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The relationship between technological pedagogical content knowledge of mathematics teacher candidates and teaching mathematics anxiety

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Abstract

The aim of this study is to examine the relationship between pre-service mathematics teachers' technological pedagogical content knowledge and their anxiety about teaching mathematics according to gender and class variables. The relational survey model, which is one of the general survey model types, was used in the research carried out by following the quantitative paradigm. Data were collected online from 196 pre-service teachers using the "Mathematics Teaching Anxiety Scale" and the "Technological Pedagogical Content Knowledge Scale". T-test, one way ANOVA and Pearson's Product Moments Correlation Analysis were used in the analysis of the data. The results showed that the pre-service teachers' genders and classes did not affect their mathematics teaching anxieties and technological pedagogical content knowledge. It also revealed a weak positive relationship between the pre-service teachers' technological pedagogical content knowledge and mathematics teaching anxieties.

1. Introduction

The discipline of mathematics forms the cornerstone of knowledge in many different scientific fields. This discipline is based on a cumulative understanding of mathematics rather than a dogmatic set of rules. Mathematics education should enable the students to build this developing structure in real-life rather than only in the theoretical framework of the classrooms. From this point of view, mathematics teaching has been one of the most complex and rapidly developing research areas within which many theoretical approaches have been developed (Goos & Bennison, 2008; Zevenbergen, 2005).

2. Literature

In 1986, Lee Shulman launched a new way of thinking about the knowledge that teachers need to teach their students, with a structure he calls pedagogical content knowledge (PCK). This way of thinking integrates content knowledge -the primary resource teachers need to teach- and pedagogical knowledge containing general teaching-learning knowledge. PCK, the intersection of these two sets of knowledge, is the method of representing and formulating the knowledge that makes the subject intelligible to students (Shulman, 1986, 1987).

Today, emerging technologies are easily accessible for educational purposes, and combining these technologies in the curriculum grants many opportunities for teachers while carrying out education programs. However, it has brought several difficulties and problems for practitioner teachers. Here, the

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critical edge is the integration of current technologies with the content and pedagogical approaches during the education process.

In the 21st century, the integration of content and pedagogical knowledge alone has been insufficient for teachers, and this has necessitated another component, technology. From this perspective, a technological, pedagogical content knowledge (TPCK) framework was created by scientists (Mishra & Koehler, 2006) by including technology knowledge in PCK proposed by Shulman (1986). The TPCK is a framework for the knowledge that teachers need to make instructional decisions about integrating digital technologies as educational tools. In the 21st century, prospective teachers are expected to combine technology into the content and the pedagogical approaches in the classroom. Research on using technology in educational environments has usually focused on mathematics learning processes and outcomes (Artigue, 2002; Trouche, 2005). However, including technology in the education process may be a different experience also for teachers in the mathematics teaching process.

Many previous studies have examined the anxieties of teachers and prospective teachers about whether they could explain mathematical content using appropriate pedagogical approaches (Peker, 2009; Bursal & Paznokas, 2006; McGlynn-Stewart, 2010). With the addition of the technology component, it has become necessary to re-examine mathematics teachers' anxieties about teaching mathematics and the set of knowledge they should have (Uçar & Ertekin, 2019; Yanuarto, Maat & Husnin, 2020). From this point of view, it is a current issue to examine the relationship between the integration of digital education materials into the knowledge of the content and pedagogy and the pre-service teachers' anxiety about teaching mathematics. Today's pre-service teachers will be the teachers of the future. Therefore, it is crucial to examine their anxieties about mathematics teaching and their knowledge within the scope of TPCK and determine whether there is a relationship between their TPCK and mathematics teaching anxiety. This study aims to reveal the relationship between primary school mathematics teacher candidates' anxieties about mathematics teaching and their TPCK and whether their mathematics teaching anxiety and TPCK differ according to gender and class. In line with this purpose, the problem statement of the research is: Is there a significant relationship between pre-service mathematics teachers' technological pedagogical content knowledge and mathematics teaching anxiety in terms of gender and class variables?. In this context, answers were sought to address the following sub-problems in the study:

1. Do pre-service mathematics teachers' anxiety about mathematics teaching differ according to the "Gender" and the "Class" variables?

