a TPACK item from TPACK-21 scale. Table 7 illustrates sample TPACK items from other scales in Turkey. Items from previous TPACK scales are examining teachers' knowledge and use of technological tools in a specific content area and their impact on students' learning environment. The difference of TPACK-21 scale can be seen in this part as for the other parts of the scale. The reason why this study adapts this scale is the importance of 21st century skills of students.

Table 7

Sample TPACK Items from TPACK Scales in Turkey

-
- I can apply my technological knowledge, content knowledge, and pedagogical knowledge all together to create an effective learning environment (Canbazoglu-Bilici et al., 2013).
 - Using computer aided technologies which are convenient to different learning content of social studies course (Akman & Güven, 2015).
-

Table 7 (cont.d)

<i>Sample TPACK Items from TPACK Scales in Turkey</i>
• I think I can decide which technologies affect positively teaching and learning. (Kartal et al., 2016). • Integrating the outcomes of science with appropriate strategies, methods, techniques and technologies? (Kiray, 2016). • Ability to take into account mathematical contents, learning-teaching strategies and relevant new technologies during lesson planning. (Önal, 2016).

The TPACK scales administered in Turkey and their sample items were illustrated in order to be able to observe their similarities and differences from TPACK-21 scale. The main feature of the TPACK-21 scale different than these scales is being grounded on 21st century skills pedagogically.

Chapter 3

Methodology

This chapter explains the research design and gives information about the characteristics of participants, procedures and limitations.

3.1 Research Design

This research is the adaptation study of a scale named “The Technological Pedagogical Content Knowledge for Twenty-First Century Skills (TPACK-21)” developed by Valtonen, et al. (2017) to determine the TPACK of teachers, by applying it to science and mathematics teachers and adapting it to Turkish. In order to adapt the scale, some steps were considered such as, permission from the developers, translation and back translation, expert opinions to make the linguistic equivalence, collecting the data, and conducting reliability and validity analyses. With the validation and reliability process, evidence to the appropriateness of the scale to teachers in Turkey is provided. In addition, according to the data collected from the sample, descriptive results were provided as well.

3.2 Participants

In order to obtain data, the survey was sent to science and mathematics teachers in the second term of the 2019-2020 academic year. During the data collection process, teachers were giving lessons online because of the global pandemic. Therefore, they completed the survey in an online platform, voluntarily. The convenience sampling method was used in which the sample can be defined as people who are easy to access by the researcher in terms of availability (Lavrakas, 2008; Fraenkel, Wallen & Hyun, 1993).

The total number of the participants of the study was 309 consisting science and mathematics teachers who are teaching at secondary schools or primary schools. They were asked about their workplace as public schools, private schools, private study centers or other educational institutions. Based on their demographic information, the

characteristics of the sample can be seen in Table 8 in terms of their gender, years of experience, subject area, faculties graduated from and institutions they teach. According to the National Education Statistics (2020) that MoNE in Turkey published, 60.3 percent of teachers are female. Therefore, it can be considered that the percentages of male (30.7%) and female (69.3%) teachers in the sample of this study was representative for the population. The number of mathematics teachers and science teachers participating in the study was very close to each other. Also, among the participants, the number of teachers working in private schools and teachers working in public schools were almost equal. Lastly, almost half of the participants were teachers in their first five years of their experience (49.5%). And more than half of the sample were teachers graduated from education faculties (63.1%).

Table 8

The Characteristics of the Sample

Characteristics	n	%	Characteristics	n	%
Gender			Faculty graduated		
Female	214	69.3	Education	195	63.1
Male	95	30.7	Other faculties	114	36.9
Subject area			Institution		
Primary Mathematics	65	21	Public School	127	41.1
Primary Science	57	18.4	Private School	123	39.8
Secondary Mathematics	92	29.8	Private Study Center	45	14.6
Secondary Science	95	30.7	Other	14	4.5
Years of teaching experience					
1-5 years	153	49.5			
6-15 years	94	30.4			
16 years or more	62	20.1			

3.3 Procedures

Çüm and Koç (2013) listed the steps of scale adaptation process according to the suggestions of Hambleton and Patsula (1999); Hambleton, Merenda and Spielberger (2005). In this study, the following steps were followed in order:

- Firstly, it was decided that adapting the TPACK-21 scale will be more useful than developing a new scale as the reasons were explained in the significance of the study.
- Permission was obtained from the developers of the TPACK-21 scale to adapt it to Turkish.
- The structural equivalence of the scale was ensured, i.e. the meaning of the items and concepts in the original scale is the same when it was translated into Turkish and applied to Turkish culture.
- Highly qualified experts in both languages were asked to help in translating the scale and giving feedback to the final version.
- The scale was translated into Turkish. An English language instructor who has a master's degree in educational technology translated the survey English to Turkish. The first draft of the scale was sent to a group including seven mathematics teachers, three science teachers and an academician to receive their feedback about the items. After preparing an excel sheet including both Turkish and English versions of items, it was sent to three different experts in language, working at the top universities in Turkey and have a good command of both languages. They gave feedback about the translation. One of the experts made the back translation of the Turkish items to English.
- After evaluating at what degree the Turkish translations of the items met the meaning and correcting the mistakes, the last versions of the items were included the scale with minor changes.
- The adapted scale was administered to 309 science and mathematics teachers in Turkey.
- The descriptive, validity, reliability and item analyses were done with the data obtained from the sample.

3.3.1. Data Collection Instrument

The scale adapted to Turkish was a survey named “Technological Pedagogical Content Knowledge for Twenty-First Century Skills (TPACK-21)” developed by Valtonen et al. (2017). The developers of the scale indicate that the development of the TPACK-21 scale was a long process starting from 2013. They reviewed the existing TPACK scales first and created a draft based on them. The 21st century skills were added to pedagogical knowledge related items i.e., PK, PCK, TPK, TPACK by benefiting from Schmidt et al (2009) scale for TPACK items and added some 21st century skills involved TPACK items. After deciding on 86 items, in the development process, the scale was administered to the sample (n=96) calling this step as Study 1 (Valtonen, Sointu, Siegl & Kukkonen, 2015). Based on the results of Study 1, some statements were re-written, and some were removed to be administered in Study 2 (n=267). According to the descriptive statistics and exploratory factor analysis of the data, the quality of TPACK-21 scale was improved (Valtonen et al., 2015). Worthington and Whittaker (2006) emphasize the necessity of using factor analyses to test new instruments. Therefore, the TPACK-21 scale was updated to be validated by using CFA by Valtonen et al. (2017). The final version of TPACK-21 scale has 38 items.

