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Abstract

This study aimed to investigate and compare the perception of TPACK competence of graduate students studying at the institutes of Natural Sciences, Social Sciences and Educational Sciences based on the variables of gender, graduate program level and field. The participants of the research consist of 186 graduate students studying at the institutes of Karatay, Necmettin Erbakan and Selçuk University. TPACK Competence Scale was used to collect research data. The results of the research showed that graduate students‘ technological knowledge and TPACK competence were moderate. It was also found that male graduate students‘ technological knowledge and technological content knowledge were high, whereas female participants had a high-level perception of pedagogical knowledge. In addition, perceptions of TPACK competence varied based on the field and level of graduate education.

Introduction

―Remote teaching” has become a worldwide phenomenon due to COVID-19, resulting in a temporary shift to online teaching (Ananga, 2020; Angelova, 2020; Atabey, 2021; Bradley, 2021; Cakin & Kulekci Akyavuz, 2021; ElSaheli-Elhage, 2021; Hodges at al., 2020; Ilhan, G. O., Kaba & Sin, 2021; Marpa, 2021; Paudel, 2021; Serhan, 2019; Unger & Meiran, 2020). These exceptional circumstances have brought the use of technology in education to the attention of a broader university public. A meta-analysis review of forty years of research about the effect of technology on learning revealed a significant, positive small to moderate effect favoring the utilization of contemporary technology under certain experimental conditions over more traditional teaching (i.e., technology free) in the control group (Tamim et al., 2011). Today, it is important to design environments that can increase students‘ skills and competencies by keeping students at all levels in learning environment in order for distance education applications to be effective and efficient (Bertiz & Kocaman Karoğlu, 2020; Doğru, 2020; Holmes, 2018; Kafai, Tynes & Richard, 2014; Uzorka et al., 2021). The environments that are directly effective in distance education students‘ learning, content, pedagogy and technology competence levels are important in instructional technology research (Alharthi, 2020; Cohen, 2017; Jacobsen, 2019; Jordan, 2014).

In today‘s world, education is one of the areas where technology is used most actively. For this reason, discussions about whether or not technology should be included in education are issues of the past and studies are now being conducted on how it should be included in education in the most functional, effective and useful way. With the increase of alternative solutions in the field of technology in education, studies on educational technology have focused on new and more diverse issues such as blended learning, open learning, flexible learning, integrated learning, distance learning, distributed learning, online learning, e-learning (Akturk & Saka Ozturk, 2019; Akman & Guven, 2015; Hill & Uribe-Florez, 2020; Moore & Kearsley, 1996; Macdonald, 2006; Tekin, Baş, Geçkil & Koyuncuoğlu, 2019). Thus, education and technology have been used together, and accordingly, education has raised generations that use technology in vital activities properly. Technology integration in education is the basis for this to be successful (Abass, Arowolo, & Igwe, 2021; Flynn-Wilson & Reynolds, 2021; Liao, 2007; McCannon & Crews, 2000; Omiles et al., 2019; Olowo et al., 2020; Pambayun et al., 2019; Perdana, Jumadi, & Rosana, 2019; Wallace-Spurgin, 2018).

The evidence seems to support that teaching staff and academics play an important factor in the integration of technology into learning and teaching process (Elliston, 2020; Fraillon, Ainley, Schulz, Friedman, & Duckworth, 2019; OECD, 2015). Dillenbourg (2016) coined the term ‗orchestration' in this vein. Academics and teaching personnel must handle various tasks while balancing multiple constraints. They must determine whether or not to use a particular technology in a given situation. Findings about high-quality learning environments can direct certain decision-making processes (Merrill, 2002). Since effective master‟s and doctoral education programs are related to the scientific competence of graduate students and their learning in all respects, it can be argued that these programs are also based on increasing the students‟ versatile competencies (Nadiri, Kandampully & Hussain, 2009). Therefore, it can be stated that in order to prepare graduate students to use technology effectively, master‟s and doctoral programs should focus on the content, pedagogical applications and technical skills as well as how technology can be integrated with the education as a result of the interaction of these structures (Ariyapala & Edzan, 2002; Jegede & Owolabi, 2005). As Shulman (1986) stated, as being an expert on a subject and being an educator are different from each other, it is not enough to be able use rapidly changing and developing technological tools or to be familiar with the software related to them.