2. Do pre-service mathematics teachers' TPCKs differ according to the "Gender" and the "Class" variables?

3. Is there a relationship between pre-service mathematics teachers' TPCKs and their mathematics teaching anxiety levels?

3. Methodology

3.1. Research Model/Design

This quantitative research aims to determine the relationship between pre-service teachers' technological pedagogical content knowledge and their mathematics teaching anxieties. The study has adopted the relational scanning model, one of the general scanning model types. In relational research, the relationship between two or more covariant variables is examined with no attempt by the investigator to influence them. Identifying and studying human behavior in both individual and social relationships is a very complex process. Relational research aims to identify these complex relationships (Neuman, 2006).

3.2. Data Collecting Tools

Data collection tools were personal information form, TPCK scale, and Mathematics Teaching Anxiety Scale. Detailed information about the scales used in the research is below.

3.2.1. Technological Pedagogical Content Knowledge Scale

The Technological Pedagogical Content Knowledge Scale (TPCK), developed by Schmidt et al. (2009) and adapted into Turkish by Dikkartın-Övez and Akyüz (2013), determines the TPCK of teacher candidates. The items in this 27-item, 5-point Likert-type scale are graded as 1=I am incompetent, 2=I am slightly competent, 3=I am partially competent, 4=I am quite competent, and 5=I am fully competent. The items in the scale are grouped under four dimensions. The items related to mathematics knowledge (MK) and technological knowledge (TK) are two separate groups. The items in "pedagogical knowledge" and "pedagogical content knowledge" pool under a single dimension called Mathematics Education Knowledge (MEK). In addition, the items related to "technology-pedagogy," "technological-content," and "technological-pedagogical-content knowledge" gather under a single factor named technological integration into mathematics education (TIME).

Table 1 shows the reliability coefficients (Cronbach's Alpha) of the scale's factors calculated by Dikkartın-Övez and Akyüz (2013) and the number of items in the dimensions.

Table 1.

The Reliability Coefficients of the Technological Pedagogical Content Knowledge Scale

Factors	Cronbach's Alpha	The Number of Items
MK	.82	3
TK	.83	6
MEK	.85	8
TIME	.86	10
TPCK	.91	27

3.2.2. The Mathematics Teaching Anxiety Scale

The teacher candidates' mathematics teaching anxiety was measured with the Mathematics Teaching Anxiety Scale developed by Peker (2006). The 23-item 5-point Likert-type scale items were graded as 1=Strongly Disagree, 2=Disagree, 3=Undecided, 4=Agree, 5=Strongly Agree. The last 13 questions with positive responses were reverse-coded. The scale consists of four factors. Table 4 shows the reliability coefficients (Cronbach's Alpha) calculated by Peker (2006) for the scale and the number of items included in the factors.

Table 2.

Mathematics Teaching Anxiety Scale Reliability Coefficients

Factors	Cronbach's Alpha	The Number of Items
Factor 1: Pre-service teachers' content knowledge and mathematics teaching anxiety	.90	10
Factor 2: Pre-service teachers' self-confidence and mathematics teaching anxiety	.83	6
Factor 3: Pre-service teachers' attitudes towards teaching mathematics and mathematics teaching anxiety	.71	4
Factor 4: Pre-service teachers' content education knowledge and mathematics teaching anxiety	.61	3
Overall Anxiety	.91	23

3.3. Sampling or Study Group

The research study group consists of pre-service teachers studying in the 1st, 2nd, 3rd, and 4th grades of the 2021-2022 academic year Elementary Mathematics Teaching program of a state university located in the northwest of Turkey. Since the study covered all graders studying in the Primary Education Mathematics Teaching program, "Maximum diversity sampling" was used. In addition, "Convenience sampling" was used because the preferred study group was around the researcher and easily applicable. The data were collected online from 196 2021-2022 Academic Year's Teacher candidates using the "Anxiety Scale for Teaching Mathematics" and the "Technological Pedagogical Content Knowledge Scale." Before collecting the data online, the teacher candidates were provided with survey-related clear information by the researcher. The tables containing the demographic characteristics of the study group include the distributions of the prospective teachers' gender and class info. Table 3 shows the descriptive statistics of teacher candidates by gender.

