ADAPTATION OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE SCALE INTO TURKISH CULTURE WITHIN THE SCOPE OF 21ST CENTURY SKILLS

Abstract: The purpose of this study was to test the validity and reliability of Turkish version of the 21st century skills-oriented TPACK scale, developed by Valtonen et al., (2017). The participants of the study selected with using the convenient sampling included 339 pre-service teachers who enrolled in the teacher education faculty of a state university located in the western part of Turkey. Confirmatory factor analysis was performed for the construct validity of the scale, and Rasch analysis for its validity and reliability. Rasch person and item reliability coefficients for the TPACK were around .90. Rasch analysis showed that infit and outfit mean values were in the acceptable fit range. In addition, correlations between the factors showed a strong relation in the theoretical model, indicating a good construct validity. Also, all dimensions of the scale were significantly related to teaching self-efficacy of pre-service teachers. Examination pre-service teachers' responses, it was found that they believed that they had adequate knowledge at content and pedagogic matters, but their knowledge at technology and integrating it with pedagogic and context knowledge were at satisfactory level. Educational implications and future directions were discussed.

Keywords: 21st century skills, pre-service teacher education, Rasch analysis, self-efficacy, TPACK

Alpaslan Muhammet Mustafa, PhD
Associate Professor
Mathematics and Science Education
Muğla Sıtkı Koçman University
Muğla-Turkey
Contact:
E-mail: mustafaalpaslan@mu.edu.tr
ORCID: 0000-0003-4222-7468

Ulubey Özgür, PhD
Associate Professor
Educational Science
Muğla Sıtkı Koçman University
Muğla-Turkey
Contact:
E-mail: , oulubey@mu.edu.tr
ORCID: 0000-0001-7672-1937

Ata Rıdvan, PhD
Associate Professor
Computer Education and Instructional Technology
Muğla Sıtkı Koçman University
Muğla-Turkey
Contact:
E-mail: ridvanata@mu.edu.tr
ORCID: 0000-0002-5008-9328

INTRODUCTION

In today's world digital technologies have begun to spread in every area of life in light of the rapidly growing information and therefore personal development and transformation needs emerge. In order to keep up with this development and transformation, it becomes inevitable for individuals to acquire new knowledge and skills. This situation leads to the formation of new competence and skill concepts. These include creative and innovative thinking, problem solving, and 21st century skills including communication and collaboration (Voogt & Roblin, 2012). Pre-service and in-service teachers are expected to have new skills (Organization for Economic Co-operation and Development [OECD], 2018). In this context, new education policies and educational standards have been created (Binkley et al., 2012; Geisinger, 2016).

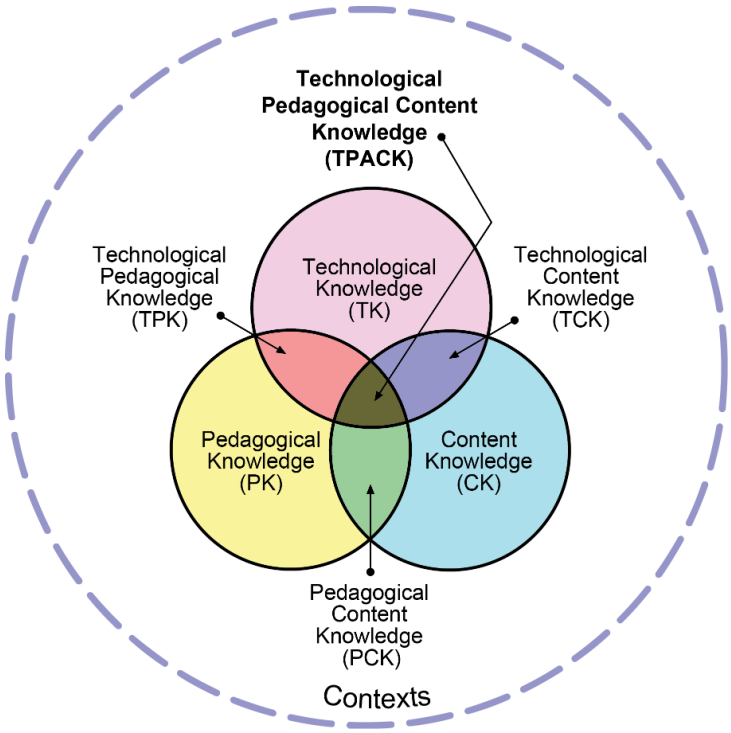
Teacher education has an important stand in the training of 21st century teachers and pre-teachers. Teachers must embrace various pedagogical approaches to benefit from information communication technologies (ICTs) in an efficient and effective manner and to support the development process of 21st century skills of students (Voogt et al., 2013). Accordingly, it can be said that 21st century skills should be included in teacher education. From this point on, it was aimed to examine 21st century skills of educators within the scope of technological pedagogical content knowledge (TPACK) that focuses on pedagogical, professional and ICT competences of educators.