In this study, it was asked to the developers of the TPACK-21 scale if it can be adapted to Turkish and administered to the teachers in Turkey. After receiving permission and the completed survey from the owners of the scale, it was adapted and administered to science and mathematics teachers in Turkey. The consent mail from the authors can be seen in Appendix B. The developers explained that for the pedagogy related items, they used only 21st century skills including ones, hence resulted in 38 items in total.

In the Turkish version of the scale, the title was changed as “21. Yüzyıl Becerileri İçin Teknolojik Pedagojik Alan Bilgisi (TPAB-21)”. The original version was specific to the content area of “natural sciences” but Valtonen et al. (2017) state that it can be changed for other content areas. In order to obtain data from science and mathematics teachers, the items related to the content knowledge were changed as the areas of

science and mathematics. According to the results of the analysis, with one CK item removal because of the its low correlation (.53) between CK factor and its load on more than one factor, the final version consists of 37 items in total.

The survey is a 6-point Likert type in which 1 represents the statement “I need a lot of additional knowledge about the topic” (*Konu hakkında çok fazla ek bilgiye ihtiyacım var*) and 6 represents “I have strong knowledge about the topic” (*Konu hakkında oldukça yeterli bilgim var*). The survey starts with informative explanations about the study and informed consent for participants, including that the data obtained from the participants will be used only for research purposes, participation is voluntary, they can leave the survey at any time and their names will not be asked. In the next part of the survey, there are some definitions of 21st century skills to make the concepts clear. Table 9 includes the definitions placed at the beginning of the original scale by Valtonen et al. (2017). These definitions were also given in the adapted Turkish form:

Table 9

The Definitions Given in the Survey

Information and communication technology (ICT)

All devices including computers, smartphones, tablets and software, applications, social media, online learning environments.

Reflective thinking

The ability of evaluating the reliability of information and comparing different sources of information

Self-directed Learning

Awareness of individuals’ own learning, ability and studying.

Problem solving

Skills consisting of solving problems and tasks that have not been encountered before by deduction and combining previous knowledge and experiences.

Creative thinking

The ability to create a new thing by using individuals’ own skills and combine different sources of information.

Critical thinking

The ability to learn and investigate the reliability of information and making comparisons between different sources.

The prepared survey consists of five parts with thirty-eight items and was prepared on an online survey platform then it was sent to the participants via the link connected to the survey. After the informed consent form and written explanations at the beginning of the survey, 4 questions aiming at determining the demographic characteristics (gender, subject area, grade levels they teaching, kinds of schools they teaching, years of experience and faculties they graduated from) of the participants included in the study were asked. The other pages of the survey start with an instruction about the items and examine teachers' conceptions about the components of TPACK. The instructions include explanations of how teachers should think and decide while answering the items at each part. For example, before the PCK items, there is a statement as; *"Evaluate the following items in the context of your knowledge of teaching Mathematics / Science"*.

In the Turkish form of the scale, the seven items measuring pedagogical knowledge were named as PB1 to PB7 by using the first letters of its' Turkish name "Pedagogik Bilgi". Likewise, three items for content knowledge, AB1 to AB3 (Alan Bilgisi); four items for technological knowledge, TB1 to TB4 (Teknoloji Bilgisi); six items for pedagogical content knowledge, PAB1 to PAB6 (Pedagogik Alan Bilgisi); four items for technological content knowledge, TAB1 to TAB4 (Teknolojik Alan Bilgisi); six items for technological pedagogical knowledge, TPB1 to TPB6 (Teknolojik Pedagoji Bilgisi); and seven items for technological pedagogical content knowledge named as TPAB1 to TPAB7 (Teknolojik Pedagogik Alan Bilgisi).

After analyzing the data, it is found that the adapted form of the scale has 6 factors and 37 items: 7 PK items, 3 CK items, 4 TK items, 6 PCK items, 4 TCK items, 6 TPK items, 7 TPACK items. The internal consistency of the scale was determined using the Cronbach's alpha reliability coefficient and was found as .97.

3.3.2. Data Collection Procedures

There are many studies conducted about TPACK of teachers and pre-service teachers in Turkey. After deciding to adapt TPACK-21 scale to Turkish and contribute to the enrichment of the TPACK literature a different perspective, 21st century skills, the procedure of data collection was decided. There are some steps followed in this study for data collection process according to the suggestions of Creswell and Clark

(2017). First of all, it was decided that the participants will be science and mathematics teachers in Turkey because of their convenience. The data were collected in the second term of the 2019-2020 academic year in Turkey.

Delivering the survey to teachers was a little challenging, as the transition to the online system in education was made due to the global Covid-19 outbreak. After the coronavirus cases seen in Turkey, K-12 schools changed their education process as online distance education (Telli & Altun, 2020). Therefore, the survey was prepared on an online survey tool and the link was sent to science and mathematics teachers via mail, social media etc. Teachers were informed about the aim of the research at the beginning of the survey. It is also indicated that it is of their own volition to complete the survey. Therefore, their consent was obtained by explaining that the data collected will be used only for scientific purposes. 309 of the teachers responded to the survey and their answers were recorded.

3.3.3. Data Analysis Procedures

The psychometric properties of scales should be considered in adaptation studies for demonstrating that the adapted version of the scale has construct validity and internal consistency. In this study, after collecting data from participants, it was cleared from outliers. To make sure that factor analysis can be conducted on the data set, Bartlett and KMO tests were done. Then validity and reliability analyses were done in order.

Urdan (2001) suggests using factor analysis and reliability analysis for social sciences research which including a scale with more than one item. In this study, first of all, the scores of participants were transformed to z-scores. The outliers that are not between the values -3 and +3 were removed from the data set. With the subtraction of 4 participants' responses to the survey, the analysis process was carried out with 305 responses. To conduct the factor and reliability analyses, SPSS v23 and Amos v25 were used. By using Amos, CFA was conducted for construct validity. Then, by using SPSS, to determine the reliability of the scale, Cronbach's Alpha coefficient, item-total correlations for upper and lower groups, and t-test were conducted. The descriptive statistics were investigated in terms of related demographics of participants as well.

George and Mallery (2002) state Cronbach's Alpha values larger than .90 are accepted as excellent in terms of reliability. Thompson (2004) indicates, reliability is necessary but not sufficient condition for validity. Factor analysis can be used to test construct validity when a scale is developed or adapted. The used confirmatory factor analysis (CFA) tests the factor models clearly (Thompson, 2004) and verifies the factor structure (Suhr, 2006). Researchers should have some expectations from factor analysis, such as the number of factors, which item belongs to which factor or if there is a correlation between the factors. In this study, it was tried to reach the same factor structure as found in the development study of the scale.