Table 3.

Distribution of Mathematics Teacher Candidates by Gender

Variable (Gender)	Frequency	Percentage
Female	144	73,5
Male	52	26,5
Total	196	100,0

Table 1 shows that of the 196 teacher candidates participating in the research, 73.5% were female (n=144), and 26.5% were male (n=52).

Table 4 shows the descriptive statistics of teacher candidates by class.

Table 4.

Distribution of Mathematics Teacher Candidates by Class

Variable (Class)	Frequency	Percentage
1st Grade	46	23,5
2nd Grade	57	29,0
3rd Grade	42	21,5
4th Grade	51	26,0
Total	196	100,0

Of the 196 pre-service teachers, 46 (23.5%) were 1st graders, 57 were 2nd graders (29.0%), 42 were 3rd graders (21.5%), and 51 were 4th graders (26.0%).

3.4. Data Analysis

In the current study, in which data analysis was performed with SPSS 22, the significance level was 0.05. The participants' gender and class information distributions were determined using descriptive statistics, such as frequency (f) and percentage (%). Kolmogorov-Smirnov Normality test was used to determine which tests would be applied in data analysis. The test result has shown that the "Mathematics Teaching Anxiety Scale sub-dimensions" and the "TPCK Scale sub-dimensions" p values were less than the significance level of 0.05, and the dataset was not normally distributed. However, considering that the skewness and kurtosis values between -1.5 and +1.5 (Tabachnick and Fidell, 2013) or -2.0 and +2.0 (George and Mallery, 2010) indicate a normal distribution, the data, which did not show a normal distribution in the Kolmogorov-Smirnov test, were re-evaluated with the skewness and kurtosis criteria of George and Mallery (2010). Besides, the extreme values in the data group were determined using a box plot chart in the SPSS program, and the nine pre-service teachers' data with extreme values were excluded from the dataset. Thus, all the skewness and kurtosis values obtained in the study were within the normality range, and each variable was accepted as "normally distributed" within itself. Based on this result, "Pearson Product Moments Correlation Analysis Technique" was used to determine the relationship between the teacher candidates' mathematics teaching anxiety levels and TPCK levels. This technique was used because the two variables in question are discrete variables and these two variables show a normal distribution.

Table 5.

Kolmogorov-Smirnov normality test results for the Mathematics Teaching Anxiety Scale and the TPCK Scale's sub-dimensions

Sub-dimensions and overall totals	n	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis	Kolmogorov-Smirnov Test	
								Statistics	p-Value
Anxiety-Content	196	10,0	40,0	21,28	7,001	,590	,104	,108	,000
Anxiety-Self-confidence	196	11,0	30,0	21,19	3,668	,167	,168	,084	,002
Anxiety-Attitude	196	11,0	20,0	16,76	1,971	,116	,000	,288	,000
Anxiety-Content Education	196	9,00	15,0	12,16	1,408	,396	,565	,317	,000
Anxiety Total	196	60,0	92,0	71,40	5,504	1,109	2,538	,104	,000
TK	196	12,0	30,0	21,73	3,317	,063	,226	,095	,000
MK	196	7,0	15,0	11,34	1,555	,026	,28	,198	,000
MEK	196	19,0	40,0	30,76	3,675	-,282	1,403	,164	,000
TIME	196	25,0	50,0	38,04	4,481	,230	1,449	,173	,000
TPCK Overall Total	196	76,0	135,00	101,88	10,251	,391	1,287	,092	,000

In these normally distributed scales, "scale mean total scores" and "mean sub-dimension scores" were compared according to the "Gender" variable using the "t-test for independent samples." In these normally distributed scales where the number of classes was more than two, "scale mean total scores" and "mean subscale scores" were compared according to the "Class" variable using "One-Way Analysis of Variance (ANOVA)."