TPACK

TPACK, built on Shulman's (1986) "Pedagogical Content Knowledge" idea, is one of the leading models for effective technology integration in education. TPACK is a theoretical approach put forward by Mishra and Koehler (2006), which tries to identify the skills that teachers need for technology adaptation while dealing with complex and versatile issues in the content knowledge subjects (Figure 1).

Three basic knowledge forms, Content Knowledge (CK), Pedagogy Knowledge (PK), and Technology Knowledge (TK) are located at the center of the TPACK framework. In addition, TPACK emphasizes the interactions between these components beyond the technological, pedagogical and field knowledge components. It is located in a common intersection area where technological, pedagogical and content knowledge are interactive with each other. In other words, the model which is the intersection of these three components, contains Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). Accordingly, considering the contents of the knowledge types that form the TPACK model; the CK includes knowledge that covers the concepts, theories and ideas related to the subject to be learned or taught. PK mainly covers teaching and learning practices or methods, including classroom management skills, lesson planning and assessment. TK covers a broad understanding of information technologies, tools and resources. On the other hand, PCK expresses the understanding that supports the determination of the most appropriate method for the content to be taught and the best teaching of the content. TCK refers to providing richer and more flexible content with the most appropriate technology for the content in the field. TPK includes the understanding of how teaching and learning can be improved when certain tools are used in certain ways. Finally, TPACK expresses the understanding of how to teach content using various technologies and always take this process to a higher level in order to improve previous experiences (Koehler, Mishra & Cain, 2013).

Figure 1. TPACK model proposed by Mishra and Koehler (2006).



21ST CENTURY SKILLS

21st century skills have been defined by various international or national institutions, organizations and academic research. Some examples can be Partnership for 21st Century Learning (P21), ATC21S skills framework the OECD skills framework, and International Society for Technology in Education (ISTE) skills framework (Griffin and Care, 2015; ISTE, 2016, 2017; OECD, 2018; P21, 2019,). For instance, P21 is defined in four main titles and 17 subtitles that students need to be successful in professional and daily life in addition to the 21st century learning outcomes. The main title of "learning and innovation skills" covers creative thinking and innovation, critical thinking and problem solving, communication and collaboration skills. The main title of "Information, media and technology skills" covers information literacy, media literacy and information communication technologies literacy skills. On the other hand, the main title of "life and career skills" refers to flexibility and adaptability, entrepreneurship and self-direction, social and intercultural skills, productivity and leadership and responsibility skills. In addition, the main title of "major topics and 21st century themes" states English, language arts, world languages, art, mathematics, economics, science, geography, history, management and citizenship as the basic subjects that should be taught in schools. Also 21st interdisciplinary themes are indicated as global awareness, financial, economic, business and entrepreneurship literacy, citizenship literacy, health literacy and environmental literacy (P21, 2019). On the other hand, the competencies required for today's students to adapt to an ever-evolving technological environment, according to ISTE standards, are handled in the form of digital literacy, innovation, computational thinking, communication and global collaboration skills.

Despite different definitions, all these standards aim to provide students with basic skills such as collaboration, technology literacy, social and cultural competencies, creativity, critical thinking and problem solving. Another characteristic feature of these definitions is that they emphasize the importance of ICT skills. In particular, students are expected to use ICTs as an efficient vehicle in areas related to 21st century skills such as the students' learning, collaboration, problem solving, and creative and innovative thinking (Sanger and al., 2018). ICTs are reported to have common ground with other 21st century qualifications components. In other words, ICT skills are an important place in the 21st century skills(Voogt et al., 2013).

TPACK MEASUREMENT

It is very important to use valid and reliable measurement tools in the development of TPACK knowledge and skills of in-service and pre-service teachers. In the literature related to TPACK studies, there are many measurement tools used by the researches which help us better understand the TPACK developments of pre-service teachers. Meta-synthesis studies in the literature indicate that the most used self-report measurement tools are among five different research models generally (self- report, open-ended questions, performance evaluation, observation and interview) in the field of TPACK (Koehler, Shin, and Mishra, 2012; Wang, Schmidt-Crawford, and Jin, 2018). From these studies, Koehler et al. (2012) examined 66 studies conducted between 2006 and 2010. Koehler et al. (2012) stated that the most important problem in the studies examined was reliability and validity. Also, they stated that the TPACK area is in continuous development, and more specific scales should be used. Similarly, Wang et al. (2018) analyzed 88 TPACK studies published between 2007-2014. They stated that the self- report scales used in the TPACK area generally focused on the definition of seven areas of knowledge defined by Mishra and Koehler (2006), and emphasized that scales for the integration of technology into educational practices, enrichment of teaching and learning have gained importance in recent years.

