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Research Article

A Study on the Relationship Between the Pre-service Mathematics Teachers' Technological Pedagogical Content Knowledge and Mathematics Teaching Anxiety

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Abstract

The aim of this study is to investigate correlation between the mathematics teaching anxiety levels of pre-service mathematics teachers and their technological pedagogical content knowledge levels. In this study, we have utilized correlational survey model as a quantitative research approach. The research has been conducted on 277 pre-service teachers who are studying at the 1st, 2nd, 3rd and 4th grades of Mathematics Teaching and Primary Education Mathematics Teaching departments of a state university located at Central Anatolia region of Turkey in 2018-2019 academic year. In order to analyze the data, Pearson Correlation Coefficient and Multiple Regression Analysis have been used. The results of the study revealed that there is an inverse, medium level and statistically meaningful relation between all subdimensions of Technological Pedagogical Content Knowledge Scale (TPACK-Math) and Mathematics Teaching Anxiety Scale (MATAS). In addition, it was found that technological knowledge (TK), content knowledge (CK) and technological pedagogical content knowledge (TPCK) sub-dimensions were significant predictors of "the anxiety originated from content knowledge"; TK and CK sub-dimensions were significant predictors of "the anxiety originated from self-efficacy"; CK and Contexts Knowledge sub-dimensions were significant predictors of "the anxiety originated from the attitude toward mathematics teaching"; the Contexts Knowledge sub-dimension was a significant predictor of "the anxiety originated from pedagogical content knowledge".

Keywords

Mathematics teaching anxiety • Technological pedagogical content knowledge • Pre-service teachers

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Mathematics is a science that most of the people including students and teachers have negative attitudes about it and lots of them think it is difficult to learn and teach (Delice, Ertekin, Aydın, & Dilmaç, 2009). However, mathematics is frequently used in our everyday life in addition to the scientific activities. It is claimed that people who used mathematics effectively are more successful in life. Based on this fact, various international institutions counts numerical abilities like problem solving as basic educational needs. Thus, mathematics is one of the essential lesson of the school program starting from preschool education to primary school (Baykul, 1999).

While importance of mathematics is becoming more visible, mathematics teaching is gaining more importance, too. One of the main purposes of mathematics teaching is to bring thinking skills to the individuals to let them solve real world problems. On the other hand, mathematics teaching is intended for teaching individuals to let them use mathematics in their everyday life, solve problems, share their solutions and ideas, have self-confidence in mathematics, study as a team, develop positive attitudes towards mathematics (Republic of Turkey Ministry of National Education, 2009). In this sense, teachers plays first fiddle in bringing the mentioned skills to the students.

Quality of mathematics teaching is affected by the skills of teachers; their perspectives on mathematics; and the importance that teachers gave to the cognitive developments of the students and also to the mathematics (Yenilmez & Duman, 2008). In addition, attitudes of teachers towards both mathematics and teaching lesson affect attitudes of students as well (Karakaş-Türker & Turanlı, 2008). On the other hand, Baloğlu (2001) states that problems in learning and teaching mathematics are caused by math anxiety. Because of all these reasons, it is not possible to say that it would be a rational approach to try to avoid mathematics teaching anxiety without reducing math anxiety.

Recent studies (Hacıömeroğlu, 2014; Peker & Ertekin, 2011) show that the anxiety about the lesson to be taught is related to the anxiety about teaching the lesson. In other words, the mathematics anxiety of the pre-service teachers may emerge as mathematics teaching anxiety in the future. Existence of the pre-service teachers with both mathematics anxiety and mathematics teaching anxiety were emphasized in several researches (Bekdemir, 2007; Hoşşirin-Elmas, 2010; Peker, 2009).

Mathematics anxiety was first described as “a syndrome of emotional reactions to arithmetic and mathematics” by Dreger and Aiken (1957). Teaching anxiety, which many educators express it as a difficult situation to cope, has been defined as anxiety in the teaching process that involve the preparation and application of classroom activities (Gardner & Leak, 1994). Mathematics teaching anxiety was defined as the tension and anxiety experienced by teachers during teaching mathematical concepts, theories, and formulas or during problem solving (Peker, 2006).