Previous studies and projects show that a large budget was allocated and efforts were made for the effective use of technology in education. However, even if the schools have technological equipment, it is the educators who will implement the curriculum using educational technologies (Schoepp, 2005; Tekin, Koyuncuoğlu, Geçkil, & Baş, 2019). Educators must have adequate pedagogical, technical, and content-based expertise, as well as an understanding of the interactions between these types of knowledge, in order to effectively use technology to promote learner-centered education (Moule, Ward, & Lockyer, 2011; Lilly, Fitzpatrick, & Madigan, 2015). From this point of view, it can be stated that graduate students as individuals with high self-efficacy levels in TPACK and related fields is important both for achieving the goals of their programs and quality university education. TPACK skills should be evaluated with a holistic approach in order to improve graduate students‟ technological and pedagogical competencies, teaching and learning, and prepare them for academic processes.

TPACK is a structure which aims to define the knowledge that teachers need while they are integrating it in their teaching. With the use of it they deal with the sophisticated and fixed nature of teacher knowledge. It includes seven components. Three of them are primary forms of knowledge: 1) Content, 2) Pedagogy, 3) Technology and four form of knowledge that intersect the three primary forms: 4) Technological Pedagogical Content Knowledge, 5) Pedagogical Content Knowledge, 6) Technological Content Knowledge, 7) Technological Pedagogical Knowledge (Parker, 2020).

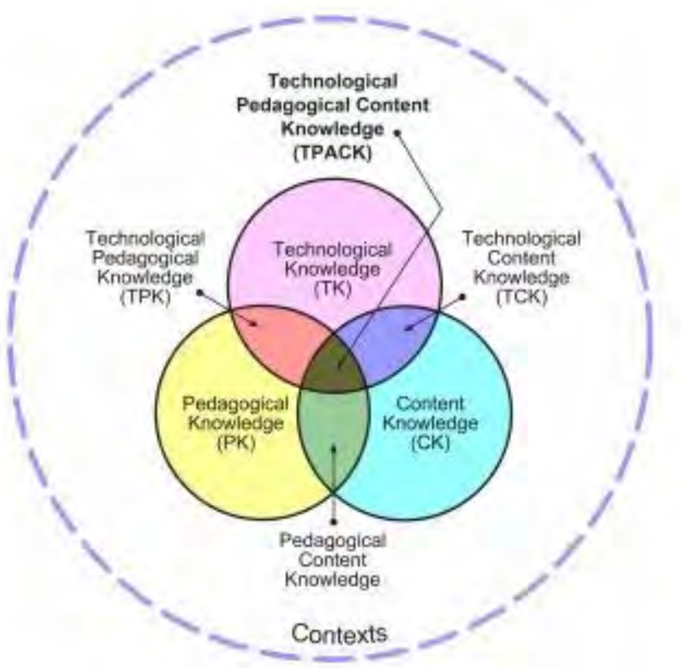

Figure 1. TPACK Model (Mishra & Koehler, 2006, 2009)

Content knowledge, pedagogical knowledge, and technological knowledge are represented by the circles in the TPACK diagram. The places where the circles intersect — where the three types of information come together — can be explained in the following way (Mishra & Koehler, 2006, 2009; Harris & Hofer, 2009):

- Pedagogical Content Knowledge (PCK) deals with the teaching process (Schmidt et al., 2009; Shulman, 1986). It is different for various content fields since it blends both content and pedagogy with the goal being to develop better teaching practices..
- Technological Pedagogical Knowledge (TPK) is a set of skills, identified by Mishra and Kohler in 2006. Teachers develop to identify the best technology to promote a particular pedagogical approach.
- Technological Content Knowledge (TCK) TCK helps teachers create examples and cases where technology can be effectively integrated into their teaching (Margerum-Leys & Marx, 2002).