The development of scale by combining the TPACK competencies with 21st century skills, description of the TPACK competences of teachers comprehensively is important to meet today's skills and expectations better. Furthermore, reproduction and renewal are important stages in the development of scientific knowledge (National Academies of Science, Engineering and Medicine, 2019). The validity and reliability of a self- report scale, testing the validity and reliability of the scale in different cultures is a requirement in generating new and effective information. Moreover, face-to-face education has been transformed into distance education in many countries with the COVID-19 pandemic process. This pandemic process created an opportunity to review the readiness level of countries in terms of educational technologies, to evaluate teachers' and students' technology literacy, ability to use educational technologies, their interests and attitudes. The distance education process requires teachers to continue their education by using the technological infrastructure provided to them. For this reason, it is important to determine and develop the 21st century skills-supported TPACK and skills of pre-service teachers by blending the technology, pedagogical and content knowledge of the teachers, the teaching knowledge of the students and 21st century skills. In line with this rationale, the purpose of this study was to test the validity and reliability of the 21st century skills-oriented TPACK scale (TPACK-21) developed by Valtonen et al., (2017) by adapting into Turkish culture. Accordingly, the research questions were sought:

1. Is the factor structure of TPACK-21 scale confirmed in Turkish culture?

2. What are the reliability results of the TPACK-21 scale?

METHODS

RESEARCH MODEL

This study was a descriptive study, which aimed to test the validity and reliability (Psychometric properties) of the TPACK-21 developed by Valtonen et al. (2017). Therefore, a quantitative survey model was employed.

CONTEXT OF THE STUDY

Teacher education in Turkey has been constantly changing since 1848, when the initial teacher education was established. Teacher education includes a 4-year university-level education period and students are placed according to their scores they gain from the test, Higher Education Institutions Exam, conducted by the Student Selection and Placement Center. In order to enroll in any teacher education program a student must be among the first 300 thousand at the test. Furthermore, the curriculum in education faculties has been updated since 2018. This update was made according to research and new economic, social and cultural needs in the field. In the new teacher program, pre-service teachers must take courses within the scope of content knowledge, professional knowledge and general culture. Content knowledge courses include content knowledge and pedagogical content knowledge courses. Professional knowledge

courses include general professional courses and technological pedagogical courses. General culture courses include general qualification courses and elective courses according to the needs and interests of the students.

Participants

The participants of the study selected with using the convenient sample included 339 pre-service teachers who enrolled in the teacher education faculty of a state university located in the western part of Turkey. There is a total of 93 education faculties in Turkey. The selected education faculty is a medium level faculty based on the 2019 Higher Education Institutions Exam base scores. Therefore, the findings of this study from the selected sample can be generalized to the population. Participants are 11 different teaching area including German, Physical Education, Instructional Technologies and Computer Education, Science, English, Mathematics, Preschool, Psychological Counseling and Guidance, Primary, Social Studies and Turkish Language teaching. 226 of the participants were female and 113 were male. Since pedagogical content knowledge and technological pedagogical content knowledge courses are usually taught in the third grade, only the third and fourth grade preservice teacher were invited to participate in the study. While 154 participants were fourth year students, 185 participants were third year students. Recommended sample size for polytomous items in Rasch analysis were 250 participants (Linacre, 2002). A sample of 339 pre-service teachers would be enough for robust item estimations.

Instruments

Technological Pedagogical Content Knowledge Scale

TPACK-21 is a 38-item six-point Likert type developed by Valtonen et al. (2017) (1 = I have too many knowledge gaps, 6 = My knowledge level is very good). The scale consists of seven sub-dimensions defined by Mishra and Koehler (2006). The scale aims to measure the knowledge level of pre-service teachers in the relevant field by integrating the 21st century skills and TPACK skills that pre-service teachers should have. The measurement tool covers reflective thinking, problem solving, creative thinking, critical thinking and information and communication technology competence as 21st century skills. Reflective thinking is one's ability to think consciously about their own education, learning and skills. Problem solving is the ability of solving new tasks that the individual does not know beforehand, by combining previous knowledge and experiences in a new way. Creative thinking is defined as using own skills to create something new and comparing different sources of information. Critical thinking is the ability to comprehensively process information, evaluate the reliability of information, and compare different sources of information. Finally, the information and communication technologies competence is expressed as an effective and efficient use of web-based applications and software, social media services and online learning environments as well as different devices such as computers, tablets and smartphones. Sample items, number of items and reliability levels reported by Valtonen et al. (2017) were given in Table 1.

Table 1. Information on the sub-dimensions of TPACK-21

Sub-dimension	Sample item	Item number	Reliability coefficient *
PK	I can guide students' discussions in group work (2-5 students)	7	.93
CK	I have sufficient knowledge to improve the content of my specialty	4	.92
TK	I am familiar with new technologies and their features	4	.88
PCK	In my specialty, I know how to guide students to think critically	6	.95
TPK	I know how to use ICT as a tool for students to share their thoughts and ideas	6	.95
TCK	I know websites with online materials for my specialty	4	.89
TPACK	In my specialty, I know how to use ICT as a tool to develop students' reflective thinking skills	7	.96
*Reported by Valtonen et al. (2017)			

Valtonen et al. (2017) reported fit index (CFI= 0.98, TLI= 0.98, RMSEA= 0.063 [0.057; 0.069]) after removing technological pedagogical content knowledge sub-dimension as the result of the confirmatory factor analysis using the least squares prediction method weighted according to the mean and variance.

