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Adaptation of the TPACK-21 Scale to Turkish: A Validity and Reliability Study*

Meltem SUNMAN** **Gürsu AŞIK*****

Abstract. This study aims to adapt the TPACK-21 (Valtonen et al., 2017) scale to Turkish. Based on the 21st century skills, this scale consists of 6-point Likert type items. Measuring the technological pedagogical content knowledge that teachers should have to integrate 21st century skills into their classroom settings will give an idea about whether they have the competencies recommended by the Ministry of National Education (2017). For the adaptation process, the researchers followed the necessary steps: permission, translation, pilot study, validity, and reliability processes. The data were collected from 309 science and mathematics teachers in Turkey. For psychometric analysis of the scale, a confirmatory factor analysis (CFA), item-total correlations for upper and lower groups according to 27% segment, and a Cronbach's alpha reliability analysis were performed. 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 acceptable values and Cronbach's alpha coefficient was found as .97, the scale is valid and reliable. In addition, a descriptive analysis was conducted according to demographic information.

Keywords: TPACK, 21st century skills, Scale adaptation

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** Orcid ID: https://orcid.org/0000-0003-1901-4042, PhD student, University College London, United Kingdom, sunmanmeltem@gmail.com
*** Orcid ID: https://orcid.org/0000-0003-2004-8856, Assist. Prof. Dr., Bahçeşehir University, Turkey, gursu.asik@es.bau.edu.tr

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1. INTRODUCTION

TPACK Framework

TPACK is a theoretical framework constructed on Shulman's (1986,1987) pedagogical content knowledge concept to explain the interaction between teachers' understanding of technology and their PCK.

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. After some publications, Mishra and Koehler (2009) published the actual description of the TPACK framework after their studies in 2005, 2006 and 2008. Pierson (2001), who used the term TPACK for the first time, stated that TPACK characterizes the technology integration of educators. The terms ICT-related PCK and technology-enhanced PCK were used previously (Angeli & Valanides, 2005; Niess, 2005). The representation "TPCK" (technology, pedagogy, and content knowledge) was replaced with the more useful form "TPACK" (technology, pedagogy, and content knowledge) (Thompson & Mishra, 2007). Figure 1 illustrates the TPACK model with three main components: CK, PK, and TK. Their intersections consist of PCK, TPK, TCK, and TPACK, which have equal importance for the model (Koehler & Mishra, 2009).

According to the framework illustrated in Figure 1, the intersections represent more detailed knowledge for teachers than the main components. To illustrate, pedagogical knowledge comprises content-specific teaching knowledge whereas pedagogical knowledge involves a deep understanding of the instructional process. The knowledge of how teachers can use technology to improve their teaching for specific content is known as technological pedagogical content knowledge, which is the intersection of all three. Teachers should be educated on the qualities of a technology tool, its applicability for students, and how it may be utilized to teach a particular content area (Angeli & Valanides, 2009).

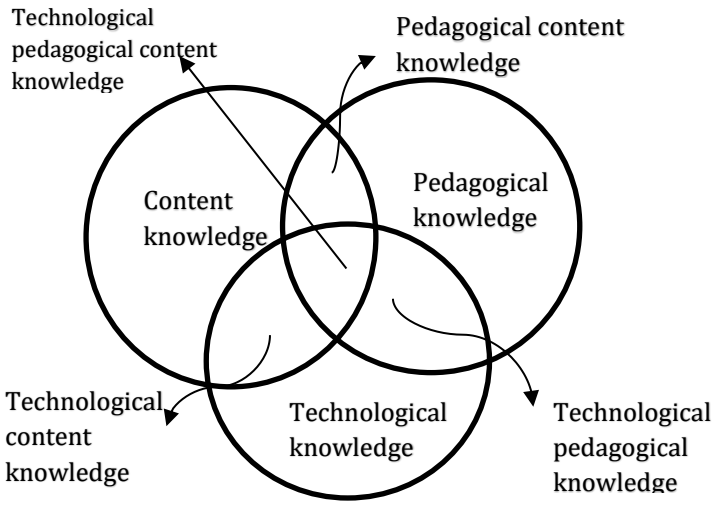


Figure 1. TPACK Model (Mishra & Koehler, 2006, p. 1025)

TPACK is, in essence, the intersection of a teachers' expertise in technology, pedagogy, and a particular content area. Since the 21st century, as a rapidly changing era, has raised the need for new skills for students, it is critical for teachers to have technology

knowledge as well as pedagogical and content knowledge. It is unavoidable for teachers to be exposed to such technologically advanced teaching environments; therefore, it is crucial for them to create proper instructions that meet the needs of the twenty-first century (Akaygun & Aslan-Tutak, 2016). Furthermore, according to Turkey's Ministry of National Education (2011), teachers should be good role models as well as prepare students for the needs and understandings of the twenty-first century.

One of the biggest concerns is how students can acquire and develop the 21st century skills. Students can learn and improve them through experience by integrating 21st century skills into the classroom. Teachers, in particular, play a critical role in placing these skills into educational institutions. Teachers can guide students in acquiring these skills through activities both within and outside of the classroom as well as the methods and strategies they apply (Cansoy, 2018). As a result, students developing these skills achieve better both inside and beyond the school environment.