Confirmatory factor analysis tests and verifies how the factor structure of a scale fits the data to the hypothesized model (Uysal, 2020). Since it derives from the theoretical framework and analysis of the model, besides being confirmatory, CFA is actually exploratory to some extent (Gerbing & Hamilton, 1996). The most important difference of confirmatory factor analysis (CFA) from exploratory factor analysis (EFA) is possibly that it is more flexible than the classical test theory's assumption that there is no correlation between errors involved in measurement. From this point of view, EFA seems more appropriate for scale development process and CFA for adaptation process (Güngör, 2016). Scale development studies generally use EFA in order to explore the factor structure of the scale, whereas CFA is used in both development and adaptation studies for the purpose of confirming the structure determined by EFA. It is necessary to use CFA while deciding if the adapted form of the scale has differences from original version in terms of factor structure (Akçay, Gelen, Tiryaki & Benek, 2018). The theoretical framework of TPACK has already presented its subcomponents as PK, CK, TK, PCK, TPK and TCK. The factor structure explored in the development of the TPACK-21 scale was found as the same with these subcomponents. Since the original scale has a theory and the number of factors is known beforehand, and also the items on the scale do not have a cultural link, this adaptation study considers using CFA in order to verify the factor structure and theoretical framework defined in the original study. The expectation from the analyses was evidence to suitability of the adapted version of the scale to teachers in Turkey.

In order to make sure that the data set is suitable for conducting CFA, Barlett test and the Kaiser-Meyer-Olkin (KMO) test were applied. As can be seen in Table 10, KMO test values were determined as 96 percent (.96) and this value indicates that the

data set is suitable for factor analysis. Barlett test significance value was found as .00 and can be considered as statistically significant. It also shows that there is a high correlation between variables and that the data set is suitable for factor analysis (Tabachnick & Fidell, 2007).

Table 10

<i>Results of KMO and Bartlett's Test</i>		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.96
Bartlett's Test of Sphericity	Approx. Chi-Square	10044.80
	df	703
	Sig.	.00

After being sure that the data set is suitable for CFA, it was conducted by using AMOS. The results of the chi-square statistics and fit indexes are the evidence to decide whether the factor model confirmed or not. Chi square/degrees of freedom (χ^2/df) value changes based on the sample covariance matrix and sample size and values between 2 and 1 or 3 and 1 are considered as acceptable values (Carmines & McIver, 1981, as cited in Aşık, 2009). However, since the chi-square value is very easily affected by the sample size, other goodness of fit indices was produced. Root Mean Square of Approximation (RMSEA) assumes equal correlation distribution to test hypothesis and if it is smaller than .08 it shows a good fit (Karademir, 2013). Goodness of Fit Index (GFI) value is an indicator of the comparison that can be done in two different models tested in the same sample. The GFI value is expected to be .90 and above in general (Kline, 2005; Huck, 2012) but the values between .80 and above are acceptable as well (Akman & Güven, 2015). To compare the absolute fit for the specified model with the independence model, Tucker-Lewis Index (TLI) and Comparative Fit Index (CFI) are used (Malkanthe, 2015). TLI and CFI values in the range of .94 - .90 and .90 - .95 respectively have acceptable fits (Kiray, 2016; Akman & Güven, 2015).

3.4 Limitations

This study adapts the TPACK-21 scale to Turkish with the aim of contribution to the enrichment of the TPACK literature. However, there is a limitation caused from reasons beyond control. Starting in March, the increasing number of Covid-19 cases in Turkey was the most important factor that limits accessing to more participants (Budak & Korkmaz, 2020). As in the many countries, Turkey suspended the education in order to support the call “stay at home”. Then, distance education started in order to compensate and complete the academic year (Üstün & Özçiftçi, 2020). All data were collected via an online survey tool because teachers were working from home due to the global pandemic. Therefore, the sample size can be accepted as a limitation. Although the statistical results show that sample size is enough and appropriate for conducting factor analysis and reliability analysis, it could have been more teachers as participants if this compelling situation would not happen.

Chapter 4

Results

This chapter represents the results reached from analyses of the data. The first section includes the construct validity evidence obtained from confirmatory factor analysis. In the second section, the results of the item analysis were stated. For the reliability analysis of the scale, Cronbach's Alpha value and item-total correlations were included in the third section.

4.1 Results of Descriptive Analysis

The TPACK-21 scale is 6-point Likert type and the item points are ranged between 1 to 6. The mean scores for each factor given in Table 11 shows that teachers feel confident about each component of TPACK structure. In more detail, teachers' view of their PK has the highest mean value 4.91 (SD= .94) but the CK has the lowest ($\bar{X}$ =4.42, SD=1.14). Moreover, the correlations between the factors show the importance of improving a knowledge area may affect the level of another knowledge component of TPACK of teachers.

Table 11

Correlation Matrix of TPAB-21 Factors, Means ($\bar{X}$) and Standard Deviations (SD)

	PK	CK	TK	PCK	TCK	($\bar{X}$)	SD
PK						4.91	.94
CK	.80					4.42	1.14
TK	.60	.71				4.84	.98
PCK	.91	.72	.52			4.85	.93
TCK	.65	.73	.85	.80		4.81	.91
TPK	.68	.66	.69	.79	.85	4.69	.97

On the other hand, some demographic information was also asked to teachers. According to collected demographic information from the sample, the mean scores of gender, subject area, institution, teaching experience and graduated faculties groups

were examined. Teachers were expected to answer the items of the scale according to their self-report on their knowledge. Since the mean score are between 4 and 5 for each group with small standard deviations, it can be said that teachers generally feel confident about their TPACK. In other words, the mean scores are between “4: *I have some knowledge*” and “5: *I have good knowledge*”. According to responses of gender groups, the mean score of males is closer to “5: *I have good knowledge*” than females. Similarly, science teachers from both levels of education have the highest mean score among all the other groups with 4.90, i.e., they believe their knowledge of technology, pedagogy and content is quite enough. Mean scores of teachers according to their institutions showed that private school teachers ($\bar{X}$ =4.88, SD=.68) have the closest value to “5: *I have good knowledge*” among other institutions. Finally, views of teachers from education faculties and other faculties have almost the same mean values 4.74 (SD=.71) and 4.73 (SD=.75) respectively.