TEACHER SELF-EFFICACY SCALE

Studies in the literature have showed that there is a relationship between TPACK and teaching self-efficacy. For instance, Joo, Park and Lim (2018) showed in their study that there was a moderate relationship between teachers' self-efficacy and TPACK level of Korean pre-service teachers (r = .49, p <.01). In another study, Keser, Karaoglan-Yilmaz, and Yilmaz (2015) examined the technology use self-efficacy and TPACK levels of Turkish pre-service teachers and stated that there was a high level relationship between these variables (Spearman's rho=. 78, p <. 001). In this context, it was expected that there was a relationship between TPACK level and teachers' self-efficacy. The Teacher Self-Efficacy Scale developed by Schmitz and Schwarzer (2000) was used to determine teachers' self-efficacy. The scale was adapted to Turkish by Yilmaz, Koseoglu, Gercek, and Sonran (2004). The scale, which is a 4-point Likert type (1: not suitable for me, 4: completely suitable for me), consists of two sub-dimensions and 10 items. The management behavior sub-dimension consists of six items and measures teachers' ability to cope with stress and emotions when faced with a difficult situation. The innovative behavior dimension consists of four items and measures the self-efficacy of displaying innovative behavior. Each item was removed from the coping behavior and innovative behavior sub-dimensions since they had a low factor load in the study of Yilmaz et al. (2004). With this process, the scale consists of a total of eight items. Reliability value Cronbach's alpha was reported as .79 for eight items.

PROCEDURES IN THE SCALE ADAPTATION PROCESS

The adaptation study of the TPACK-21 into Turkish culture was carried out by following process specified by Çapik et al. (2018). First, the scale was translated from English into Turkish by researchers. Conceptual and semantic deductions were made while translating. Then the opinions of two Turkish and two English education experts were evaluated. Modifications were made in line with their opinions. Later, two experts independently made back-translation. The translations of the experts were examined and it was determined that the translations were semantically compatible with each other. Opinions of pre-service teachers were taken in order to examine the comprehensibility of the scale. At the final stage of the translation process, translators and experts gathered in a panel session to check the translations. In the next step, field experts evaluated the relevance of the scale for culture, comprehensibility and the purpose. It was sent to determine whether the scale was understood by pre-service teachers in the target audience. The Turkish version of the TPACK-21 was finalized in line with the feedback of pre-service teachers. Finally, to make the TPACK available for all pre-service teacher disciplines, "the natural science" phrase was replaced with "in my field of expertise" because the TPACK-21 was originally developed for the science teacher field.

DATA ANALYSIS

Confirmatory factor analysis was performed using the MPLUS program for the construct validity of the data, and Rasch analysis for its validity and reliability. Rasch analysis method is a method of testing validity and reliability, which is generally used on Likert type scales considering the latent trait theory (Ilhan & Guler, 2017). In the Rasch model, which was first developed by George Rasch, instead of the classical test theory, the abilities of individuals and the difficulty levels of the items are determined and the possibilities of individuals to respond to the items are taken into consideration (Rasch, 1961). In the classical test theory, statistical values such as mean value and standard deviation are calculated from the raw scores obtained from the answers given by the individuals in the scale of Likert type. However, not all items are equally difficult in tests that measure attitude, knowledge and skills (Bond & Fox, 2015). In addition, although the researcher assumes that the range between the options is equal in Likert type scales, it is relative (Elhan & Atakurt, 2005). For example, expressions such as 1: strongly disagree, 2: disagree, which are found in most Likert- type scales, are semantically relative although one or two numerical expressions are given. Therefore, Rasch analysis argues that this type of ranking is not really equally ranged-internal scale, but rather it is

ordinal type scaling. Therefore, in such scales, before calculating statistics such as mean value, etc. from the data, they must be converted into interval-ranged or ratio-proportion units (Bond & Fox, 2015).

In the Rasch analysis, the unit defined as logit is used and it indicates the natural logarithm of the individual's probability of success (Elhan & Atakurt, 2005). In Rasch analysis, considering the ability and item difficulty values of the individual in calculating this natural logarithm, the possibility of the individual to answer a question correctly is expressed (Yildiz & Uzunsakal, 2018). Rasch analysis combines people's ability and item difficulty on a common axis.The conversion to this axis converts scores into interval scores (Bond & Fox, 2015).

In this study, Rasch analysis was performed in Winsteps 3.80 software. First, the reliability coefficient of individuals and items was calculated. Then, item measurement indices (Infit and Outfit) values were examined. In addition, confirmatory factor analysis was performed in the MPLUS software to test the construct validity. In confirmatory factor analysis, the adjusted weighted least squares parameter estimation method by mean and variance weighted least squares mean and variance [WLSMV]) were used as the scale is considered a ordinal type. The good fit values are considered to be lower than RMSEA= .06 and greater than CFI= .95 for good fit (Hu & Bentler, 1999). Finally, within the scope of criterion validity, correlations with self-efficacy beliefs were examined. Structural equation model was also used with WLSMV estimation method to determine the correlations.