The key to achievement is that educators can effectively integrate the understanding of pedagogical content knowledge (PCK). Educators use teaching process and methods (pedagogical knowledge, PK) to transform the content knowledge (CK) into the content that pupils can comprehend and learn. At the same time, pupils use their own cognitive levels, motivations, and interests to transform, adjust, and characterize the subject content (Shulman, 1987; Chen, Liao, Chang, Hung, & Chang, 2019). Being familiar with technology well does not mean that TPACK is known well. In order for graduate students to use technology in their academic fields in the future, it is important to have the knowledge and skills to use technology and to consider appropriate pedagogical approaches while using technology (Koh, Chai, & Tsai, 2013). In addition, while integrating technology into teaching environments, attention should be paid to the suitability of the chosen technology for the purpose of the subject (Doering et al., 2009; Niess, 2005). It is stated that, the technology used with appropriate pedagogical methods is highly related to the relevant subject area.

The technological knowledge acquired by individuals during their education prepares them for professional life. The most important of these technological developments is information and communication. Universities have given great importance to information and communication technologies recently (Eryılmaz, 2018). Information and communication technologies should be integrated into the education programs, especially at graduate levels. In light of this information, it can be argued that content, pedagogy and technology skills are acquired later. Thus, it would be useful to determine individuals‘ skill level first in order for individuals to gain these skills (Liu, 2009). However, graduate students, who are future academician candidates, being familiar with the use of technological tools does not mean that they use technology effectively for the purposes of the course. They need to use technologies related to content knowledge effectively and efficiently to increase their future students‘ understanding by integrating them with their pedagogical knowledge (ISTE, 2012). The realization of this is possible with a dynamic graduate education process that will train qualified academicians who always improve themselves based on developing science and technology.

As a result, graduate students should be individuals who can effectively and efficiently utilize technology, renew their existing knowledge resources, improve themselves, internalize new teaching approaches and integrate them into their teaching. One of the important models that emerged in this context is the Technological Pedagogical Content Knowledge model (Mutlu, Polat, & Alan, 2019; Mishra & Koehler, 2008). A graduate student with technological pedagogical content knowledge (TPACK) can provide a good learning teaching environment by integrating educational technology with pedagogical knowledge, which will be used in accordance with the content. Chai et al. (2010) state that conducting TPACK survey studies with mostly small samples limits statistical inferences. Based on the TPACK concept, there was limited research in national and international institutions that provide graduate education.

At the end of this study, it is assumed that the rich and in-depth findings obtained with quantitative data will be useful in terms of providing an effective model for training of masters and doctoral students who integrate the technology needed by the 21st century with their courses and revising the course contents for education programs in institutes. This study aimed to determine Technological Pedagogical Content Knowledge perceptions of graduate students studying in different graduate programs and to reveal the relationship between these concepts through a descriptive approach. Determining the level of technological pedagogical content knowledge of master and doctoral students will make significant contributions to the research on the subject. It is assumed that it will guide administrators, lecturers and academician candidates who carry out their activities at the university level. Therefore, answers to the following questions were sought in the study.

- What is the profile of graduate students‘ technological pedagogical and content knowledge (TPACK)?
- Do graduate students‘ TPACK competencies differ based on gender?

- Do graduate students‘ TPACK competencies differ based on their level of graduate education, masters and doctoral education?
- Do graduate students‘ TPACK competencies differ based on their academic field?

Method

This research used causal comparison and correlational research designs. Causal comparison design is a research method that aims to investigate the subject by comparing at least two groups that differ on this subject. In this research design, the subject and case studied emerge without researcher‘s interference or manipulations. In this design, there is no influence or intervention by the researcher while forming the groups to be compared. In this research with the help of causal comparison design; TPACK competencies and competence perceptions of graduate students studying in the institutes of natural, social and educational sciences were analyzed by comparing them based on the variables of gender, graduate education level and field.