Table 12

Mean Scores of Related Groups

Variable	n	$\bar{X}$	SD
Gender			
Female	214	4.68	.74
Male	95	4.87	.69
Subject area			
Primary Mathematics	65	4.56	.74
Primary Science	57	4.90	.55
Secondary Mathematics	92	4.58	.74
Secondary Science	95	4.90	.75
Institution			
Public School	127	4.69	.70
Private School	123	4.88	.68
Private Study Center	45	4.52	.80
Other	14	4.53	.94
Years of teaching experience			
1-5 years	153	4.67	.74
6-15 years	94	4.70	.71
16 years or more	62	4.74	.73
Faculties graduated			
Education faculties	195	4.74	.71
Other faculties	114	4.73	.75

4.2 Results of Confirmatory Factor Analysis

Interpreting the goodness of fit indices and factor loadings according to the results of confirmatory factor analysis determines the validity of the adapted scale. Confirmatory factor analysis is more useful than exploratory factor analysis as it tests the theory directly and measures the model fit in several ways (Thompson, 2004). Valtonen et al. (2017) show the factor structure of the original version of the scale as 6 factors including PK items, TK items, CK items, PCK items, TCK items and TPK items. They removed the TPACK factor from the model and indicated it as latent entity of the other factors due to the fact that it may have strong relationships with all the other factors.

By using AMOS, the factor structure and framework explored in the development study were tested in this study. According to the results reached through the CFA, the low correlation (.53) between the item belongs to content knowledge “I know the basic theories and concepts of mathematics/ science” (*Matematikteki/Fen Bilimlerindeki teori ve kavramları bilme*) and its factor, it was removed from the model. Adding a correlation between related items under the same factor is acceptable if it is consistent with the theoretical framework. Based on this fact, correlations between errors $e2 \leftrightarrow e3$, $e4 \leftrightarrow e5$, $e15 \leftrightarrow e16$ and $e29 \leftrightarrow e30$ were added because of having high modification indices as 42.28, 21.09, 13.94 and 40.22 respectively. Figure 2 illustrates the confirmatory factor model of the scale by demonstrating the relation of each item with its factor.

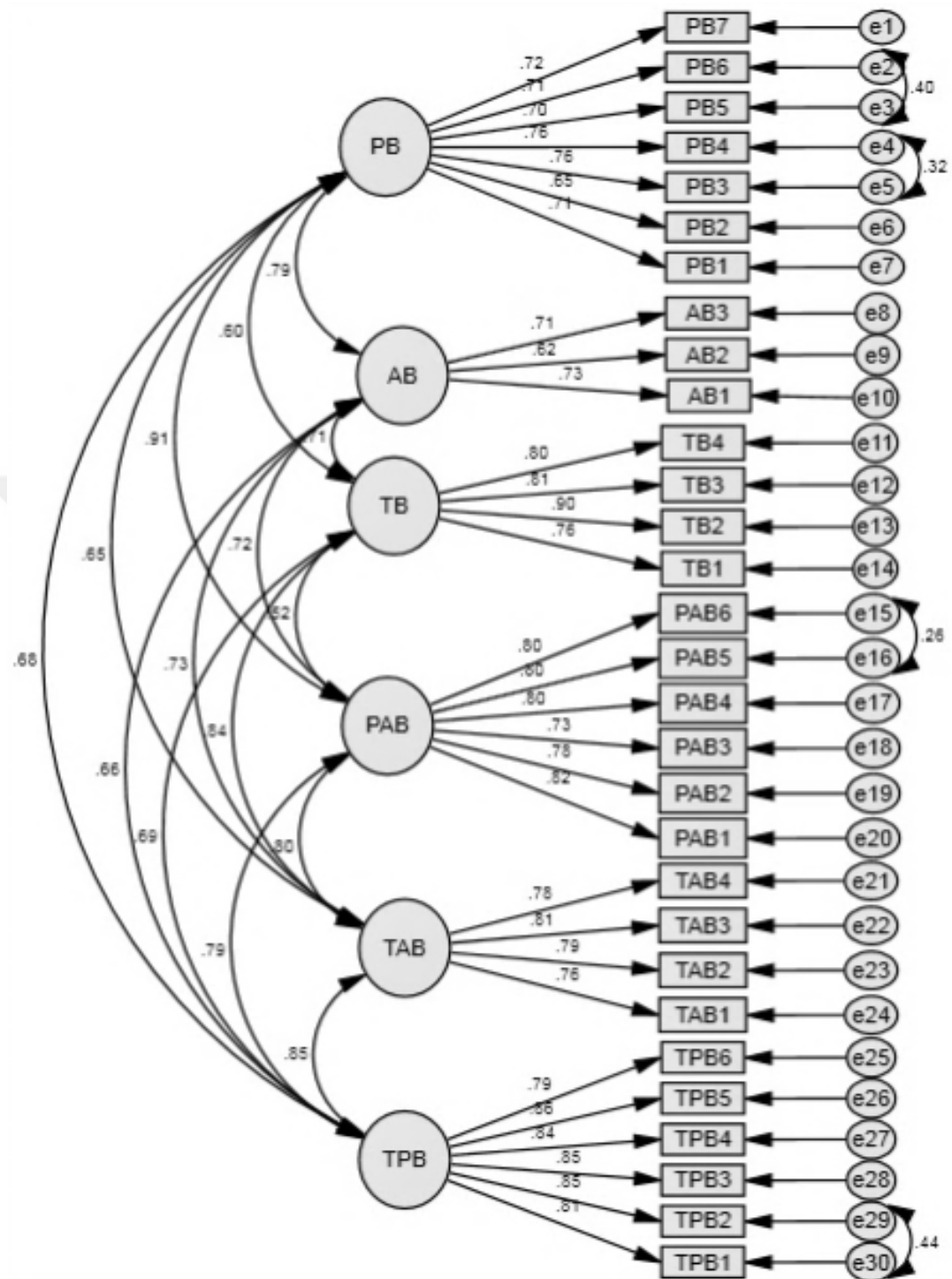


Figure 2. Confirmatory Factor Model of TPAB-21 Scale

According to the outputs obtained from CFA of the model in Figure 2, CMIN/DF (χ^2/df) value and goodness of fit indices were interpreted in order. In this study, with

the values of χ^2 (933,188) and df (386), χ^2/df was found as a good value (2.42). Similarly, the RMSEA value found as .068 in this study is acceptable.

According to the outputs obtained as a result of the analysis made in this research, the GFI value was found to be .83 as acceptable. Lastly, TLI (.91) and CFI (.92) values obtained from the analysis of this study have an acceptable adaptation.