RESULTS

In this part of the paper, the findings related to the Rasch analysis and validity analyses were included. While Rasch person reliability coefficient for the TPACK was found to be .90, the item reliability coefficient was .91. These values were higher than the cut-off value .70, indicating that sample and items were reliable (Bond & Fox, 2015). The fit indices of Rasch analysis were given in Table 2. The fit indices include important information about the psychometric properties of the PACK-21. The first column of the Table 2 showed the total score of each item. Based on this, while the pre-service teachers reported that they needed the most information on Item 8 (I can solve problems related to ICT), they rated that they had sufficient knowledge on Item 21 ("I know how to guide students' creative thinking in my field of expertise). In the second column, the measurement score presented the Rasch measurement value of the items.

The high measurement score indicated a lower agreeability of the item (difficult item). In other words, the high measurement score showed that the participants tend to choose 1 (I have a lot of information deficiency) in the Likert scale of 6. Similarly, a low Rasch analysis score indicated the agreeability of that item was high (easy item). In other words, participants tend to choose “my level of knowledge is very good” for items with low measurement scores. These results indicated that while pre-service teachers stated that they needed more information for Item 8, they stated that they had sufficient information in Item 21. Moreover, pre-service teachers generally stated a need for more information about the items related to technological knowledge, whereas they believed that their knowledge level in the pedagogical knowledge was sufficient.

The infit and outfit values in Table 2 give information about the fit values of the items. These fit values show the residual amount between the data obtained and the values estimated by the Rasch model. The infit value shows that weighted mean residuals based on the low variance while the outfit value gives the average mean score. Zstd value gives the z-standard score status of the fit values. The negative value of the Z standard value indicates a good overlap between the actual value and the estimated value, while a positive value indicates that there is a difference between the estimated value and the actual value.

Bond and Fox (2015) stated that the z-standard score less than -2.00 shows very good to be the true. If this value is higher than 2.00, it can be said that there is a misfit between the model and the predicted value. Therefore, Bond and Fox (2015) recommend that the average of infit and outfit values be between 0.6 and 1.4 for a good fit for Likert type scales. As seen in Table 2, infit and outfit mean values and z scores were in the acceptable fit range. In the last column, point serial correlation values were displayed. Since these values were greater than .30, this indicates that a correlation between the scale items were stronger than medium level.

Table 2. Rasch analysis results

Total	Model		Infit		Outfit		Pt/mea	Items
Score	Measure	SE	Mnsq	Zstd	Mnsq	Zstd	Corr.	
1293	1.13	0.14	1.14	0.92	1.13	0.81	0.64	Tpack8
1322	.62	0.14	1.36	1.08	1.40	1.30	0.54	Tpack9
1330	.58	0.14	1.32	1.88	1.36	1.11	0.54	Tpack11
1332	.57	12.16	0.69	-1.11	0.69	-1.13	0.82	Tpack26
1333	.55	12.16	0.56	-1.22	0.55	-1.33	0.84	Tpack37
1344	.52	12.16	0.65	-1.49	0.63	-1.62	0.83	Tpack34
1345	.52	12.16	0.54	-1.47	0.54	-1.50	0.82	Tpack35
1345	.52	12.16	0.63	-1.66	0.63	-1.67	0.85	Tpack38
1357	.40	12.16	0.89	-0.65	0.89	-0.70	0.82	Tpack30
1359	.40	12.16	0.47	-1.09	0.46	-1.21	0.86	Tpack36
1378	.34	12.16	0.55	-1.35	0.54	-1.41	0.83	Tpack25
1379	.34	12.16	0.73	-1.79	0.71	-1.02	0.81	Tpack32
1380	.34	12.16	0.70	-1.03	0.71	-1.01	0.85	Tpack33
1404	.33	0.14	1.30	1.77	1.49	1.20	0.62	Tpack15
1409	.29	0.14	0.91	-0.51	0.93	-0.4	0.70	Tpack1
1412	.29	12.16	1.03	0.26	0.96	-0.18	0.75	Tpack24
1426	.27	12.16	0.89	-0.63	0.87	-0.79	0.80	Tpack22
1428	.24	12.16	0.79	-1.36	0.79	-1.39	0.80	Tpack29
1437	.24	12.16	1.09	0.62	1.05	0.38	0.77	Tpack31
1440	.22	12.16	0.91	-0.55	0.88	-0.7	0.79	Tpack23
1449	.21	0.14	0.86	-0.86	0.89	-0.68	0.76	Tpack12
1466	.19	12.16	0.93	-0.42	0.88	-0.75	0.77	Tpack27
1473	.16	12.16	1.34	1.95	1.47	1.61	0.67	Tpack28
1483	.02	0.14	0.78	-1.43	0.77	-1.54	0.77	Tpack14
1510	-.02	0.14	1.37	1.11	1.33	1.93	0.50	Tpack10
1520	-.04	0.14	0.83	-1.04	0.83	-1.09	0.71	Tpack4
1523	-.39	12.15	0.70	-1.01	0.72	-1.87	0.74	Tpack2
1525	-.39	12.15	0.70	-1.05	0.69	-1.15	0.82	Tpack13
1534	-.48	12.15	0.66	-1.34	0.65	-1.44	0.77	Tpack3
1535	-.48	12.15	0.97	-0.14	0.98	-0.06	0.76	Tpack6
1543	-.59	12.15	0.77	-1.53	0.75	-1.67	0.80	Tpack5
1551	-.69	12.17	1.18	1.09	1.23	1.35	0.58	Tpack16
1570	-.75	12.17	1.34	1.32	1.49	1.10	0.49	Tpack19
1573	-.77	12.15	0.91	-0.54	0.87	-0.80	0.78	Tpack7
1586	-.97	12.17	1.36	1.94	1.52	1.79	0.55	Tpack20
1590	-1.03	12.17	1.46	1.8	1.41	1.58	0.51	Tpack17
1598	-1.27	12.17	1.43	1.81	1.45	1.45	0.53	Tpack18
1601	-1.42	0.18	1.43	1.79	1.47	1.52	0.59	Tpack21
MEAN	1446.7	12.15	0.99	-0.3	0.98	-0.3		
P. SD	26.6	12.01	0.40	1.4	0.38	2.4		