3.5. Research Procedures

The current study aims to determine the relationship between pre-service elementary mathematics teachers' technological pedagogical content knowledge and their mathematics teaching anxiety. Data analysis in the research was carried out in five primary stages. In these stages:

(i) The collected data were preprocessed for the statistical procedure. The normal distribution of data was tested with skewness and kurtosis in SPSS.

(ii)At the outset, the study had included 205 pre-service teachers; nine showing extreme data values in the box plot chart created in the SPSS program were excluded from the evaluation. The research data included 196 pre-service teachers.

(iii) Mean and standard deviation (SD) scores were calculated for all subscale scores through the determining frequency and percent (%) values of the participant demographic characteristics.

(iv) Before testing the mathematics anxiety scale and the technological pedagogical content knowledge scale according to various demographic variables, the assumption of normal data distribution was tested with the Kolmogorov-Smirnov test. The normal distribution value was less than the statistical significance level ($p<.05$). Therefore, kurtosis-skewness measures were used to describe the normal distribution. The kurtosis and skewness values showed that the distribution was linear. In this respect, parametric tests were used in the study. The statistical significance level was taken as 0.05 in the SPSS software analysis. In this context:

- Independent groups t-test was used to determine whether the subscale scores of the students in the sample group differed according to the "Gender" variable.
- ANOVA was used to determine whether the subscale scores of the students in the sample group differed according to the "Class" variable.
- Scheffe test and LSD test were used to determine between which groups the statistical difference occurs after ANOVA.

(v) Pearson's Product Moments Correlation Analysis was employed to determine the relationships between the Mathematics Anxiety Scale and the subscales of the Technological Pedagogical Content Knowledge Scales.

3.6. Findings and Discussions

3.6.1. Findings related to the first sub-problem

The first sub-problem of the study was: Does mathematics teaching anxiety of pre-service mathematics teachers differ according to "Gender" and "Class" variables? In order to determine whether there was a statistically significant difference between the pre-service teachers' "mathematics teaching anxiety scale's sub-dimension mean scores" and the "total mean scores" according to the "Gender" variable, the data showing normal distribution were analyzed with the T-Test for Independent Samples. Table 6 shows the results.

Table 6.

t-test results according to the "Gender" variable

Mathematics teaching anxiety scale's sub-dimensions	Gender	n	Mean	Standard deviation	t	p
Anxiety-Content	Female	144	21,8958	6,67290	2,047	,042*
	Male	52	19,5962	7,65752		
Anxiety-Self-confidence	Female	144	20,6042	3,37042	-3,877	,000***
	Male	52	22,8269	3,98881		
Anxiety-Attitude	Female	144	16,5972	1,88968	-1,831	,071
	Male	52	17,2115	2,13593		
Anxiety-Content Education	Female	144	12,0833	1,37154	-1,325	,187
	Male	52	12,3846	1,49711		
Anxiety-Total	Female	144	71,1806	5,26189	-,941	,348
	Male	52	72,0192	6,14048		

*.05; **.01;***.001

Table 6 shows no statistically significant difference between the means of male and female teacher candidates in almost all sub-dimensions. {Anxiety-Attitude (t_275= -1,831; p>.05); Anxiety-Content Education (t_275= -1,325; p>.05), Anxiety-Total (t_275= -,941; p>.05)}. However, there was a difference in the self-confidence in teaching mathematics between male and female pre-service teachers {Anxiety-Self-Confidence (t_275 = -3,887; p<.05)}. Accordingly, male teacher candidates' self-confidence in teaching mathematics ($\bar{x}$=22,82) was higher than female teachers ($\bar{x}$=20,60). Besides, there was a difference between male and female pre-service teachers in the Anxiety-Content sub-dimension (t_275= 2,047; p<.05). Content-related anxiety of female teacher candidates ($\bar{x}$=21,89) was higher than males ($\bar{x}$=19,59).

One-Way Analysis of Variance (ANOVA) was used to determine whether there was a statistically significant difference according to the "Class" variable between the teacher candidates' Mathematics teaching anxiety scale's normally distributed "sub-dimension mean scores" and "total score averages." Table 7 shows the results.

Table 7.