Participants

The participants in this research consist of graduate students studying in the institutes of science, social and educational sciences at universities in Turkey. Reaching students in the institutes of the universities in Turkey requires much time, effort, labor and cost. Therefore, convenient sampling technique was used and 196 masters and doctorate students studying at the institutes of natural, social and educational sciences at Selçuk and Necmettin Erbakan University were selected as participants. After obtaining the necessary permissions, a questionnaire was given to graduate students of the related institutes. Descriptive information of the graduate students is given in Table 1.

Table 1. Participant Characteristics

Variable	Group	Frequency (n)	Percentage (%)
Gender	Female	91	46.43%
	Male	105	53.57%
Level	Master‘s	132	67.35%
	PhD	64	32.65%
Institute	Natural Sciences	66	33.67%
	Social Sciences	71	36.22%
	Educational Sciences	59	30.10%
	Total	196	

When the table is examined, 46.43% of the graduate students participating in the study were female and 53.57% were male. 67.35% of the participants pursued their master‘s education and 32.65% pursued their doctoral education. 33.67% of graduate students studied in natural sciences, 36.22% in social sciences and 30.10% in educational sciences institutes.

Data Collection Tools

Personal information form and TPACK scale were used in order to obtain the data for the purpose of the research. In this section, information about data collection tools was given such as, for what purpose they are used, by whom they were developed, and their reliability were tested.

Technological Pedagogical Content Knowledge Scale

―Technological Pedagogical Content Knowledge Scale" developed by Mishra and Kohler (2006) and was adapted to Turkish form by Kaya et al. (2013) and Şahin (2011) was used to determine the technological pedagogical content knowledge of Master's and Doctoral students. The scale is a five-point Likert type and has a rating of ―(5) Strongly agree, (4) Agree, (3) Neutral, (2) Disagree and (1) Strongly disagree". The reliability coefficient of the scale is 0.91. In the scale, there are 47 items consisting of 7 sub-dimensions; 6 items for content knowledge, 6 items for pedagogical knowledge, 15 items for technological knowledge, 4 items for technological content knowledge, 7 items for pedagogical content knowledge, 4 items for technological pedagogical knowledge and 5 items for technological pedagogical content knowledge.

Data Analysis

The analysis of the data collected was conducted through a package program. Descriptive statistical techniques were used to determine the students' Technological Pedagogical Content Knowledge and Teacher Self-Efficacy levels. In order to determine whether the Technological Pedagogical Content Knowledge and teacher self-efficacy perceptions vary based on the variables, Independent Samples t-test and One Way ANOVA test were used. The answers to the items of the TPACK scale used in the study were analyzed by calculating arithmetic mean values. The following formula is used to calculate the arithmetic mean values:

$$\bar{X} = (\text{Always x } 5) + (\text{Often x } 4) + (\text{Sometimes x } 3) + (\text{Rarely x } 2) + (\text{Never x } 1) / N$$

A criterion was developed for the interpretation of the calculated arithmetic mean. This criterion was developed according to the formula: Criterion= A-B/5 (A- 5 points corresponding to ―Always" option, B- 1 point corresponding to ―Never" option, ―5"- Number of options)= 5 – 1/5=0.80. According to this criterion, the following ranges were determined: 1.00-1.79 Very low, 1.80-2.59 Low, 2.60-3.40 Moderate, 3.41-4.20 High, 4.21-5.00 Very high.

Findings

When Table 2 is examined, the mean scores of technological knowledge, pedagogical knowledge, field knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge and technological pedagogical content knowledge are respectively 2.743±0.69; 3.36±0.69; 4.02±0.63; 2.55±0.34; 3.23±0.52; 3.04±0.64 and 2.70±0.92. The values showed that the content knowledge competencies of the graduate students participating in the study were high, their pedagogical knowledge, technological content knowledge and pedagogical content knowledge competencies were above moderate, whereas their competencies in other areas were moderate.

Table 2. Graduate Students‘ Technological Pedagogical Content Knowledge Levels

TPACK Dimension	Mean	Std. Deviation
TK	2.74	0.25
PK	3.36	.69
CK	4.02	.63
TPK	2.55	.34
TCK	3.23	.52
PCK	3.04	.64
TPACK	2.70	.92

When Table 3 is examined, it is seen that there was no significant difference among mean TC, TPK and TPACK scores ($p>0.05$) based on gender. However, a significant difference was found in among mean TC, PK, TCK and PCK scores ($p<0.05$). The mean PK, TCK, and PCK scores of female graduate students were significantly higher than those of male participants.