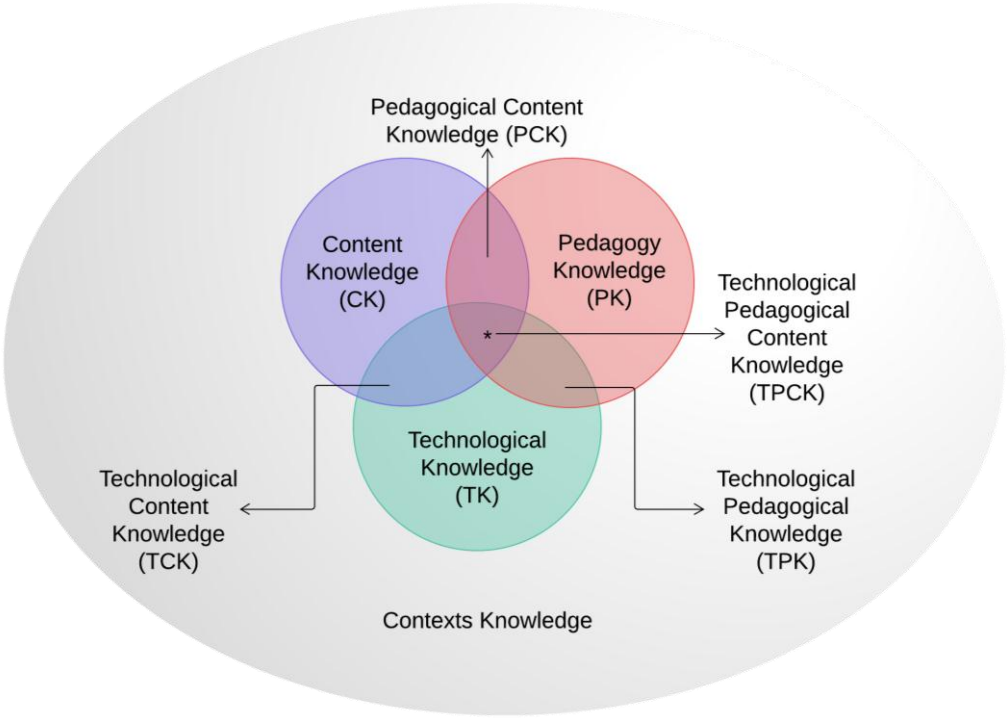
It is crucial for the teachers who want to perform mathematics teaching in accordance with modern understanding to make use of technology in learning-teaching processes (Republic of Turkey Ministry of National Education, 2008; National Council of Teachers of Mathematics [NCTM], 2000). As a result of their research, Graham et al. (2009) states that technology cannot be independent of pedagogy and content knowledge and they focus on integrating technology into the education process. As a result of the studies carried out in this context, behavioral understanding is abondoned and technology, content and pedagogical knowledge were accepted as a whole. Thus, new criteria were determined regarding teacher competences (Niess, 2005).

Recent developments in information, communication and technology have made it requisite to use technology in order to increase the efficiency of education in the learning and teaching process (Niess, 2005). FATİH Project is one of the biggest and most important project carried out in Turkey for the purpose of technology integration in education. In accordance with 21st century conditions, FATİH project aims to educate individuals to increase their technology usage in

all levels of education and in all areas of life (Karabacak & Küçük, 2016). With the FATIH project, "computers for each class" approach is started. However, it has not been possible to reach the target because of the teachers who are not equipped in terms of technological pedagogical content knowledge and insufficient technological infrastructure. In this sense, it seems it is crucial for the teachers to have technological pedagogical content knowledge. In addition, a few of the required qualifications, which teachers should have, are technology literacy and effective/efficient usage of their technology, content and pedagogy knowledge in the classroom activities (Mishra & Koehler, 2006).