Comparison of prospective teachers' mathematics teaching anxiety according to the "Class" variable

Mathematics teaching anxiety scale's sub-dimensions	Class	n	Mean	Standard Deviation	F	p	Scheffe Test Value	LSD Test Value
Anxiety-Content	1st grader	46	20,9565	7,47427	,482	,695	-	-
	2nd grader	57	21,8772	6,64688				
	3rd grader	42	21,8333	7,81779				
	4th grader	51	20,4706	6,31618				
Anxiety-Self-confidence	1st grader	46	21,3913	3,96360	,403	,751	-	-
	2nd grader	57	21,1579	3,94964				
	3rd grader	42	20,6905	3,11948				
	4th grader	51	21,4706	3,54600				
Anxiety-Attitude	1st grader	46	17,0870	2,40209	,808	,491	-	-
	2nd grader	57	16,5088	1,91910				
	3rd grader	42	16,6429	1,55895				
	4th grader	51	16,8431	1,91178				
Anxiety-Content Education	1st grader	46	12,0652	1,78141	1,247	,294	-	-
	2nd grader	57	12,0351	1,20956				
	3rd grader	42	12,0476	1,14663				
	4th grader	51	12,4902	1,41947				
Anxiety-Total	1st grader	46	71,5000	5,26097	,049	,986	-	-
	2nd grader	57	71,5789	5,50632				
	3rd grader	42	71,2143	6,36506				
	4th grader	51	71,2745	5,09933				

*.05; **.01;***.001

Table 7 shows that the differences in the sub-dimension and total score averages between the different-grader teacher candidates were not statistically significant {Anxiety-Content (F_273 =,482; p>.05); Anxiety-Self-Confidence (F_273 =,403; p>.05); Anxiety-Attitude (F_273 =,808 p>.05); Anxiety-Content Education (F_273 =1,247 p>.05); Anxiety-Total (F_273 =,049; p>.05)}. Scheffe Test and LSD test analysis applied to determine the current differences between groups showed that the difference between the groups was not significant.

3.6.2. The second sub-problem

The second sub-problem of the research was: Does the TPCK of pre-service mathematics teachers differ according to the "Gender" and "Class" variables? The "t-Test for Independent Samples" was used to find if any statistically significant difference existed between the pre-service teachers' TPCK scale's sub-dimension and total mean scores according to the "Gender" variable. Table 8 shows the results.

Table 8.

t-test results according to the "Gender" variable

TPCK scale's sub-dimensions	Gender	n	Mean	Standard Deviation	t	p
TK	Female	144	21,0556	3,23179	-5,105	,000***
	Male	52	23,6346	2,79375		
MK	Female	144	11,2292	1,52241	-1,695	,092
	Male	52	11,6538	1,61955		
MEK	Female	144	30,5764	3,65387	-1,166	,245
	Male	52	31,2692	3,72124		
TIME	Female	144	37,7778	4,43357	-1,397	,164
	Male	52	38,7885	4,57331		
TPCK	Female	144	100,6389	9,88720	-2,891	,004
	Male	52	105,3462	10,54009		

*.05; **.01;***.001

Table 8 shows the difference between the mean of the TPCK Scale sub-dimensions {TK (t_{275}=-5,105; p<.001) and TPCK (t_{275}= -2,891; p<.01)} was statistically significant according to the "Gender" variable. There was a statistically significant difference in favor of male teacher candidates for the TK and TPCK sub-dimensions in the group averages. According to the analysis, the mean TK ($\bar{x}$=23,63) of male pre-service teachers was higher than the mean TK ($\bar{x}$=21,05) of female pre-service teachers. Similarly, male pre-service teachers' TPCK ($\bar{x}$=105,34) averages were significantly higher than female teacher candidates' TPCK ($\bar{x}$= 100,63) averages. No significant difference existed between male and female teacher candidates in other sub-dimension scores and overall total scores {MK (t_{275}= -1,695; p>.05), MEK (t_{275}= -1,166; p>.05), TIME (t_{275}=-1,397; p>.05)}.

"One-Way Analysis of Variance (ANOVA) was conducted to determine whether there was a statistically significant difference between the pre-service teachers' TPCK scale sub-dimension mean scores and the total mean scores by the "Class" variable. Table 9 shows the results.