In order to test the construct validity of the scale, confirmatory factor analysis was performed in Mplus 6.12 program using WLSMV estimation the fit values of the scale as χ^2 (644) = 1131.07, RMSEA= .047 (CI: 042, .052), CFI= .98 and TLI= .98. These fit indices showed that the data fit well with the theoretical structure of the scale. In addition, the WRMR value calculated in the WLSMV estimation method was found to be 0.96. A value less than 1.0 is good indicators of method. WLSMV estimation method is a prediction method generally used for ordinal type scales. Confirmatory factor analysis resulted in the fit (Yu, 2002). Factor loads of the items, given in Table 3, were higher than .30 cut-off value. That indicated that the items had a good correlation with the latent factor. In addition, correlations between the factors showed a strong relation, as expected in the theoretical model, indicating a good construct validity.

Table 3. Factor loads of items

Factors	Items	Factor loadings
PK	Tpack1	0.73
	Tpack2	0.78
	Tpack3	0.77
	Tpack4	0.81
	Tpack5	0.71
	Tpack6	0.77
	Tpack7	0.77
TK	Tpack8	0.73
	Tpack9	0.84
	Tpack10	0.83
	Tpack11	0.75
CK	Tpack12	0.80
	Tpack13	0.77
	Tpack14	0.80
	Tpack15	0.78
PCK	Tpack16	0.75
	Tpack17	0.77
	Tpack18	0.77
	Tpack19	0.77
	Tpack20	0.78
	Tpack21	0.77
TPK	Tpack22	0.80
	Tpack23	0.78
	Tpack24	0.81
	Tpack25	0.82
	Tpack26	0.80
	Tpack27	0.81
TCK	Tpack28	0.80
	Tpack29	0.88
	Tpack30	0.81
	Tpack31	0.86
TPACK	Tpack32	0.81
	Tpack33	0.74
	Tpack34	0.78
	Tpack35	0.82
	Tpack36	0.72
	Tpack37	0.82
	Tpack38	0.83

Criterion Validity

In order to test the validity of the TPACK-21, the pre-service teachers' relationship with self-efficacy perception was examined. Structural equation modeling with WLSMV estimation method were used. Fit values of the analysis were in good fit (χ^2(953) =1449.73, RMSEA= .039 (CI: .035, .043), CFI= .98 and TLI= .98. WRMR value was found as .93. The correlations between TPACK-21 factors and self-efficacy factors were displayed in Table 4.

Table 4. Correlation values between factors

No.	Factors	1	2	3	4	5	6	7	8
1	PK	1.00							
2	CK	.49	1.00						
3	TK	.61	.45	1.00					
4	PCK	.63	.43	.59	1.00				
5	TPK	.49	.62	.52	.53	1.00			
6	TCK	.52	.68	.63	.57	.71	1.00		
7	TPACK	.51	.59	.60	.58	.69	.71	1.00	
8	Management	.50	.26	.50	.53	.34	.42	.38	1.00
9	Innovative behavior	.51	.32	.49	.58	.30	.33	.31	.55
Note. All correlation values are statistically significant at the .01 level.									

All correlations were a medium or high level between the factors. The correlation among the factors in the instrument can be an indicator that the scale provides construct validity (Thompson, 2004). The high correlations among technological pedagogical knowledge, technological content knowledge and technological pedagogical content knowledge compared to other factors indicated that these three factors were very close to each other. This result is reasonable because all of them includes integrating technology, pedagogy and content knowledge with teaching purposes. All TPACK sub-dimensions were related to self-efficacy perception. Among them, the strongest relation was between pedagogical content knowledge and innovative behavior ($r= .58$, $p<.001$) whereas the weakest one was between the content knowledge and management ($r= .26$, $p<.01$). Overall, as expected, all dimensions were significantly related to teaching self-efficacy of pre-service teachers, which indicated that the instrument had the validity.