Teachers should be able to use the internet efficiently to bring the world into the classroom and enable students to learn cooperatively by using digital tools and 21st century skills. Thus, it is important for teachers to understand how to integrate the 21st century skills and technology into their classroom settings (Tucker, 2014). These skills include reflective thinking, critical thinking, creative thinking, and information, media and technology skills. (Gelen, 2018). Teachers' roles have evolved to meet the needs of the twenty-first century. In addition to the subject area, they should teach pupils the 21st century skills (Shafie, Majid & Ismail, 2019). As a result, teachers must guise and encourage students to improve their twenty-first-century skills. Teachers should also be able to apply innovative educational approaches involving information and communication technology. Educators and students from all over the world take advantage of educational technology advancements in their teaching and learning processes to improve the quality of the learning environment.

According to a study conducted by İlhan and Oruç (2016), the use of multimedia tools has a better influence on students' academic performance than the traditional social studies classroom. Furthermore, students claim that using technology in class boosts their eagerness to learn (Francis, 2017). The importance of using new technologies in higher education was highlighted by Martinez-Rivera and Duță (2015). They showed how technology enables students to collaborate during the learning process. In this regard, teachers play a critical role in adequately integrating technology into their classrooms and increasing students' achievement, motivation, and abilities.

In recent years, it has been highlighted that teachers' TPACK should be assessed in terms of their competency to improve students' 21st century skills. Although there are TPACK measures developed in Turkish, the focus of this study is on teachers' TPACK for the 21st century skills. A systematic literature review of TPACK in Turkey was undertaken by Baran and Canbazoglu Bilici (2015). Eleven of the thirty papers the researchers reviewed used the TPACK scale created by Schmidt et al. (2009). To increase students' 21st century skills, it is critical to investigate teachers' technological, pedagogical, and content expertise. In this light, determining whether they use the 21st century skills into their lessons or not provides some insight into the obtained competencies that MoNE (2017) of Turkey suggests teachers develop. The value of the TPACK scales, according to

Valtonen et al. (2015), is that they are based on some instructional techniques such as the 21st century skills. As a result, the TPACK-21 scale they developed can be used to assess teachers' technological pedagogical content knowledge to help students to improve their 21st century skills. Teachers in science and mathematics were given the TPACK-21 scale, which had been translated into Turkish.

TPACK Scales in the Literature

One of the first developed scales in the literature 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 a factor analysis. This valid and reliable scale has been very effective for examining teachers' TPACK conceptions and starting 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 which were not related to the study such as pre-service teachers' evaluations about their professors. The final version had 29 seven-point Likert-type items with five factors, which were 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 Vatanartıran (2013) in order to apply to secondary school teachers. According to Karadeniz and Vatanartıran (2013), the importance of the knowledge about managing 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) contribute to the enrichment of Turkish literature with a reliable and valid survey with five factors for secondary school teachers of different subjects.

There are many other TPACK scales administered in Turkey that can be categorized into two groups as development studies and adaptation studies. Table 1 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 these scales.

Table 1

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 & Vatanartıran (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
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

According to Mtebe and Raphael (2018), during their use of ICT in 21st century teaching environment, teachers should 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 the 21st century skills in Turkish. Shafie, Majid and Ismail (2019) state that teachers are expected to teach not only subject matter areas but also the 21st century skills. Unfortunately, not all teachers have a chance to take training for that purpose. Therefore, 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 the 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 the 21st century skills into their classroom by enhancing their technological, pedagogical, and content knowledge about teacher education or in-service training in Turkey.

Comparing the items of the mentioned TPACK scales and the TPACK-21 scale will be beneficial for showing the difference of the TPACK-21 scale. As for all the other parts of the TPACK-21 scale, TPACK items include the 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 the TPACK-21 scale. Table 2 illustrates sample TPACK items from other scales in Turkey. Items from previous TPACK scales examine teachers' knowledge and use of technological tools in a specific content area and their impact on students' learning environment. The difference in TPACK-21 scale can be seen in this part as for the other parts of the scale.

Table 2

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 (Canbazoğlu-Bilici et al., 2013).
- Using computer aided technologies which are convenient to different learning content of social studies course (Akman & Güven, 2015).
- 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 observe their similarities and differences from TPACK-21 scale. The main feature of the TPACK-21 scale different from these scales is being grounded on the 21st century skills pedagogically.

21st century skills

Compared to the past, nowadays, it is easier to equip children with 21st century skills as they are the digital natives who use their technological devices effectively (Prensky, 2001). Binkley et al. (2012) present a classification according to how we think, work, and live in the world. Regardless of their socio-economic background, students need to develop higher-order thinking skills such as creative and critical thinking, problem solving, collaboration, and ICT literacy. These skills are a prerequisite for success in all aspects of life (Şahin et al., 2014).

Table 3

21st Century Skills

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

(Binkley et al., 2012, p.18)

In recent years, the Ministry of National Education in Turkey has conducted various studies on 21st century skills that students need to acquire and develop. In the report published in 2017, new skills were listed under the title of Competencies. In this part, a great emphasis was placed on the need for teachers to transfer the 21st century skills to students, which also matches the model provided by Binkley et al. (2012). Some of the competencies presented by MoNE (2017) are:

- Mathematics competence (including problem solving, creative thinking, etc.),
- 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 the 21st century skills. Selecting from thirty-two literature review documents, they included eight important frameworks (P21, EnGauge, ATCS, NETS/ISTE, NAEP, EU, OECD and UNESCO) in their study. According to their investigation, some common 21st century skills are collaboration, creativity, critical thinking, problem solving, self-direction, and ICT skills.