Table 9.

The comparison of prospective teachers' TPCKs by the "Class" variable

Sub-dimensions	Class	n	Mean	Standard deviation	F	p	Scheffe Test Value	LSD Test Value
TK	1st Grader	46	21,0217	3,18670	2,196	,090	-	Between 1st and 3rd Graders*
	2nd Grader	57	21,4561	3,61579				
	3rd Grader	42	22,7381	2,96368				
	4th Grader	51	21,8824	3,24128				
MK	1st Grader	46	11,0435	2,04349	1,761	,156	-	
	2nd Grader	57	11,1579	1,53285				
	3rd Grader	42	11,6667	1,24287				
	4th Grader	51	11,5490	1,23796				
MEK	1st Grader	46	30,1304	5,22647	1,724	,163	-	Between 1st and 4th Graders*
	2nd Grader	57	30,3509	3,74877				
	3rd Grader	42	30,9286	2,56042				
	4th Grader	51	31,6471	2,36494				
TIME	1st Grader	46	37,8043	5,88640	,510	,676	-	
	2nd Grader	57	37,7018	3,90953				
	3rd Grader	42	38,7619	3,13757				
	4th Grader	51	38,0588	4,61914				
TPCK	1st Grader	46	100,0000	12,95977	1,710	,166	-	
	2nd Grader	57	100,6667	10,60043				
	3rd Grader	42	104,0952	7,42050				
	4th Grader	51	103,1373	8,77501				

*.05; **.01;***.001

Table 9 shows no statistically significant difference in the TPCK sub-dimension and total score averages among prospective teachers in different classes. {(TK (F_273=2,196; p>.05), MK (F_273=1,761; p>.05), MEK (F_273=1,724; p>.05), TIME (F_273=,510; p>.05), TPCK Overall Total (F_273=1,710; p>.05)}. While the Scheffe Test analysis performed to know between which groups there was a difference showed no significant difference, the LSD test revealed a significant difference of 0.05 between the 1st and 3rd grades in TC and between the 1st and 4th grades in MEK.

3.6.3. The Third sub-problem

The third sub-problem of the study was: Is there a relationship between pre-service mathematics teachers' TPCKs and their mathematics teaching anxiety? The Pearson product-moment Correlation Analysis was carried out to determine whether there was a significant relationship between the participants' TPCKs and their mathematics teaching anxiety. Table 10 shows the results.

Table 10.

The Correlation Values Showing the Relationship Between TPCK and Mathematics Teaching Anxiety Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.TK	1									
2. MK	,366	1								
3. MEK	,339	,551	1							
4. TIME	,461	,419	,612	1						
5. TPCK	,703	,651	,819	,869	1					
6. Anxiety-Content	-,248	-,409	-,450	-,256	-,415	1				
7. Anxiety-Self-Confidence	,280	,440	,454	,288	,446	-,587	1			
8. Anxiety-Attitude	,281	,206	,288	,170	,300	-,547	,513	1		
9. Anxiety-Content Education	,364	,356	,504	,381	,519	-,438	,487	,613	1	
10. Anxiety-Total	,064	-,062	-,308	,025	,009	,573	,228	,162	,242	1

*.05; **.01;***.001

Correlations range from -1 to 1. Although they do not have definite borders, values close to -1 and +1 indicate a strong relationship; values between -0.50 and 0.50 show a medium level of relationship, and values approaching zero indicate a low level of relationship. However, statistically significant relationships are more important than strong ones in correlation calculations (Tekin, 2006). Based on this information, Table 10 shows a weak positive relationship between pre-service teachers' TPCKs and their mathematics teaching anxiety (r=,009 p<.01). The participants' TPCK sub-dimensions were moderately positively correlated within themselves, as were their Mathematics Teaching Anxiety scale sub-dimensions. The teacher candidates' "TPCK sub-dimensions" and the "Mathematics Teaching Anxiety Scale Anxiety-Content sub-dimension" were moderately negatively correlated. In addition, all the correlations of sub-dimensions of these scales were statistically significant. Table 10 shows that the lowest relationship was between the "Technological Pedagogical Content Knowledge Scale's TPCK sub-dimension" and the "Mathematics Teaching Anxiety Scale's Anxiety-Total sub-dimension" (r=,009 p<.01); the highest relationship was between "TPCK" and the "Mathematics Teaching Anxiety Scale's Anxiety-Content Education sub-dimension" (r=,519 p<.01).