DISCUSSION

In this study, the 21st century skills integrated Technological Pedagogical Content Knowledge Scale, developed by Valtonen et al. (2017), was adapted to Turkish culture and tested its validity and reliability. In the analysis, first, Rasch analysis was invoked to measure its person and item reliability. Next, for the construct validity of the TPACK-21, confirmatory factor analysis with WLSMV estimation method suggested for ranking and classification type scales was performed. The analysis resulted in the fit values of the scale as $\chi^2(644) = 1131.07$, RMSEA = .047 (CI: .042, .052), CFI = .98 and TLI= .98. The ratio of chi-square to degree of freedom was 1.75. This value is less than 3.0 good fit cut-off value (Jöreskog & Sörbom, 1993; Kline, 2005). This result indicated that the model fitted well with the data. RMSEA is another fit index commonly reported in CFA. The cut-off value for the RMSEAindex is .05, and less than that value is an indicator of good fit (Browne and Cudeck, 1993; Hu and Bentler, 1999; Vieira, 2011). A .047 value of the RMSEA, the confidence interval between .042 and .052, indicated that the model had a good fit with the data. In the confirmatory factor analysis, the CFI (Comparative Fit Index) and TLI (Tucker-Lewis ndex) values of .95 and above are indicative of perfect fit of the model (Hu and Bentler, 1999; Şimsek, 2007). Analysis resulted in .98 values of CFI and TLI, indicating that the model fit well with the data. The factor loading values of the scale were between .71 and .86. The factor loading is the correlation between the latent factor and the item. According to Kline (1994), factor loading values over.60 are high values. As the factor loadings were above.70, this showed that all items were highly correlated with their corresponded latent factors. A high factor loading increases the average variance extracted value, which is another way to test the validity. Therefore, a higher value than .70 for confirmatory factor analysis and .50 for exploratory factor analysis point out that the variance explained by the items is higher than error variance. Overall, it can be concluded that the data fit well with the theoretical structure of the scale. Valtonen et al. (2017), found fit indices

(CFI=.98, TLI= .98, RMSEA= .063 [.057; .069]). Compared to the fit values, it can be said that similar results were found. In fact, it can be stated that the RMSEA value was better in the Turkish TPACK-21. Also, Valtonen et al. (2017) excluded the technological pedagogical field knowledge dimension in confirmatory factor analysis and there were six dimensions in the original of the TPACK-21. Yet, results of confirmatory factor analysis in this study showed that seven-factors structure of the TPACK-21 was valid. The results of this study suggest that cultural and social factors may be influence the structure of an instruments and thus, the factor structure of any adapted instrument should be checked before using it in a study. As for reliability, while the TPACK scale's Rasch person reliability coefficient was found to be .90, the item reliability coefficient was.91. It can be said that the scale is reliable because its reliability values are .70 and above (Büyüköztürk, 2003; Özdamar, 2013). Valtonen et al. (2017) found the Cronbach Alpha values of the scales between .88 and .96, which were close to the results of this study. These values show that the adapted scale is reliable.

As a criterion validity, the relations of TPACK-21 with the self-efficacy perception of teacher candidates was examined by utilizing structural equation modeling with WLSMV estimation. As a result of the analysis, fit indices were found as (χ 2 (953)= 1449.73, RMSEA= .039 (GA: .03, .04), CFI= .98 and TLI= .98., and WRMR value were as .93 . Studies have showed that self-efficacy and TPACK are highly correlated (Joo, Park and Lim, 2018; Keser, Karaoğlan-Yilmaz and Yilmaz, 2015). For instance, Joo, Park and Lim (2018) showed that there was a moderate correlation between self-efficacy and TPACK (r=. 49; Cohen et. al., 2003). In this study, the correlation coefficients between sub-dimensions of TPACK-21 and self-efficacy varied from moderate (e.g., r=.26 between content knowledge and management) to high (e.g., r= .58 between pedagogic content knowledge and innovative behavior). This variation can be due to the multidimensional nature of TPACK. Results of this study showed that the Turkish version of the TPACK-21 displayed almost the same item-factor structure with the original TPACK-21. Hambleton, Merenda and Spielberger (2005) state that translation of a scale means more than one language to another. Adaptation of a scale to another culture is the adaptation process carried out in cultural change. The results showed that Finn and Turkish teachers candidates had similar experiences in terms of technological and pedagogical content knowledge. In this context, the validity and structure of the TPACK-21 should be explored with teachers in the different countries because the experiences of pre-service teachers in different geographies are different.

21st century skills include the skills such as critical thinking, creativity, innovative thinking, and collaboration. To be a qualified teacher, it is very important for teacher candidates to have these skills and use ICT tools efficiently (Sanger et. al., 2018). ICT skills have an important place in the 21st century skills (Voogt et. al., 2013). Therefore, pre-service teachers should integrate the ICT skills with the 21st century skills. The adapted measurement tool has an important role in determining teacher candidates' 21st century and TPACK skill levels so that teacher education programs can design for the elimination of the shortcomings of the teacher candidates in the related field in accordance with the requirements of the age.