Significance and purpose of the study

There are various pedagogical approaches that teachers can use so that students can develop the 21st century skills. Teachers should mainly be able to use information and communication technologies. The need to create learning environments by integrating technology into their lessons has revealed the importance of conducting research on TPACK (Emara, 2020). Valtonen et al. (2015) emphasize that teachers' pedagogical knowledge is a key factor in successfully integrating ICT into the classroom. Brown, Neal and Fine (2011) also support the idea of using technology in the classroom by considering the connections between the 21st century skills and TPACK. Similarly, Cherner and Smith (2017) emphasize that the TPACK framework should focus on students' adoption of the 21st century skills.

Although there are various TPACK scales adapted to Turkish, this study aimed to contribute to the literature with a scale adaptation grounded on the 21st century skills. Measuring the technological pedagogical content knowledge that teachers should have to integrate the 21st century skills into their classrooms will give an idea about whether they have the competencies recommended by the Ministry of National Education (2017).

Valtonen et al. (2015) emphasize the importance of TPACK scales in terms of being based on some pedagogical approaches such as the 21st century skills. The TPACK-21 scale they developed for this purpose can be used to measure teachers' technological pedagogical content knowledge to improve students' 21st century skills.

It is of great importance to examine the teachers' conceptions about the 21st century skills students should gain. In their article, Valtonen et al. (2017) indicate that today's teachers and students should have the 21st century skills because of the life changes 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 the 21st century skills can be measured by their technological, pedagogical, and 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 the 21st century skills. The structure and contents of the TPACK scales available were included in the sections of the literature review.

The necessity of using technology in education is increasing day by day. The Ministry of National Education in Turkey is taking crucial steps in the field of digitalization in education. Technology-related learning outcomes have been added to curricula at all levels (MoNE, 2017). Thus, teachers and students were encouraged to use technology in the learning and teaching process. Especially in the global pandemic period, the importance of technology use has been revealed with the transition of education to online platforms worldwide. Therefore, it has become important to conduct research on how developments in information and communication affect education. Since teachers are the essential elements that give meaning to education, it will be significant to examine to what extent they can adapt technology into their teaching (Keleş, Öksüz & Bahçekapılı, 2013). Niess (2011) also stated that examining TPACK of teachers will provide information about their use of appropriate ICT in lessons and how they can prepare suitable instructional designs for students. In order to examine TPACK of teachers in terms of the 21st century skills, this study contributes to the Turkish literature by adapting TPACK-21 scale and providing evidence of its suitability for teachers in Turkey. Therefore, this study aims to adapt the TPACK-21 scale into the Turkish language and test its psychometric properties (i.e., verify the validity and reliability of the scale administered in the fields of science and mathematics). The research question "Is the TPACK-21 scale adapted to Turkish valid and reliable?" was investigated.

2. METHOD

This study is a scale adaptation study following important steps during the process. The name of the adapted scale is "The Technological Pedagogical Content Knowledge for

Twenty-First Century Skills (TPACK-21)", developed by Valtonen et al. (2017). After obtaining permission from the owners, the items were translated into Turkish by an English language instructor with a master's degree in Educational Technology. For the linguistic equivalence, it has also been determined whether the items meet the original meanings or not. Subsequently, the views about the clarity of the items and the suggestions from seven mathematics, three science teachers and an academician in education faculty were collected, and the items were revised. The final version was reached according to the opinions of three English language experts working at the English teaching departments in top universities in Turkey. The following steps were collecting the data and conducting reliability and validity analyses. In addition, according to the data collected from the sample, descriptive results were provided as well.

Participants

The adapted scale was administered to 309 volunteer science and mathematics teachers in Turkey. 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). During the 2019-2020 academic year, teachers in Turkey were teaching online because of the global pandemic. Therefore, the data were collected via an online surveying tool. According to their answers to demographic questions, Table 4 illustrates the characteristics of the sample.

Table 4

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

Science and mathematics have come to the fore as important subjects for students to prepare for the future and adapt to the twenty-first century (National Research Council, 2011). With innovative learning settings, individuals may be able to succeed in these areas. According to Akgündüz et al. (2015), the new generation should be able to combine technology and engineering disciplines with mathematics and science to create life-enhancing breakthroughs. STEM (science, technology, engineering, and mathematics) is an emerging teaching paradigm that addresses this requirement. This teaching method suggests that science, mathematics, and information technology courses be taught using concepts and processes appropriate for the twenty-first century. (Aşık et al., 2017). Teachers, especially in these disciplines, should develop and design instructions that foster the 21st century skills using pedagogical knowledge and technology. The ethics committee approval for this study was obtained from the Ethics Committee of Bahçeşehir University, dated 29/12/2021 and numbered 2021/11.

Data Collection Tool

This study adapted the 6-point Likert type scale named "Technological Pedagogical Content Knowledge for Twenty-First Century Skills (TPACK-21)" developed by Valtonen et al. (2017). The items were grouped under subcomponents of TPACK frameworks. They added the 21st century skills to pedagogy related items (PK, PCK, TPK, TPACK) by benefiting from Schmidt et al. (2009) TPACK scale. After two studies by Valtonen et al. (2015; 2017), the final version of the scale includes 38 items.