Table 3. Graduate Students‘ TPACK Scores Based on Gender

TPACK	Gender	N	Mean	Std. Deviation	-t-	-p-
	Female	91	2.70	0.29	-2.59	0.01
TK	Male	105	2.79	0.22		
	Female	91	3.48	0.69	2.32	0.02
PK	Male	105	3.25	0.67		
	Female	91	3.99	0.66	-0.45	0.65
CK	Male	105	4.03	0.60		
	Female	91	2.53	0.33	-0.89	0.37
TPK	Male	105	2.57	0.35		
	Female	91	3.15	0.46	-2.07	0.04
TCK	Male	105	3.30	0.57		
	Female	91	2.94	0.62	-2.10	0.04
PCK	Male	105	3.13	0.64		
	Female	91	2.59	0.94	-1.54	0.12
TPACK	Male	105	2.79	0.90		

When Table 4 is examined, it is seen that there was no significant difference in the mean TK, TPK, PCK and TPACK scores based on the graduate education program ($p>0.05$). However, a significant difference was found among the mean scores of PK, CK and TCK depending on the graduate education level ($p<0.05$). The mean PK, CK and TCK scores of the doctoral students were significantly higher than those of the master‘s students.

Table 4. Graduate Students‘ TPACK Scores Based on Their Graduate Education (Master‘s/PhD)

	Education	N	Mean	Std. Deviation	t	p
	Master‘s	132	2.74	0.23	-.648	.518
TK	PhD	64	2.76	0.31		
	Master‘s	132	3.26	0.66	-2.976	.003
PK	PhD	64	3.56	0.69		
	Master‘s	132	3.87	0.62	-4.948	.000
CK	PhD	64	4.32	0.53		
	Master‘s	132	2.55	0.32	-.032	.975
TPK	PhD	64	2.55	0.38		
	Master‘s	132	3.18	0.50	-1.970	.050
TCK	PhD	64	3.34	0.56		
	Master‘s	132	3.01	0.58	-.946	.346
PCK	PhD	64	3.10	0.75		
	Master‘s	132	2.75	0.86	1.243	.215
TPACK	PhD	64	2.58	1.05		

When Table 5 is examined, a significant difference was found among the mean TC, PK, TPK, TCK and TPACK scores based on the field and institute studied ($p<0.05$). According to the results of the Scheffe test, the mean TK, PK, TPK, TCK and TPACK scores of the participants who study at the Institute of Natural Sciences were the highest. In addition, students in the Institute of Educational Sciences obtained the highest mean PK scores.

Table 5. Graduate Students‘ TPACK Scores based on Field

		N	Mean	Std. Deviation	F	p	
	1. Institute of Natural Sc.	66	2.86	0.29	4.24	0.02	1>3; 1>2
TK	2. Institute of Social Sc.	71	2.70	0.21			
	3. Institute of Educational Sc.	59	2.67	0.26			
	1.00	66	3.22	0.65	2.54	0.08	3>1; 3>2
PK	2.00	71	3.31	0.64			
	3.00	59	3.58	0.75			
	1.00	66	3.99	0.71	2.13	0.12	
CK	2.00	71	3.92	0.56			
	3.00	59	4.15	0.60			
	1.00	66	2.64	0.35	4.86	0.01	1>2
TPK	2.00	71	2.46	0.28			
	3.00	59	2.55	0.38			

	1.00	66	3.38	0.54	3.88	0.02	1>2
TCK	2.00	71	3.16	0.54			1>3
	3.00	59	3.15	0.45			
	1.00	66	3.07	0.73	2.55	0.08	
PCK	2.00	71	3.14	0.56			
	3.00	59	2.89	0.60			
	1.00	66	2.85	0.91	3.20	0.04	1>3
TPACK	2.00	71	2.75	0.88			
	3.00	59	2.45	0.96			