Table 13

The Fit Indices of Factor Analysis

$\chi^2/df (\leq 3)$	.80<GFI<.89	.90<CFI<.95	.90<TLI<.94	RMSEA (<.08)
2.42	.83	.92	.91	.068

The results of the confirmatory factor analysis provide evidence to the validity of TPAB-21 scale. Table 13 shows all the fit indices that are acceptable, and which resulted in a valid adapted TPACK-21 scale which is suitable for science and mathematics teachers in Turkey. The final version of the scale was confirmed with six factors (PB, AB, TB, PAB, TAB, TPB) as in the original study not including TPACK as a separate factor.

4.3 Results of Item Analysis

After the factor analysis phase, the total scores were ranked from the lowest to the highest and the participants with the highest score ($n_1= 82$) according to the 27% segment are labeled as the upper group, while the participants with the lowest score ($n_2= 82$) are labeled as the lower group. Independent samples t-test was used to find whether there is a statistically significant difference between the upper and lower groups for each item.

Moreover, the mean ($\bar{X}$) and standard deviation (SD) of each item and Pearson correlation coefficient (r) of item-total correlation was calculated. It was found that there is a statistically significant difference between the mean scores of the groups. Table 14 shows the results of the item analysis. The r values of Pearson correlation coefficient indicate the correlation between each item's score and the total.

Table 14

Item Analysis Results

Items	$\bar{X}$	SD	t-test	r
AB1	4.47	1.31	-13.29*	0.75
AB2	4.33	1.29	-10.25*	0.66
AB3	4.51	1.23	-10.85*	0.70
PB1	4.81	1.21	-11.63*	0.73
PB2	4.98	0.99	-8.24*	0.60
PB3	4.79	1.10	-12.78*	0.75
PB4	4.71	1.17	-13.62*	0.75
PB5	5.12	0.91	-11.25*	0.71
PB6	4.94	1.02	-12.34*	0.73
PB7	4.63	1.05	-13.94*	0.79
PAB1	4.79	1.14	-17.39*	0.83
PAB2	4.79	1.05	-14.31*	0.79
PAB3	4.99	1.01	-14.14*	0.76
PAB4	4.71	1.16	-15.78*	0.80
PAB5	4.60	1.14	-15.10*	0.82
PAB6	4.76	1.12	-15.79*	0.83
TB1	4.74	1.13	-13.23*	0.79
TB2	4.84	1.19	-14.25*	0.77
TB3	4.96	1.07	-12.31*	0.72
TB4	4.73	1.18	-11.46*	0.71
TAB1	4.73	1.16	-13.17*	0.73
TAB2	4.68	1.11	-14.09*	0.76
TAB3	4.94	1.02	-15.26*	0.81
TAB4	4.67	1.15	-14.61*	0.81
TPB1	4.61	1.18	-15.91*	0.83
TPB2	4.54	1.22	-16.50*	0.86
TPB3	4.76	1.17	-16.17*	0.85
TPB4	4.70	1.16	-15.40*	0.83
TPB5	4.68	1.17	-17.51*	0.87
TPB6	4.65	1.15	-14.20*	0.83
TPAB1	4.83	1.10	-13.31*	0.79
TPAB2	4.57	1.19	-16.63*	0.84
TPAB3	4.57	1.15	-12.70*	0.79
TPAB4	4.71	1.10	-15.67*	0.85
TPAB5	4.63	1.14	-16.02*	0.86
TPAB6	4.73	1.13	-15.70*	0.84
TPAB7	4.65	1.17	-14.53*	0.84

*The values are significant at $p=.01$ level.

4.4 Results of Reliability Analysis

In statistics, internal consistency gives information about the independence of a scale from random error and Cronbach's Alpha is the most used statistic to measure internal consistency. The Cronbach's Alpha value of TPAB-21 scale was found .971 as can be seen in Table 15 which is accepted high since it is preferred to have the values above .80 (Pallant, 2010).

Table 15

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.971	.972	37

Item total statistics indicates the correlation between each single item and the total score (Takunyacı et al., 2019). According to the correlation coefficients of items and total in Table 16, all of the values are above .40 which means there is no item that is irrelevant to the scale. As Gliem J. and Gliem R. (2003) state, the corrected item-total correlation between each item and total scores should be at least .40. Looking at the Cronbach's Alpha values if the corresponding item is deleted, it is decided that there is no need to delete any item because none of them is larger than .971 (Pallant, 2010). Therefore, the scale has good internal consistency.

Table 16

Item-Total Statistics

	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PB1	0.61	.971
PB2	0.51	.971
PB3	0.63	.971
PB4	0.64	.971
PB5	0.60	.971
PB6	0.61	.971
PB7	0.66	.971
AB1	0.57	.971
AB2	0.52	.971
AB3	0.56	.971
TB1	0.65	.971
TB2	0.65	.971
TB3	0.59	.971
TB4	0.57	.971
PAB1	0.73	.970
PAB2	0.70	.970
PAB3	0.64	.971
PAB4	0.70	.970
PAB5	0.74	.970
PAB6	0.74	.970
TAB1	0.63	.971
TAB2	0.69	.970
TAB3	0.73	.970
TAB4	0.73	.970
TPB1	0.74	.970
TPB2	0.80	.970
TPB3	0.78	.970
TPB4	0.74	.970
TPB5	0.78	.970
TPB6	0.77	.970
TPAB1	0.72	.970
TPAB2	0.77	.970
TPAB3	0.72	.970
TPAB4	0.77	.970
TPAB5	0.80	.970
TPAB6	0.76	.970
TPAB7	0.78	.970

Chapter 5

Discussion and Conclusions

In this chapter, the answers to the research question are discussed and concluded. The final part includes suggestions for future studies.

5.1 Discussion

This study mainly aimed to adapt the TPACK-21 scale developed by Valtonen et al. (2017) to Turkish for further investigation on teachers. Some steps were taken during the adaptation process. Items in the scale do not include any cultural link and the terms used in the scale are the common ones in educational literature. In the original scale, there is a statement as “The CK in this TPACK-21 questionnaire is always content specific, i.e., sciences in this case, but it can be changed for other contents, e.g., mathematics, languages, physical education” (Valtonen et al., 2017, p.30). Therefore, it was changed as science and mathematics in this study. By taking into consideration these properties, the translation and back translation processes have been done carefully by obtaining experts’ opinions. After deciding the final Turkish version, it was administered to 309 science and mathematics teachers in Turkey. The statistical analyses were conducted to the collected data to test the validity and reliability of the adapted scale. TPACK of teachers participating in the study was observed as well.