In the adapted version, we call the scale in Turkish "21. Yüzyıl Becerileri İçin Teknolojik Pedagojik Alan Bilgisi (TPAB-21)". The original version was specific to the "natural sciences" content area, but Valtonen et al. (2017) state that it can be changed for other content areas. Therefore, to obtain data from science and mathematics teachers, this study changed the items of "natural science" as the areas of "science and mathematics".

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, and they can leave the survey at any time. In the next part of the survey, there are some definitions of the 21st century skills to clarify the concepts.

The prepared survey consisted 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, four questions aiming at determining the demographic characteristics (gender, subject area, grade levels they are teaching, kinds of schools they are teaching, years of experience, and faculties they graduated from) were asked. The other pages of the survey start with an instruction about the items and examine teachers' conceptions about the

components of TPACK. In addition, the instructions include explanations of how teachers should think and decide while answering the items at each part.

In the Turkish version of the scale, the seven items measuring pedagogical knowledge were numbered from PB1 to PB7 by using the first letters of its' Turkish name "Pedagojik Bilgi". The same method was used for three items of content knowledge, AB1 to AB3 (Alan Bilgisi); four items of technological knowledge, TB1 to TB4 (Teknoloji Bilgisi); six items of pedagogical content knowledge, PAB1 to PAB6 (Pedagojik Alan Bilgisi); four items of technological content knowledge, TAB1 to TAB4 (Teknolojik Alan Bilgisi); six items of technological pedagogical knowledge, TPB1 to TPB6 (Teknolojik Pedagoji Bilgisi); and seven items of technological pedagogical content knowledge TPAB1 to TPAB7 (Teknolojik Pedagojik Alan Bilgisi).

3. DATA ANALYSIS

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. After collecting data from participants, outliers were cleared from the data of this study. To ensure that a factor analysis can be conducted on the data set, Barlett 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 including a scale with more than one item. In this study, first of all, participants' scores were transformed to z-scores. Then, 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. SPSS v23 and Amos v25 were used to conduct the factor and reliability analyses. By using Amos, CFA was conducted for construct validity. Then, to determine the reliability of the scale, Cronbach's Alpha coefficient, item-total correlations for upper and lower groups, and t-test were conducted by using SPSS. The descriptive statistics were investigated in terms of related demographics of participants.

In order to make sure that the data set is suitable for conducting CFA, the Barlett test and the Kaiser-Meyer-Olkin (KMO) test were applied. As shown in Table 5, KMO test values were determined as 96 per cent (.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 statistically significant. It also shows high correlation between variables and that the data set is suitable for factor analysis (Tabachnick & Fidell, 2007).

Table 5

Results of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.96
Bartlett's Test of Sphericity	Approx. Chi-Square	10044.80

	df	703
	Sig.	.00

4. FINDINGS

Results of Descriptive Analysis

The TPACK-21 scale is a 6-point Likert type, and the item points range between 1 to 6. The mean scores for each factor given in Table 6 shows that teachers feel confident about each component of TPACK structure. In more detail, teachers' views of their PK have 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 6

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 teachers. According to the collected demographic data from the sample, the mean scores of gender, subject area, institution, teaching experience, and graduated faculties groups were examined. The teachers were expected to answer the scale items according to their self-report on their knowledge. Since the mean score is 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 range between "4: *I have some knowledge"* and *"5: I have good knowledge*". According to the 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). The 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, teachers' views from

education faculties and other faculties have almost the same mean values 4.74 (SD=.71) and 4.73 (SD=.75) respectively.

Table 7

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

Results of Confirmatory Factor Analysis

Interpreting the goodness of fit indices and factor loadings, according to the confirmatory factor analysis results, determines the validity of the adapted scale. A 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 six 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 the 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. 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; therefore, it was removed from the model. However, 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↔e3, e4↔e5, e15↔e16, and e29↔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.