Technological pedagogical content knowledge (TPACK) was defined by Mishra and Koehler (2006) and formed by the addition of technology dimension to pedagogical content knowledge (PCK), which Shulman (1986) is added to the literature. Thus, technological pedagogical content knowledge is a new knowledge type that is located at the intersection of technological knowledge, pedagogy knowledge and content knowledge. TPACK interacts with these three main knowledge types (Niess, 2005). In addition, TPACK consists of the interaction between technology, content and pedagogy components and it is a derived new knowledge that differs from these three main concepts of knowledge. As a result of the different intersections of these three main knowledge types, new knowledge types are emerged (See Figure 1).

Figure 1. TPACK Framework (Koehler & Mishra, 2008)



The integration of technology into education is not easy as described. Researches show that teachers are not sufficient and don't have self-confidence in this subject, they have problems in integrating technology into their courses and they don't use technology effectively in their lessons (Bozkurt & Cilavdaroğlu, 2011). Overcoming the internal barriers of teachers is as important as equipping schools with technological tools (Albayrak-Sarı, Canbazoğlu-Bilici, Baran, & Özbay, 2016). Teachers are expected to face various difficulties in transferring information if they cannot use technology effectively for various reasons. As a result of this situation, it is possible that teachers will develop negative attitudes towards teaching their own profession.

Providing technology based learning and teaching experiences to the pre-service teachers in their university education, which is a pre-stage of professional teaching, and encouraging them to deal with technology as producers will enable them to overcome the technology related difficulties that they will face in their teaching life. In addition, it should be emphasized not only how to use technology, but also how to use technology for learning and teaching processes by teacher training programs (Koehler, Mishra & Yahya, 2007).

Pre-service teachers should closely follow technological developments and update themselves in order to be efficient in their fields. With the use of technology, pre-service teachers gain the opportunity to easily access and learn the new developments in their fields and improve themselves in these new areas and integrate technology into their educational and teaching processes. It is expected for the pre-service teachers who can incorporate the components of TPACK model will have higher self-confidence (Avcı, 2014) and consequently lower teaching anxiety. As a result, it is hoped that ability of pre-service teachers to use technology effectively and their TPACK competencies will prevent teaching anxiety they may experience in their lessons. For this purpose, in order to shed light on the situation mentioned in the present study, it was aimed to determine the relationship between TPACK and mathematics teaching anxiety levels of pre-service mathematics teachers and the answer to the following questions:

- Is there a relationship between TPACK levels and mathematics teaching anxiety levels of pre-service mathematics teachers?
- Does TPACK levels of pre-service mathematics teachers predict mathematics teaching anxiety?

Method

Research Design

This study has a quantitative research paradigm in the context of data. In this study, it was aimed to investigate the correlation between pre-service teachers' technological pedagogical content knowledge and mathematics teaching anxiety. Therefore, the research model was determined as the relational survey model, which is one of the general survey models. Relational survey models are the research models aiming to determine the existence and/or degree of covariance between two and more variables (Karasar, 2006).

Participants

The study group consisted of pre-service teachers who are studying in the 1st, 2nd, 3rd and 4th grades of Mathematics Teaching and Primary Education Mathematics Teaching departments of a state university in Central Anatolia region of Turkey in the 2018-2019 academic year.

Maximum variation sampling was used because all grade levels (1st, 2nd, 3rd and 4th) in both Mathematics Teaching and Primary Education Mathematics Teaching departments were included in the study. In addition, convenience sampling method was used because a study group was chosen which was close to the researcher and applicable.

Data Collection Tools

Technological Pedagogical Content Knowledge Scale (TPACK-Math) and Mathematics Teaching Anxiety Scale (MATAS) were used as data collection tools.

Technological Pedagogical Content Knowledge Scale (TPACK-Math) which was used to determine TPACK levels of pre-service teachers was developed by Önal (2016). There are 59 items in this 5-point Likert-type scale. The scale consists of nine factors, unlike the known TPACK scales. These factors are technological knowledge (TK), content

knowledge (CK), pedagogy knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), online technological pedagogical knowledge (TPK online), offline technological pedagogical knowledge (TPK offline), technological pedagogical content knowledge (TPCK) and contexts knowledge.

The reliability coefficients (Cronbach's Alpha) calculated by Önal (2016), the re-calculated reliability coefficients (Cronbach's Alpha) for the current research and the number of items included in the factors are presented in Table 1.