The items of TPACK-21 scale are pedagogically grounded on 21st century skills. Although the main focus of TPACK-21 scale is 21st century skills, each part of the scale serves different purposes. Teachers’ self-assessments of knowledge in their subject area is being asked in CK part, while their familiarity with new technologies in TK items. Even if there is a general idea and approach as “who knows the content can teach” in Turkey, content knowledge is not enough to be a good teacher (Matematik Eğitimi Derneği [MED], 2013). Beyond the idea of transmitting only subject matter content knowledge to students, it is important to know how to make learning easier for them by taking 21st century skills into consideration. In this context, pedagogical knowledge is a very important need for teachers.

All of the items under the components related to pedagogy such as PK, PCK, TPK and TPACK seek for teachers' knowledge about how to improve students' 21st century skills. To give an example, each of the PK items measures teachers' general pedagogical knowledge for improving students' different 21st century skills, such as critical thinking, problem solving, etc. On the other hand, to examine technology integration of teachers, the technology related items (TK, TPK, TCK, TPACK) focus on teachers' use of technology as a tool for guiding students. For example, one of the TPACK items investigates how much teachers need to know about using ICT as a tool for directing students to work as a group in mathematics/science. The responses of teachers provide information about what teachers need or in which areas they feel competent enough.

In order to answer the research question investigating whether the adapted version of the TPACK-21 scale is valid and reliable, confirmatory factor analysis, item analysis and Cronbach's alpha reliability analysis were used. Since the theoretical framework and the original study of the TPACK-21 scale determine the factors as PK, CK, TK, PCK, TCK and TPK, this adaptation study verified the six factors by CFA. Although the correlations and fit indices found in CFA are lower than in the original study, they consist of acceptable and good values. According to the results, with one content knowledge item removal because of its' low factor loading (.53), the adapted scale has thirty-seven items in total. Other items have high correlations with their factors ranging between .52 and .90. The construct validity of this six-factor scale demonstrates that the scale is suitable for measuring the TPACK of teachers in terms of 21st century skills. For each item under these factors, the item-total correlations indicate that there is a significant difference between upper and lower groups' mean scores and Cronbach's alpha value was found as .97. Therefore, internal consistency of the scale has also been indicated.

Finally, according to the descriptive analysis applied to the collected data in this study, considering the mean values for each factor, teachers generally stated that they have some knowledge and have good knowledge of the components of the TPACK. They are asked to choose one of the options from "*1= I need a lot of additional knowledge about the topic*" to "*6= I have strong knowledge about the topic*". Since the lowest mean (4.42) belongs to content knowledge items, the responses of teachers

are closer to “*I have some knowledge*”. The highest mean (4.91) belongs to pedagogical knowledge items and hence responses are closer to “*I have good knowledge*”. In the development study of the TPACK-21 scale (Valtonen et al., 2017), the scale was administered to 267 first-year pre-service teachers studying at universities in Finland. The highest mean value belongs to the same component, pedagogical knowledge, while the lowest mean belongs to a different component, technological content knowledge. They found the mean score of PK as 3.21 and TCK as 2.23.

When the mean scores found in the development study and this adaptation study were compared, the reason for Valtonen et al. (2017) founds lower mean scores may be that they administered the scale to pre-service classroom teachers who were in their first year of education. Another potential reason for the higher mean scores found in this study may be that teachers indicated their own reports. According to the Teaching and Learning International Survey (TALIS, 2018) conducted by OECD, the percentage of self-efficacy of teachers in Turkey in almost all activities are higher than the OECD average (TEDMEM, 2019). Therefore, the results may have come out higher than they actually should have been.

Furthermore, the mean scores for different groups in the sample were stated in this study. Means of the all item scores for gender groups are closer to “5: *I have good knowledge*” as for the other groups. This means that the results are quite high but not at the top score level “6: *I have strong knowledge*”. On the other hand, primary and secondary science teachers have the same highest mean scores ($\bar{X}$ =4.90) with standard deviations .55 and .75 respectively. According to the years of teaching experience groups, the lowest mean score ($\bar{X}$ =4.67) belongs to teachers who have 1 to 5-year experience while the highest ($\bar{X}$ =4.74) belongs to 16 years or more experience. Both teachers from education faculties and other faculties have the mean values closer to 5 which are 4.74 and 4.73 respectively. All these results mean that teachers feel mostly confident in integrating 21st century skills into their classroom by using their technological pedagogical content knowledge.

5.2 Conclusions

It is important to have an idea about at what degree teachers have technological pedagogical content knowledge based on 21st century skills as MoNE (2017)

emphasizes the importance of them, especially ICT skills. This study reached the aim of adapting the TPACK-21 scale which is beneficial for gaining insight about how much teachers feel their technological pedagogical content knowledge is sufficient in developing students' 21st century skills and integrate these skills into their classroom. In order to adapt the TPACK-21 scale developed by Valtonen et al. (2017), the necessary steps, such as getting permission, translation and back translation were conducted. According to the results of validity and reliability analyses of the data collected from 309 teachers, the adapted version of the scale with its new Turkish name "TPAB-21 (*Teknolojik Pedagogik Alan Bilgisi*)" is found valid and reliable. The results of CFA confirmed the theoretical framework and the factor structure found in the development study as PK, CK, TK, PCK, TCK, TPK. The internal consistency of all the 37 items is .97 which means the scale is reliable. Hence, the validity and reliability of this adapted scale indicate the suitability of it to teachers in Turkey. Additionally, the descriptive results demonstrate that teachers feel mostly confident in using their TPACK to integrate 21st century skills into classroom.

5.3 Recommendations

The adapted version of the TPACK-21 scale is ready for further research and investigation about teachers and preservice teachers in Turkey. Researchers and educators in Turkey can benefit from the scale in order to follow teachers' TPACK based on 21st century skills. In order to provide more evidence to the results, it is recommended to conduct studies by administering this scale to different sample groups in Turkey. It can also be recommended that the scale can be administered to pre-service teachers studying at universities in Turkey and comparing their knowledge among different variables may contribute to the different dimensions of the literature. Furthermore, long-term studies can be conducted to evaluate the development of the TPACK-21 of pre-service or in-service teachers. Lastly, the relation between the self-reports of teachers' TPACK-21 and their performance in TPACK areas during the integration of 21st century skills into real classroom settings may be investigated.