Discussion

This study which investigated the TPACK qualifications of graduate students studying at the institutes of Natural, Social and Educational Sciences based on the variables of gender, graduate education level and the field showed that students‘ content knowledge was high, pedagogical knowledge, technological content knowledge and pedagogical content knowledge were above moderate and the others were moderate. TPACK competencies enable students to acquire new knowledge in the field, improve their learning and cognitive activities, encourage higher forms of interaction. The education of graduate students with ICT knowledge, skills and interactive professional activity methods contribute to the development of a strong university system and helps self-realization of creative academicians. The study also examined whether graduate students‘ technological pedagogical content knowledge levels differ by gender. The results indicated that there were significant differences between technological pedagogical content knowledge levels of male and female participants in the study. It was found that there was difference in technological knowledge levels in favor of male participants and pedagogical knowledge levels in favor of females. When the literature is reviewed, it is seen that similar results were obtained as a result of comparing the level of technological pedagogical content knowledge based on the variable of gender (Bozkurt, 2016; Koh & Chai, 2011; Jacob, 2002; Jang & Tsai, 2012; Kaleli, 2020a, 2020b; Mahmutoğlu 2019; Tuncer & Bahadır, 2016; Vasil, 1993). In the research conducted by Vasil (1993), it was found that research and technology self-efficacy and use differ in favor of male. Mahmutoğlu (2019) states that female teachers showed higher pedagogical competencies and used teaching methods effectively. These findings show that male graduate students perceive themselves as competent in using technology, whereas females feel themselves more suitable and prone to teaching.

Another research finding is about whether the technological pedagogical content knowledge levels of graduate students differ significantly by the variables of graduate education level and field variables. Results showed that, the doctoral students had significantly higher TPACK competencies than the master‘s students. It was found that the students who received postgraduate education at the Institute of Natural Sciences had higher technological knowledge, whereas the participants in the Institute of Educational Sciences had higher pedagogical knowledge. These findings are similar to the research findings of Kara (2020), Özdemir and Demircioğlu (2016) and Schunk and Pajares (2002). Studies show that individuals who are educated in science-mathematics and technological fields are more competent in technological and related subjects compared to other fields (Schunk & Pajares, 2002). The results of the studies of McKeon et al. (2004), Mustar (2012), Neck and Greene (2011) corroborate the findings of this study. The trainings that people receive in the fields they study and technology contribute to having high competencies. The fact that there are advanced computer courses and applications in the curriculum of Institute of Natural Sciences, and the fact that in Institute Educational Sciences include courses and activities on teaching methods and approaches might be the reason for high competencies of the participants in these institutes.

An important finding in the study is that doctoral students had higher perception of knowledge and competence in many dimensions of TPACK scale. According to Schunk and Zimmerman (2006), multi-faceted learning-teaching processes in cognitive and psychomotor areas in the development of high level competencies specific to a field affect their self-efficacy. Bandura (2006) stated that one of the main factors determining self-efficacy is past experiences. Therefore, the fact that doctoral students who did more activities in their field and had higher perceptions of competence in the field than those who had no or little experience in that field supports the studies in the literature. In this respect, intensive and in-depth academic activities at the doctoral education made the participants more competent in TPACK.

Conclusion

It was found that technological knowledge and TPACK competence of graduate students in general were moderate. In addition, female graduate students�Ꞌ technological knowledge and technological content knowledge were low, whereas male participants‘ perception of pedagogical knowledge was low. Moreover, doctoral students‘ perceptions of TPACK competence vary according to the fields and levels of graduate education. This study also showed that the higher education system provides a background for the training of competent experts in a modern information society. Therefore, one of the primary educational concerns at the university is the use of modern information and communication technologies and interactive teaching techniques, especially in the education of graduate students. Although the change in TPACK is occurring rapidly, the cognitive characteristics of the learners change slowly. This study has the opportunity to create a positive social change over time for the lecturers and experts of TPACK. First, this study provides data to support greater emphasis on TPACK at the graduate level. Therefore, this emphasis will contribute to an increase in interest of education stakeholders in TPACK competencies.

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