Table 1

Cronbach's Alpha Results of TPACK Scale Factors

Factors	Cronbach's Alpha	Cronbach's Alpha Calculated for Our Sample	Item Number
TK	.91	.91	7
PK	.92	.90	11
CK	.91	.91	9
TPK-Online	.79	.90	3
TPK-Offline	.85	.87	3
TCK	.85	.85	5
PCK	.90	.89	7
TPCK	.93	.93	9
Contexts	.89	.87	5
Total	.97	.97	59

When the table is examined, it is seen that the coefficients obtained from our study are close to the coefficients obtained by Önal (2016) for many factors. This situation shows that the reliability of the scale is high and sufficient in the context of our research.

The mathematics teaching anxiety levels of the pre-service teachers were measured with the "Mathematics Teaching Anxiety Scale (MATAS)" developed by Peker (2006). There are 23 items in four factors in this 5-point Likert scale.

The reliability coefficients (Cronbach's Alpha) calculated by Peker (2006), the re-calculated reliability coefficients (Cronbach's Alpha) for the available research data and the number of items included in the factors are presented in Table 2.

Table 2

Cronbach's Alpha Results of Mathematics Teaching Anxiety Scale (MATAS) Factors

Factors	Cronbach's Alpha	Cronbach's Alpha Calculated for Our Sample	Item Number
The anxiety originated from content knowledge	.90	.89	10
The anxiety originated from self-efficacy	.83	.85	6
The anxiety originated from the attitude toward mathematics teaching	.71	.87	4
The anxiety originated from pedagogical content knowledge	.61	.79	3
Total	.91	.92	23

When the table is examined, it is seen that the coefficients obtained from our study are in parallel with the coefficients obtained by Peker (2006) for many factors. This situation shows that the reliability level of the scale is sufficient in the context of our research.

Data Analysis

Data analysis was performed with SPSS 18, and the significance level was set to 0.05.

Kolmogorov-Smirnov test for normality was used to determine which tests would be applied in data analysis. As a result of the test, it was found that the p values determined at the 5% significance level of Technological Pedagogical Content Knowledge Scale (TPACK-Math) and Mathematics Teaching Anxiety Scale (MATAS) subdimensions were less than 0.05 and therefore the data group did not show normal distribution. However, skewness and kurtosis values between -1.5 and +1.5 according to Tabachnick and Fidell (2013), and between +2.0 and -2.0 according to George and Mallery (2010) mean that the data shows normal distribution. In the present study, as a result of the Kolmogorov-Smirnov test, non-normally distributed data were determined. In order to re-evaluate whether these data show normal distribution, the skewness and kurtosis criterion values of George and Mallery (2010) were taken into consideration. While looking at these values, boxplot chart was used in SPSS software to determine outliers in data group. The data of 7 pre-service teachers which were seen as outliers were not evaluated. As a result, since all skewness and kurtosis values obtained from the study were in the desired range, each variable was assumed to have a normal distribution within itself. Based on this result, Pearson Product Moment Correlation Analysis technique was used to determine the relationship between mathematics teaching anxiety levels and TPACK levels of pre-service teachers.

This technique was used because the two variables are continuous variables and these two variables show normal distribution. Multiple regression analysis was used to determine whether TPACK levels of pre-service teachers predicted mathematics teaching anxiety.

Findings

Findings Related to the First Sub-Problem

The first sub-problem of the study was looked for an answer to the question “Is there a relationship between TPACK levels of pre-service mathematics teachers and mathematics teaching anxiety levels?”. Pearson Product Moment Correlation Analysis was used to determine whether there was a significant relationship between TPACK levels and mathematics teaching anxiety levels. The result of the analysis is presented in Table 3.