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APPENDICES

A. Informed Consent Form

Değerli katılımcımız,

TPAB-21 (Teknolojik Pedagojik Alan Bilgisi-21) başlıklı bu anket, Bahçeşehir Üniversitesi Eğitim Teknolojileri yüksek lisans öğrencisi Meltem Sunman tarafından Dr. Gürsu Aşık danışmanlığında hazırlanmıştır. Araştırmanın amacı TPACK-21 isimli ölçeğin Türkçeye adaptasyonunu gerçekleştirmektir. Bu nedenle soruların tümüne içtenlikle cevap vermeniz büyük önem taşımaktadır. Araştırmaya katılım gönüllülük esasına dayalıdır. Bu anket aracılığı ile elde edinilen bilgiler gizli kalacaktır ve sadece araştırma amacıyla kullanılacaktır. Çalışmaya katılmamayı tercih edebilirsiniz veya anketi doldururken istemezseniz son verebilirsiniz. Anket dört bölümden oluşmaktadır ve ortalama 6-7 dakika sürmektedir. Yanıtlarınızı soruların altında yer alan seçenekler arasından uygun olanı seçerek belirtiniz. Çalışma ile ilgili herhangi bir sorunuz olduğunda aşağıdaki kişiler ile iletişim kurabilirsiniz.

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B. 21. Yüzyıl Becerileri İçin Teknolojik Pedagojik Alan Bilgisi Ölçeği (TPAB-21)

Sizlere aşağıda ankette karşınıza çıkacak bazı kavramların tanımları verilmiştir:

- **Yansıtıcı düşünme**
Kişinin kendi eğitimi, öğrenmesi ve becerileri hakkında bilinçli düşünme becerisi.
- **Problem çözme**
Kişinin önceden bilinmeyen görev ve problemleri, tündengelim yöntemiyle ve deneyimleriyle harmanlayarak çözebilme becerisi.
- **Yaratıcı düşünme**
Kişinin yeni bir şey yaratmak veya üretmek için kendi becerilerinden faydalanma ve farklı bilgi kaynaklarını birleştirme becerisi.
- **Eleştirel düşünme**
Kişinin çok miktarda bilgiyi işleme, bilginin güvenilirliğini değerlendirme ve farklı bilgi kaynaklarını karşılaştırma becerisi.
- **Bilgi ve iletişim teknolojisi (BİT)**
Bilgisayar, tablet, akıllı telefon vb. gibi geniş bir yelpazedeki farklı cihazların yanı sıra, web tabanlı uygulamalar ve yazılımlar, sosyal medya hizmetleri (ör. Blog, Facebook, YouTube, WhatsApp, Instagram) ve çevrimiçi öğrenme ortamları (ör. Moodle, Office365).
- **Öz-yönetimli öğrenme**
Öğrenci, kendi öğrenmesinde daha fazla sorumluluk almakla yükümlüdür. Öğrenci, kendi öğrenme ihtiyaçlarını, uygun öğrenme / çalışma yöntemlerini ve çalışmanın hedeflerini dikkate alır. Öz-yönetimli öğrenme, kendi kendine öğrenme süreçlerinin farkındalığını vurgular. Öz-yönetimli öğrenme bireysel çalışma demek değildir, bunun yerine ikili veya daha büyük gruplar halinde çalışmayı da içerir.

Demografik Bilgiler:

Cinsiyetiniz

Kadın ☐

Erkek ☐

Diğer ☐

Branşınız

İlköğretim Matematik ☐

Ortaöğretim Matematik ☐

İlköğretim Fen Bilimleri ☐

Ortaöğretim Fen Bilimleri (Fizik, Kimya, Biyoloji) ☐

Öğretmenlik yaptığınız kurum

Devlet okulu ☐

Özel okul ☐

Özel etüt merkezleri ☐

Diğer ☐

Kaç yıldır öğretmenlik yapıyorsunuz?

1 yıl- 5 yıl ☐

6 yıl- 15 yıl ☐

16 yıl ve üzeri ☐

Mezun olduğunuz fakülte

Eğitim Fakültesi ☐

Diğer ☐

AŞAĞIDAKİ İFADELERİ GENEL EĞİTİM BİLGİNİZ BAĞLAMINDA DEĞERLENDİRİNİZ.

- 1: Konu hakkında çok fazla ek bilgiye ihtiyacım var
2: Konu hakkında biraz ek bilgiye ihtiyacım var
3: Konu hakkında çok az ek bilgiye ihtiyacım var
4: Konu hakkında biraz bilgim var
5: Konu hakkında yeterli bilgim var
6: Konu hakkında oldukça yeterli bilgim var

PB1: Öğrencilere grup çalışması için rehberlik etme(2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PB2: Öğrencilerin eleştirel düşüncelerini destekleme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PB3: Öğrencilerin özyönetimli öğrenmelerini destekleme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PB4: Öğrencilerin yansıtıcı düşüncelerini destekleme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PB5: Öğrencilerin problem çözme becerilerini destekleme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PB6: Öğrencilerin yaratıcı düşüncelerini destekleme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PB7: Öğrencilere, grup çalışmasında birbirlerinin düşünce ve fikirlerinden faydalanmaları için rehberlik etme (2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

AB1: Matematikte/Fen Bilimlerinde içerik geliştirme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

AB2: Matematikteki/Fen Bilimlerindeki önemli teorilerin tarihini ve gelişimini bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

AB3: Matematikteki/Fen Bilimlerindeki son araştırmalara aşina olma

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TB1: Bilgi ve iletişim teknolojileri ile ilgili problemleri çözebilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TB2: Yeni teknolojilere ve özelliklerine aşina olma

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TB3: Yeni teknolojileri kullanabilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TB4: Yeni teknolojiler ile ilgili çeşitli web sitelerine aşina olma

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

**AŞAĞIDAKİ İFADELERİ MATEMATİK/FEN BİLİMLERİ EĞİTİMİ
BİLGİNİZ BAĞLAMINDA DEĞERLENDİRİNİZ.**

1: Konu hakkında çok fazla ek bilgiye ihtiyacım var

2: Konu hakkında biraz ek bilgiye ihtiyacım var

3: Konu hakkında çok az ek bilgiye ihtiyacım var

4: Konu hakkında biraz bilgim var

5: Konu hakkında yeterli bilgim var

6: Konu hakkında oldukça yeterli bilgim var

PAB1: Matematikte/Fen Bilimlerinde, öğrencilerin grup halinde alanla ilgili problem çözmelerine nasıl rehberlik edileceğini bilme (2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PAB2: Matematikte/Fen Bilimlerinde öğrencilerin eleştirel düşüncelerine nasıl rehberlik edileceğini bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PAB3: Matematikte/Fen Bilimlerinde öğrencilere grup çalışmasında nasıl rehberlik edileceğini bilme (2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PAB4: Matematikte/Fen Bilimlerinde, öğrencilerin yansıtıcı düşüncelerine nasıl rehberlik edileceğini bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PAB5: Matematikte/Fen Bilimlerinde öğrencilerin öz-yönetimli öğrenmelerinin nasıl destekleneceğini bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