In the results of Rasch analysis, the highest average score was in pedagogical content knowledge. This result indicated that pre-service teachers believed that they could foster students to think critically, to use their thoughts and ideas, to reflect reflectively and to think creatively. Based these results, it can be said that the teacher education taken by teacher candidates at faculty of education is qualified and their pedagogical content knowledge is at a good level. However, the lowest averages of teacher candidates were in technology knowledge. This shows that teacher candidates are not familiar with new technologies, cannot use new technologies, and therefore cannot solve problems related to ICT. In teacher education undergraduate programs, it can be said that the courses such as computer and instructional technologies and material design, which are expected to help pre-service teachers improve their technology competencies, are insufficient.

When the high and low scores of pre-service teachers are considered together, it can be said

that they cannot integrate pedagogical field knowledge and technology knowledge. This problem may make it difficult for pre-service teachers to meet the requirements of their professions in the future because the formal education could not be carried out face-to-face during the COVID-19 process and distance education made it compulsory. During Covid-19, many countries has started distance education for formal education. The results of this study suggest that teachers with insufficient technology knowledge are more likely to have difficulties in this process. Insufficient technology knowledge of pre-service teachers may cause problems regarding the quality of education from pandemic processes that exist now and may occur in the future. In order to overcome this problem, the technology education in universities may need to be made more qualified and functional in accordance with the requirements of the age. By focusing on the technology knowledge of pre-service teachers, the focus should be on how to make the technology compatible with education. Koehler et al. (2012) states that program designs for adaptation of technology to education will be beneficial. Thus, pre-service teachers should be provided more courses to harmonize pedagogical knowledge with technology knowledge (Saubern, Henderson, Heinrich, & Redmond, 2020). Findings suggest that teacher education programs should explicitly target pre-service teachers' TPACK knowledge and skills.

In Turkey, all teacher education faculties should follow a national teacher education program, developed by National Higher Education. This program includes courses teaching knowledge (pedagogy knowledge), content knowledge and general culture courses. Courses related to the technology knowledge are given through, general computer course in the first semester, the instructional technology, and instructional technologies and material design courses in the fifth semester. In the existing teacher education program, there is no course that purpose to help teacher candidate integrate technology, content and pedagogic knowledge. Teacher candidates are expected to combine the skills they have gained in other courses in the context of technology and teaching profession and use them in their professions (Çoklar et al., 2007). We believe that the scale adapted is very useful in order to measure how different skills related to teaching profession can work together. Findings of this study suggest that there is a need in teacher education program for a course that are designed to foster TPACK.

SUGGESTIONS FOR FUTURE RESEARCH

Some suggestions can be made in line with the results of this research. The TPACK-21 was originally developed from teacher candidates in Finland. Therefore, the construct validity of TPACK scale in different cultures can be examined. Findings related to the validity of the TPACK-21 in different cultures and other variables can help explore the nature of the TPACK. In the original scale development study, Valtonen et al. (2017) used the MPLUS software to analyze the data. In this study, MPLUS and Winstep 3.0 software for Rasch analysis were used. Considering the limitations of these software and analyzes, the TPACK scale can be analyzed using different techniques, and the results can be compared with previous research results.

In the original development study, carried out by Valtonen et al. (2017), six factors structure gave good fit value, and the seventh factor, technological pedagogical content knowledge, was removed from the original scale because it did not give good fit values. In this study, the seven-factor structure gave very good fit values. Studies comparing the results can be done by analyzing the seven-factor structure in different social structures and cultures.

The original scale was developed for science teachers. In this study, adaptation was made for general teaching areas. Validity and reliability of the TPACK-21 can be done in different samples. Also, studies can be conducted to see if there are differences between the groups in different teaching area.

Findings of this study indicated that pre-service teachers had difficulties in solving problems related to ICT technologies and using new technologies, and websites related to emerging technologies. Qualitative research can be conducted to determine the reasons for the shortcomings of teacher candidates in this regard. In line with the results obtained from the research, updates can be made in teacher education programs. Because when pre-service

teachers start their profession, they will need to use technology intensively. For this reason, deficiencies need to be eliminated. The data were obtained from pre-service teachers. The scale adapted to teacher candidates can also be adapted to teachers. Thus, it can be tested whether the scale will be used for teachers.

LIMITATIONS

Research was conducted at a university located in the western part of Turkey. Even though the data are collected from different teaching fields, it is limited only in one education faculty, and the generalizability of the results is limited. In addition, the data were collected through google docs. Although it is not possible to completely remove the limitations within the scope of the research, it has been tried to minimize the limitations. In this context, necessary measures were taken in the process of collecting data. Data from the volunteers of the pre-service teachers were collected. No student was forced. However, the items related to the independent variables of the scale were designed to be prior to the items related to the dependent variables.

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