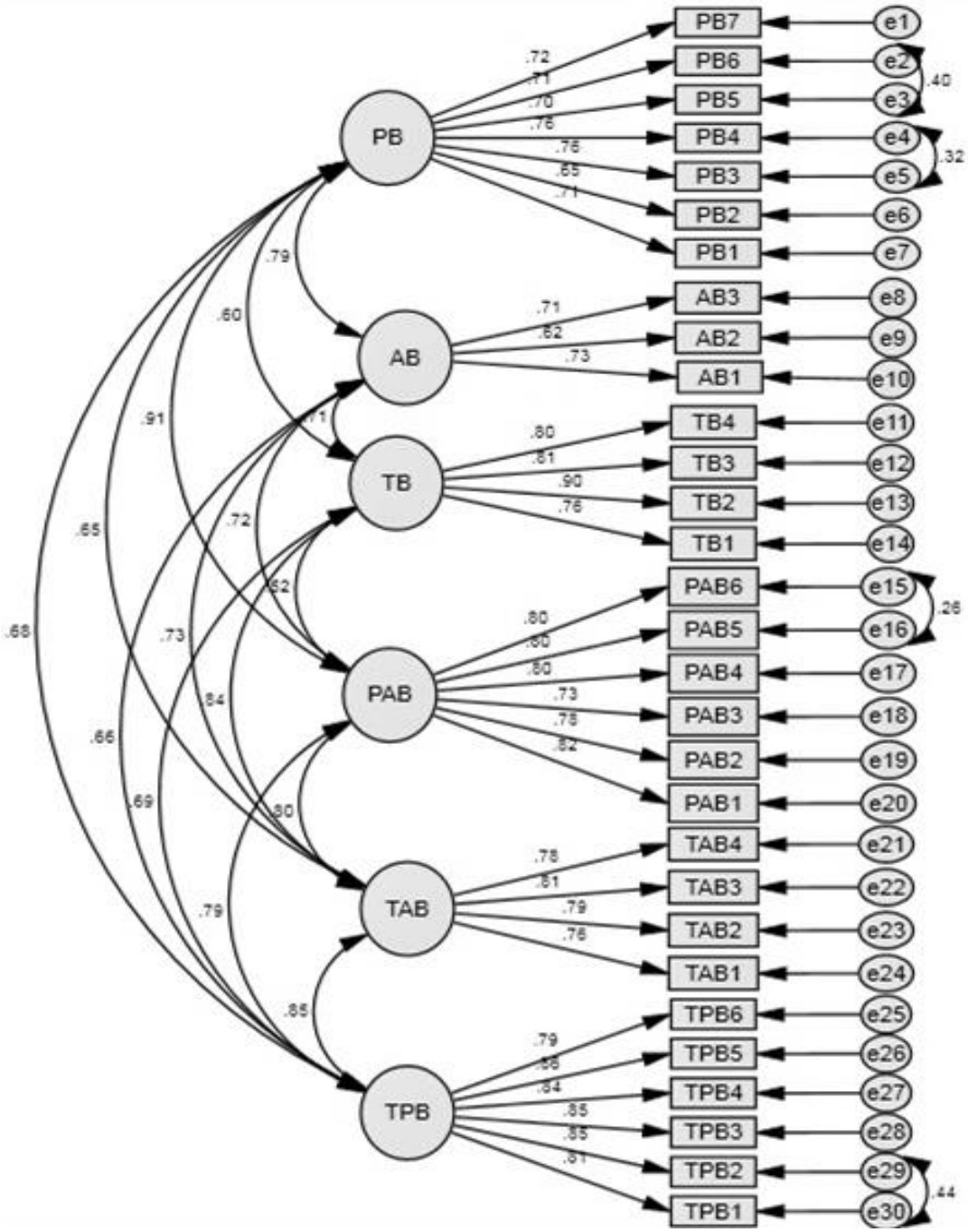


Figure 2. Confirmatory Factor Model of TPAB-21 Scale

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

Table 8

The Fit Indices of Factor Analysis

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

The confirmatory factor analysis results provide evidence of the validity of TPAB-21 scale. Table 8 shows all the fit indices that are acceptable, which resulted in a valid adapted TPACK-21 scale that 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.

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 were labelled as the upper group. In contrast, the participants with the lowest score (n_2= 82) are labelled as the lower group. Finally, 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 were calculated. It was found that there is a statistically significant difference between the mean scores of the groups. Table 9 shows the results of the item analysis. The r values of the Pearson correlation coefficient indicate the correlation between each item's score and the total.

Table 9

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.*

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 shown in Table 10, which is accepted as high since it is preferred to have the values above .80 (Pallant, 2013).

Table 10

Reliability Statistics

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

Item total statistics indicate the correlation between every item and the total score (Takunyacı et al., 2019). According to the correlation coefficients of items and total in Table 11, 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 higher than .971 (Pallant, 2013). Therefore, the scale has good internal consistency.

Table 11

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

5. DISCUSSIONS AND SUGGESTIONS

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 to science and mathematics in this study. By considering 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 on 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. For example, teachers' self-assessments of knowledge in their subject area are being asked in CK part, while their familiarity with new technologies is asked 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 considering 21st century skills. In this context, pedagogical knowledge is a vital need for teachers.

All of the items under the components related to pedagogy, such as PK, PCK, TPK and TPACK, seek teachers' knowledge about how they improve students' 21st century skills. For example, each of the PK items measures teachers' general pedagogical knowledge for enhancing students' different 21st century skills, such as critical thinking and problem solving. On the other hand, to examine teachers' technology integration, 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. Teachers' responses 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 removed because of its' low factor loading (.53), and the final version of the 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 the 21st century skills. Furthermore, for each item under these factors, the item-total correlations indicate a significant difference between upper and lower groups' mean scores, and Cronbach's alpha value was found as .97. Therefore, the 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, teachers' responses 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 knowledgewhile 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 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 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 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, which 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 of .55 and .75 respectively. According to the years of teaching experience groups, the lowest mean score ($\bar{X}$=4.67) belongs to teachers with 1 to 5-years experience while the highest ($\bar{X}$=4.74) belongs to 16 years or more experience. Both teachers from education faculties and other faculties have mean values closer to 5, which are 4.74 and 4.73 respectively. These results mean that teachers feel mostly confident in integrating the 21st century skills into their classroom by using their technological pedagogical content knowledge.

It is important to have an idea about to what degree teachers have technological pedagogical content knowledge based on the 21st century skills as MoNE (2017) emphasizes their importance, especially ICT skills. This study reached the aim of adapting the TPACK-21 scale, which is beneficial for gaining insight into how much teachers feel their technological pedagogical content knowledge is sufficient in developing students' 21st century skills and integrating 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 Pedagojik 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 its suitability to teachers in Turkey. Additionally, the descriptive results demonstrate that teachers feel most confident in using their TPACK to integrate the 21st century skills into the classroom.