Examining the changes in the "technological pedagogical knowledge" and "Mathematics teaching anxiety" by the "Class" variable of the pre-service teachers using the Scheffe Test did not reveal a significant difference.

4. Conclusion and Suggestions

This study aims to reveal the relationship between primary school mathematics teacher candidates' mathematics teaching anxiety and technological pedagogical content knowledge (TPCK) and to know whether the "technological pedagogical content knowledge" and "mathematics teaching anxiety" in pre-service teachers differ according to their "Genders" and "Classes." This quantitative research carried out in the correlational survey model employed the Technological Pedagogical Content Knowledge Scale (Schmidt et al., 2009) and the Mathematics Teaching Anxiety Scale (Peker, 2006) as data collection tools. The results showed that the pre-service teachers' genders and classes did not affect their mathematics teaching anxieties and technological pedagogical content knowledge. It also revealed a weak positive relationship between the pre-service teachers' technological pedagogical content knowledge and mathematics teaching anxieties.

The t-test for independent samples showed that the pre-service teachers' genders did not affect their mathematics teaching anxiety or technological pedagogical content knowledge. On the other hand, male teacher candidates had higher self-confidence than females in mathematics teaching anxiety. In addition, there was a significant difference between teacher candidates in favor of males in the "Technological knowledge (TK) and TPCK sub-dimensions of the Technological Pedagogical Content Knowledge Scale." The study findings complied with the research of Karataş et al. (2017), which revealed that male pre-service mathematics teachers were more technologically proficient. Durndell & Haag (2002) and Albion, Jamieson-Proctor, and Finger, (2010) declared that male teacher candidates had higher self-confidence in integrating technology into mathematics lessons. This finding complies with the current study results and explains male prospective teachers' high self-confidence in teaching mathematics.

The "Class" variable making no difference might imply no differentiation between classes in technological pedagogical content knowledge. A moderate relationship between teacher candidates' TPCKs and mathematics teaching anxieties identified in the study supports our interpretation. On the other hand, the fact that the "Content education," which will affect the TPCK levels after graduation, remained at the theoretical level is a factor affecting this result.

The literature review on mathematics teaching anxiety has shown that, in their studies, Peker et al. (2010), Peker and Ertekin (2011), Küçük-Demir et al. (2016), Altundal (2013), Tatar et al. (2016) have found that the "Gender" variable makes no significant difference in parallel with the findings of this study. Başpınar (2015) and Deringöl (2018) have determined that the "Class" variable makes no significant difference, supporting the current research findings. On the other hand, Aydın et al. (2009), Doruk and Kaplan (2013), Başpınar (2015), Küçüktepe and Balkan (2021), and Cantimer (2021) have concluded that the "Gender" variable creates a significant difference in mathematics teaching anxiety. Aydın et al. (2009), Hoşşirin-Elmas (2010), Doruk and Kaplan (2013), Hacıömeroğlu (2013), Başpınar (2015), Küçük-Demir et al. (2016), Tatar et al. (2016), Serin (2017), Küçüktepe and Balkan (2021), Cantimer (2021) have concluded that the "Class" variable creates a significant difference in mathematics teaching anxiety.

The one-way analysis of variance ANOVA result also showed that the "Class" variable did not influence the teacher candidates' "mathematics teaching anxieties " and "technological pedagogical content knowledge." According to the research findings, the sub-dimensions of the "Technological Pedagogical Content Knowledge" and "Mathematics Teaching Anxiety" scales had a weak positive correlation. There were positive and moderate intercorrelations in each "Technological Pedagogical Content Knowledge" and "Mathematics Teaching Anxiety" scale sub-dimensions, and there was a negative and moderate correlation between the "Technological Pedagogical Content Knowledge Scale TPCK sub-dimension" and the "Mathematics Teaching Anxiety Scale Anxiety-Content sub-dimension." This finding supports Jackson's (2017) finding that "mathematics teaching anxiety has no positive correlation with content knowledge." However, as Gleason (2008) has revealed, this situation might imply that the increase in the teacher

candidates' technological pedagogical content knowledge would eliminate the content-based problems in their mathematics teaching anxieties.