PAB6: Matematikte/Fen Bilimlerinde öğrencilerin yaratıcı düşüncelerine nasıl rehberlik edileceğini bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TAB1: Matematik/Fen Bilimleri öğrenmek için kullanılan çevrimiçi materyallerin olduğu web sitelerine aşina olma

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TAB2: Matematikte/Fen Bilimlerinde uzmanlar tarafından kullanılan bilgi ve iletişim teknolojileri uygulamalarını bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TAB3: Matematiğin/Fen Bilimlerinin içeriğini daha iyi anlamak için kullanılabilecek bilgi ve iletişim teknolojileri uygulamalarını bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TAB4: Matematikte/Fen Bilimlerinde zor içerikleri anlatmak için kullanılan teknolojileri bilme

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

AŞAĞIDAKİ İFADELERİ ÖĞRETİMDE TEKNOLOJİ KULLANIMI BİLGİNİZ BAĞLAMINDA DEĞERLENDİRİNİZ.

1: Konu hakkında çok fazla ek bilgiye ihtiyacım var

2: Konu hakkında biraz ek bilgiye ihtiyacım var

3: Konu hakkında çok az ek bilgiye ihtiyacım var

4: Konu hakkında biraz bilgim var

5: Konu hakkında yeterli bilgim var

6: Konu hakkında oldukça yeterli bilgim var

TPB1: Bilgi ve iletişim teknolojilerini öğrencilerin yansıtıcı düşünceleri için öğretimde bir araç olarak nasıl kullanılabileceğimi biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPB2: Bilgi ve iletişim teknolojilerini öğrencilerin öz-yönetimli öğrenmelerini desteklemek için nasıl kullanılabileceğimi biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPB3: Öğrencilere grup çalışmasında rehberlik etmek için bilgi ve iletişim teknolojilerini nasıl kullanılabileceğimi biliyorum.(2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPB4: Bilgi ve iletişim teknolojilerini öğrencilerin yaratıcı düşünceleri için öğretimde bir araç olarak nasıl kullanılabileceğimi biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPB5: Öğretimimde, öğrencilerin gruplar halinde problem çözme becerilerini geliştirmek için bilgi ve iletişim teknolojilerini nasıl kullanacağımı biliyorum.(2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPB6: Öğretimimde bilgi ve iletişim teknolojilerini öğrencilerin eleştirel düşünmelerinde bir araç olarak nasıl kullanacağımı biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

MATEMATİK/ FEN BİLİMLERİ ÖĞRETİMİNDE GEREKLİ OLAN TEKNOLOJİ, PEDAGOJİ VE ALAN BİLGİNİZİ BİR BÜTÜN OLARAK DEĞERLENDİRİNİZ.

- 1: Konu hakkında çok fazla ek bilgiye ihtiyacım var
2: Konu hakkında biraz ek bilgiye ihtiyacım var
3: Konu hakkında çok az ek bilgiye ihtiyacım var
4: Konu hakkında biraz bilgim var
5: Konu hakkında yeterli bilgim var
6: Konu hakkında oldukça yeterli bilgim var

TPAB1: Matematik/Fen Bilimleri öğretimimde, bilgi ve iletişim teknolojilerini öğrencilerin fikir paylaşma ve birlikte düşünmelerinde bir araç olarak nasıl kullanacağımı biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPAB2: Matematik/Fen Bilimlerinde, bilgi ve iletişim teknolojilerini öğrencilerin yansıtıcı düşünmelerinde bir araç olarak nasıl kullanacağımı biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPAB3: Matematik/Fen Bilimleri öğretimimde, bilgi ve iletişim teknolojilerini öğrencilerin öz-yönetimli öğrenmelerini desteklemede bir araç olarak nasıl kullanacağımı biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPAB4: Matematik/Fen Bilimleri öğretimimde, bilgi ve iletişim teknolojilerini öğrencilerin grup halinde problem çözmesinde bir araç olarak nasıl kullanacağımı biliyorum. (2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPAB5: Matematik/Fen Bilimleri öğretimimde, bilgi ve iletişim teknolojilerini öğrencilerin yaratıcı düşünmelerinde bir araç olarak nasıl kullanacağımı biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPAB6: Matematik/Fen Bilimleri öğretimimde, bilgi ve iletişim teknolojilerini öğrenci grup çalışmalarında bir araç olarak nasıl kullanacağımı biliyorum. (2-5 öğrenci)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

TPAB7: Matematik/Fen Bilimlerin öğretimimde, bilgi ve iletişim teknolojilerini öğrencilerin eleştirel düşünmelerinde bir araç olarak nasıl kullanacağımı biliyorum.

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

C. Permission to Adapt the Scale



Permission to use your scale

Meltem Sunman <sunmanmeltem@gmail.com>

22 Şubat 2020 21:05

Alici: teemu.valtonen@uef.fi

Dear Dr. Valtonen,

I am a young researcher and a master's student at Bahcesehir University, Istanbul. For my thesis, I need your consent to use the scale you introduced, which is “Technological pedagogical content knowledge for twenty-first century skills (TPACK-21) questionnaire”. Can you also please tell me, if it is okay for you, whether the questionnaire as seen in your article the same that you applied? My thesis advisor and I wish to apply it to the teachers in Turkey. We would like to share the results with you as well. I would very much appreciate if you could inform us in case you have any warnings or suggestions for us.

Best Regards!

Teemu Valtonen <teemu.valtonen@uef.fi>

24 Şubat 2020 08:43

Alici: Meltem Sunman <sunmanmeltem@gmail.com>

Sure, here is the questionnaire. Please refer to our works when publishing studies with TPACK21.

-Teemu

 **TPACK cleaned.xlsx**
19K

D. Curriculum Vitae

PERSONAL INFORMATION

Surname, Name: Sunman, Meltem

Nationality: Turkish

Date and Place of Birth: 16 August 1994, Kadıköy

Marital Status: Single

E-mail: sunmanmeltem@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
MA	Bahçeşehir University	2020
Integrated BS & MS	Boğaziçi University	2018
High School	Remzi Yapıcı Anatolian Teacher Training High School	2012

WORK EXPERIENCE

Year	Place	Enrollment
2018-2020	Bahçeşehir College Science and Technology High School, Tema Park Campus	Mathematics Teacher

FOREIGN LANGUAGES

Advanced English

HOBBIES

Music, Travelling