Recommendations

The adapted version of the TPACK-21 scale is ready for further research and investigation about teachers and pre-service teachers in Turkey. Researchers and educators in Turkey can benefit from the scale in order to follow teachers' TPACK based on the 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 suggested that the scale can be administered to pre-service teachers studying at universities in Turkey. Comparing their knowledge among various

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 the 21st century skills into real classroom settings may be investigated.

References

Akaygun, S., & Aslan-Tutak, F. (2016). STEM images revealing stem conceptions of pre-service chemistry and mathematics teachers. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 56-71.

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Çorlu, M. S., Öner, T., & Özdemir, S. (2015). STEM eğitimi Türkiye raporu [STEM education Turkey report]. *İstanbul: Scala Basım*.

Akman, Ö., & Güven, C. (2015). TPACK survey development study for social sciences teachers and teacher candidates. *International Journal of Research in Education and Science*, *1*(1), 1-10.

Angeli C. & Valanides N. (2005) Preservice elementary teachers as information and communication technology designers: an instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning 21, 292–302.*

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & education*, *52*(1), 154-168.

Aşık, G., Küçük, Doğança Küçük, Z., Helvacı, B., & Corlu, M. S. (2017). Integrated teaching project: A sustainable approach to teacher education. *Turkish Journal of Education*, *6*(4), 200-215.

Balçın, M. D., & Ergün, A. (2016). Technological pedagogical content knowledge (TPCK) self-efficacy scale for pre-service science teachers on material development: Development, reliability and validity study. *Turkish Journal of Education*, *5*(3), 130-143.

Baran, E., & Canbazoğlu Bilici, S. (2015). Teknolojik pedagojik alan bilgisi (TPAB) üzerine alanyazın incelemesi: Türkiye örneği [Literature review on technological pedagogical content knowledge (TPACK): The case of Turkey]. *Hacettepe University Journal of Education, 30*(1), 15-32.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills* (pp. 17-66). Springer, Dordrecht.

Brown, C. A., Neal, R. E., & Fine, B. (2011). Using 21st Century thinking skills applied to the TPACK instructional model. *In annual meeting of the AECT International Convention,* Hyatt Regency Jacksonville Riverfront, Jacksonville, FL.

Canbazoğlu-Bilici, S., Yamak, H., Kavak, N. & Guzey, S. S. (2013). Technological Pedagogical Content Knowledge Self-Efficacy Scale (TPACK-SeS) for pre-service science teachers: Construction, validation, and reliability. *Eurasian Journal of Educational Research, 52*, 37-60.

Cansoy, R. (2018). Uluslararası çerçevelere göre 21. yüzyıl becerileri ve eğitim sisteminde kazandırılması [21st century skills according to international frameworks and their acquisition in the education system]. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, *7*(4), 3112-3134.

Cherner, T., & Smith, D. (2017). Reconceptualizing TPACK to meet the needs of twenty-first-century education. *The New Educator, 13*(4), 329-349.

Emara, A. (2020). Identity and technology integration in an EFL context: A study of Egyptian teachers and adult learners. *Theses, Student Research, and Creative Activity: Department of Teaching, Learning and Teacher Education,* 116.

Francis, J. (2017). The effects of technology on student motivation and engagement in classroom-based learning. *All Theses and Dissertations*. 121. Retrieved from: http://dune.une.edu/theses/121

Gelen, I. (2018). Academicians' predictions of 21st century education and education in the 21st century. *European Journal of Education Studies*, *4*(5), 165-204.

Gliem, J. A., & Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education, p.83-88, October 8-10, Columbus, OH.

Ilhan, G. O., & Oruc, S. (2016). Effect of the Use of Multimedia on Students' Performance: A Case Study of Social Studies Class. *Educational Research and Reviews, 11(8), 877-882.*

Karadeniz, Ş., & Vatanartıran, S. (2013). *Adaptation of a TPACK survey to Turkish for secondary school teachers. Journal of Human Sciences, 10(2), 34-47.*

Karataş, F. İ. (2014). *An examination of in-service secondary mathematics teachers' technological pedagogical content knowledge and their technology integration self-efficacy.* (Unpublished master's thesis) Boğaziçi University Graduate School of Science and Engineering, İstanbul.

Kartal, T., Kartal, B., & Uluay, G. (2016). Technological pedagogical content knowledge self-assessment scale (TPACK-SAS) for pre-service teachers: Development, validity and reliability. *International Journal of Eurasia Social Sciences, 7*(23), 1-36.

Kaya, S., & Dag, F. (2013). Turkish adaptation of Technological Pedagogical Content Knowledge Survey for elementary teachers. *Educational Sciences: Theory and Practice, 13*(1), 302-306.

Kaya, Z., Kaya, O. N., & Emre, İ. (2013). Teknolojik Pedagojik Alan Bilgisi (TPAB) ölçeği'nin Türkçeye uyarlanması [Adaptation of the Technological Pedagogical Content Knowledge (TPACK) scale into Turkish]. *Kuram ve Uygulamada Eğitim Bilimleri, 13*(4), 2355-2377.

Keleş, E., Öksüz, B. D., & Bahçekapılı, T. (2013). Teknolojinin eğitimde kullanılmasına ilişkin öğretmen görüşleri: Fatih projesi örneği [Teachers' views on the use of technology in education: Example of Fatih project]. *Gaziantep University Journal of Social Sciences*, *12*(2), 353-366.