The relationship between the "Technological Pedagogical Content Knowledge Scale's sub-dimension TPCK" and the "Mathematics Teaching Anxiety Scale's Subscale Anxiety-Total" was minimal. This situation indicates a weak relationship between pre-service teachers' technological pedagogical content knowledge and their mathematics teaching anxiety. Although this shows a weak correlation in total scores, a moderate relationship was found between the sub-dimensions of the scales. Alshehri (2012) found a strong relationship between mathematics teaching anxiety and integrating technology into the mathematics teaching environments. In this context, the relevant literature shows some studies revealing the relationship between pre-service mathematics teachers' teaching anxiety and technological pedagogical content knowledge (Kafyulilo et al., 2015; Bick-har, 2016; Drijvers et al., 2017; Gökoğlu-Uçar, 2019). In line with the findings of the study, the literature studies on mathematics teaching anxiety show that teachers with high teaching anxiety avoid using innovative approaches and models in learning-teaching environments, whereas teachers with low mathematics teaching anxiety are open to all kinds of practices that will increase the effectiveness (Mji & Arigbabu, 2012; Alkan, 2013; Judson, 2014; Eickelmann & Vennemann 2017; Leary et al., 2017).

According to the research findings, the relationship between the Technological Pedagogic Content Knowledge Scale's TPCK sub-dimension, which gives the total score for the scale, and the "Mathematics Teaching Anxiety Scale's sub-dimension Anxiety-Content Education" was higher than the relationships in the other sub-dimensions. This situation reveals the necessity of strengthening the technological pedagogical content knowledge to control the anxiety stemming from content education. In addition, there was a very high relationship between TPCK and "Technology Integration Knowledge into Mathematics Teaching" (TIME). This situation reveals that teacher candidates should know how to integrate technological pedagogical content knowledge into mathematics teaching. Polly (2011) has found that technology integration education positively affects pre-service teachers' technological pedagogical content knowledge in mathematics teaching environments. Some studies show that the technological pedagogical content knowledge of teacher candidates who are open to the use of technology in the classroom environment and can integrate technology into learning environments is positively affected (Bakar, Maat, & Rosli, 2020; Ardıç, 2021)

The current research aims to determine the relationship between primary school mathematics teacher candidates' mathematics teaching anxiety and technological pedagogical content knowledge (TPCK) and determine whether pre-service teachers' technological pedagogical content knowledge and mathematics teaching anxiety differ according to the "Gender" and "Class" variables. The study detected no significant effect of teacher candidates' genders and class levels on their mathematics teaching anxiety and technological pedagogical content knowledge. A very low correlation was detected between pre-service teachers' mathematics teaching anxiety and technological pedagogical knowledge.

The study findings showed that the technological pedagogical content knowledge of the pre-service teachers did not change with their increasing grade level. Based on this significant finding, the authors suggest focusing more on technological pedagogical content knowledge in teacher training programs. Microteaching practices can be carried out to improve technological pedagogical content knowledge.

The fact that pre-service teachers' mathematics teaching anxiety was not affected by the "Class" variable also prompts us to reconsider the effectiveness of teacher training programs. The differentiation of anxiety levels among teacher candidates during their education is another significant reason to monitor the effectiveness of their teaching process. In this context, the current study can also help develop a policy for teacher training programs so that teacher candidates can have a TPCK-based teaching approach. In addition, the different results between the Post-Hoc test and Scheffe and LSD tests in the study and the difference with literature studies' findings on the effect of the "Class" variable on TPCK and mathematics teaching

anxiety suggest that this issue should be more examined. The current study recommends conducting more studies with different samples to examine pre-service teachers' mathematics teaching anxiety, technological pedagogical content knowledge, and their correlation.

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