Kiray, S. A. (2016). Development of a TPACK self-efficacy scale for preservice science teachers. *International Journal of Research in Education and Science*, *2*(2), 527-541.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary issues in technology and teacher education*, *9*(1), 60-70.

Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning*, *26*(6), 563-573.

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Sage Publications.

Martínez Rivera, Ó., & Duță, N. (2015). Between theory and practice: The importance of ICT in Higher Education as a tool for collaborative learning. *Procedia-Social and Behavioral Sciences, 180*, 1466-1473.

Matematik Eğtimi Derneği, (2013). Ülkemizde alan öğretmeni eğitimi nasil olmali? [How should the education of the field teacher be in our country?] Retrieved from https//www.tmed.org.tr/v1/wp-content/uploads/MEDin-BASIN-DUYURUSU2.pdf

Milli Eğitim Bakanlığı (2011). MEB 21. yüzyıl öğrenci profile [MoNE 21st century student profile]. Ankara, Millî Eğitim Basımevi. Retrieved from https://www.mev.gov.tr/earged/earged/21.%20yy_og_pro.pdf

Milli Eğitim Bakanlığı (2017). Müfredatta yenileme ve değişiklik çalışmalarımız üzerine [On our work on curriculum renewal and change]. Retrieved from http://ttkb.meb.gov.tr/*meb_iys_dosyalar/2017_07/18160003_basin_aciklamasi-program.pdf*

Milli Eğitim Bakanlığı (2017). Öğretmenlik mesleği genel yeterlikleri [General competencies of the teaching profession]. *Ankara: Öğretmen yetiştirme ve geliştirme genel müdürlüğü*. Retrieved from https://oygm.meb.gov.tr/www/ogretmenlik-meslegi-genel-yeterlikleri/icerik/39

Mishra, P., & Koehler, M. J. (2008, March). Introducing technological pedagogical content knowledge. In *annual meeting of the American Educational Research Association* (pp. 1-16).

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers college record*, *108*(6), 1017-1054.

Mtebe, J. S., & Raphael, C. (2018). Eliciting in-service teachers' technological pedagogical content knowledge for 21st-century skills in Tanzania. *Journal of learning for development*, *5*(3), 263-279.

Mulholland J. (2015) Pedagogical Knowledge. In: Gunstone R. (eds) *Encyclopedia of Science Education*. Springer, Dordrecht.

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics*. National Academies Press.

Niess M.L. (2005) Preparing teachers to teach science and mathematics with technology: developing a technology pedagogical content knowledge. *Teaching and Teacher Education 21, 509–523.*

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of educational computing research*, *44*(3), 299-317.

Önal, N. (2016). Development, validity and reliability of tpack scale with pre-service mathematics teachers. *International Online Journal of Educational Sciences, 8*(2), 93-107.

Öztürk, E., & Horzum, M. B. (2011). Teknolojik Pedagojik İçerik Bilgisi Ölçeği'nin Türkçeye uyarlaması [Turkish adaptation of the Technological Pedagogical Content Knowledge Scale]. *Journal of Kirsehir Education Faculty*, *12*(3), 255-278.

Pallant, J. (2013). *SPSS survival manual*. McGraw-Hill Education (UK).

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the horizon*, *9*(5), 1-6.

Sarı, M. H., & Bostancıoğlu, A. (2018). Application of technological pedagogical content knowledge framework to elementary mathematics teaching: A Scale adaptation study. *Journal of Theoretical Educational Science/Kuramsal Eğitimbilim Dergisi, 11*(2), 296-317.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK) the development and validation of an assessment instrument for preservice teachers. *Journal of research on Technology in Education*, *42*(2), 123-149.

Shafie, H., Majid, F. A., & Ismail, I. S. (2019). Technological Pedagogical Content Knowledge (TPACK) in teaching 21st century skills in the 21st century classroom. *Asian Journal of University Education*, *15*(3), 24-33.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, *15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Şahin, A., Ayar, M. C., & Adıgüzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory and Practice, 14*(1), 309-322.

Takunyacı, M., Masal, E., Masal, M., Ergene, Ö., & Erden, K. (2019). Fennema-Sherman mathematics attitude scales: Adaptation to Turkish culture. *Sakarya University Journal of Education, 9*(1), 208-223.

TEDMEM. (2019). *TALIS 2018 sonuçları ve Türkiye üzerine değerlendirmeler* (TEDMEM Analiz Dizisi 6) [TALIS 2018 results and evaluations on Turkey (TEDMEM Analysis Series 6)]. Ankara: Türk Eğitim Derneği.

Thompson A. & Mishra P. (2007) Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education 24, 38–39.*

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2019). Strategies to prepare preservice teachers for Technological Pedagogical Content Knowledge (TPACK): A mixed-method study. *Educational Technology Research & Development, 68,* 319-343.

Tucker, S. Y. (2014). Transforming pedagogies: Integrating 21st century skills and Web 2.0 technology. *Turkish Online Journal of Distance Education, 15(1), 166-173.*

Urdan, Timothy C. (2001). *Statistics in Plain English.* Abingdon, Oxon, Psychology Press.

Valtonen, T., Sointu, E. T., Mäkitalo-Siegl, K., & Kukkonen, J. (2015, November). Developing a TPACK measurement instrument for 21st century pre-service teachers. In *Seminar.net* (Vol. 11, No. 2).

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, *33*(3), 15-31.

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of curriculum studies*, *44*(3), 299-321.

Appendices

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.

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, tümdengelim 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 güvenirliğini 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 düşünmelerini destekleme

1 2 3 4 5 6

☐ ☐ ☐ ☐ ☐ ☐

PB3: Öğrencilerin özyönetimli öğrenmelerini destekleme

1 2 3 4 5 6

☐ ☐ ☐ ☐ ☐ ☐

PB4: Öğrencilerin yansıtıcı düşünmelerini destekleme

1 2 3 4 5 6

☐ ☐ ☐ ☐ ☐ ☐

PB5: Öğrencilerin problem çözme becerilerini destekleme

1 2 3 4 5 6

☐ ☐ ☐ ☐ ☐ ☐

PB6: Öğrencilerin yaratıcı düşünmelerini 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

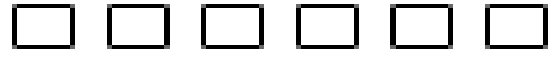
1 2 3 4 5 6

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

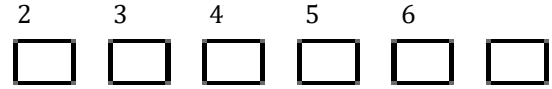
1 2 3 4 5 6

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

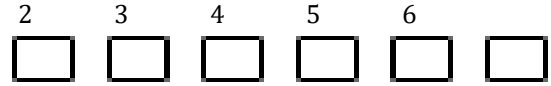
PAB1: Matematikte/Fen Bilimlerinde, öğrencilerin grup halinde alanla ilgili problem çözmelerine nasıl rehberlik edileceğini bilme (2-5 öğrenci)

1 2 3 4 5 6



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

1 2 3 4 5 6

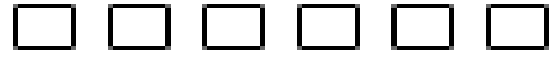


PAB3: Matematikte/Fen Bilimlerinde öğrencilere grup çalışmasında nasıl rehberlik edileceğini bilme (2-5 öğrenci)

1 2 3 4 5 6

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

1 2 3 4 5 6

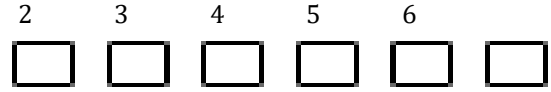


PAB5: Matematikte/Fen Bilimlerinde öğrencilerin öz-yönetimli öğrenmelerinin nasıl destekleneceğini bilme

1 2 3 4 5 6

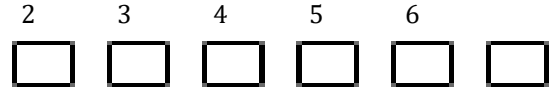
PAB6: Matematikte/Fen Bilimlerinde öğrencilerin yaratıcı düşünmelerine nasıl rehberlik edileceğini bilme

1 2 3 4 5 6



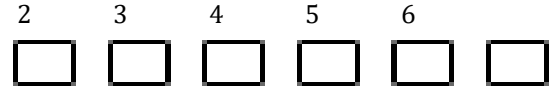
TAB1: Matematik/Fen Bilimleri öğrenmek için kullanılan çevrimiçi materyallerin olduğu web sitelerine aşina olma

1 2 3 4 5 6



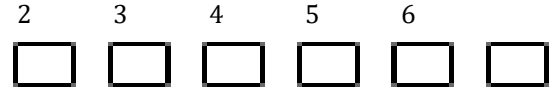
TAB2: Matematikte/Fen Bilimlerinde uzmanlar tarafından kullanılan bilgi ve iletişim teknolojileri uygulamalarını bilme

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.

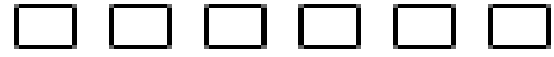
1: Konu hakkında çok fazla ek bilgiye ihtiyacım var
2: Konu hakkında biraz ek bilgiye ihtiyacım var
3: Konu hakkında çok az ek bilgiye ihtiyacım var
4: Konu hakkında biraz bilgim var
5: Konu hakkında yeterli bilgim var
6: Konu hakkında oldukça yeterli bilgim var

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

1 2 3 4 5 6

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

1 2 3 4 5 6



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

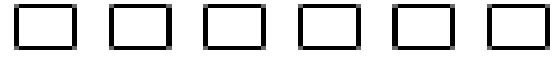
1 2 3 4 5 6

TPB4: Bilgi ve iletişim teknolojilerini öğrencilerin yaratıcı düşünmeleri için öğretimde bir araç olarak nasıl kullanılacağımı 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.

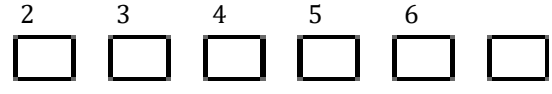
1 2 3 4 5 6

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



The ethics committee approval for this study was obtained from the Ethics Committee of Bahçeşehir University, dated 29/12/2021 and numbered 2021/11.

Statement of Contribution of Researchers to the Article:
1st author contribution rate: %50 2nd author contribution rate: %50
Conflict of Interest Statement
There is no conflict of interest
Statement of Financial Support or Acknowledgment:
No financial support was received from any institution for this study. No Acknowledgment.