Table 3

Correlation Values Showing the Relationship Between TPACK and Mathematics Teaching Anxiety Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Content Knowledge	1													
2. Self-efficacy	.566**	1												
3. Attitude toward Mathematics Teaching	.444**	.502**	1											
4. Pedagogical Content Knowledge	.374**	.446**	.682**	1										
5. Mathematics Teaching Anxiety Final Total	.873**	.818**	.730**	.656**	1									
6. TK	-.355**	-.394**	-.253**	-.287**	-.421**	1								
7. PK	-.303**	-.324**	-.399**	-.388**	-.418**	.477**	1							
8. CK	-.443**	-.394**	-.400**	-.346**	-.509**	.394**	.696**	1						
9. TPK	-.299**	-.265**	-.264**	-.270**	-.347**	.604**	.607**	.521**	1					
10. TCK	-.312**	-.318**	-.272**	-.287**	-.377**	.584**	.464**	.508**	.581**	1				
11. PCK	-.371**	-.319**	-.349**	-.368**	-.438**	.450**	.691**	.692**	.673**	.608**	1			
12. TPCK	-.262**	-.262**	-.256**	-.292**	-.329**	.629**	.527**	.513**	.683**	.687**	.632**	1		
13. Contexts	-.265**	-.246**	-.347**	-.389**	-.360**	.347**	.537**	.441**	.468**	.381**	.555**	.558**	1	
14. TPACK Final Total	-.415**	-.405**	-.404**	-.417**	-.510**	.731**	.810**	.767**	.819**	.758**	.839**	.847**	.665**	1

** p<.01

It is observed that the correlation coefficient is between -1 and +1. Values that are close to -1 and +1 indicates a strong relationship, values around +0.50 and -0.50 are considered to be moderate, and values near zero indicates a low level relationship. However, in correlation calculations, it is important for the relationship to be statistically significant rather than its strength (Tekin, 2006). When Table 3 is examined, it is seen that there is a negative and moderate significant relationship between TPACK levels of pre-service teachers and mathematics teaching anxiety levels (r=-.510 p<.01). In addition, it is seen that the sub-dimensions of TPACK-Math and MATAS were positively and moderately correlated in itself; there were negative and moderate correlation between TPACK-Math sub-dimensions and MATAS sub-dimensions; moreover, all correlations were statistically significant.

In addition, when the Table 3 is examined, the lowest relation was found to be between "contexts knowledge" subdimension of the TPACK-Math and "the anxiety originated from self-efficacy" of the MATAS (r = -.246 p <.01); the highest relationship was between the Mathematics Teaching Anxiety Final Total and Content Knowledge subdimension of MATAS (r =.873 p <.01).

According to Table 3, the lowest correlation was found between contexts knowledge and technological knowledge subdimensions of the TPACK-Math (r =.347 p <.01); the highest relationship was between content knowledge (CK) and pedagogy knowledge subdimensions of the TPACK-Math (r =.696 p <.01); the lowest relationship was between "the anxiety originated from content knowledge" and "the anxiety originated from pedagogical content knowledge" subdimensions of MATAS (r =.374 p <.01); the highest relationship was found between the "the anxiety originated from pedagogical content knowledge" and "the anxiety originated from the attitude toward mathematics teaching" subdimensions of MATAS (r =.682 p <.01).

Findings Related to the Second Sub-Problem

The second sub-problem of the study was looked for an answer to the question "Does TPACK level of pre-service mathematics teachers predict mathematics teaching anxiety?". Multiple regression analysis was used to answer this question and the results are presented in the tables. In addition, since mathematics teaching anxiety has four sub-dimensions, multiple regression analysis was repeated for each sub-dimension and results were presented.

Multiple regression analysis has basic assumptions to be considered. These are sufficient sample size, multiple linear relations, singularity, outliers and normality of distribution. Stevens (1996, as cited in Seçer, 2017) stated that the sample size should be at least 15 people per predictor variable. In this study, there are nine predictor variables, so the study group should consist of at least 135 individuals. This requirement is met since the study group consists of 277 pre-service teachers. In addition, the "tolerance" values obtained from the analysis should not be less than .10, the VIF values should be less than 10, the total score of the scale should not be analyzed simultaneously with the sub-dimensions, and the Durbin-Watson values should be between 1 and 3 (Seçer, 2017). In the context of our study, it was seen that the necessary conditions are met for multiple regression analysis due to the fact that the outliers were eliminated before the analysis and the data distribution was normal. Analysis results are presented in Table 4, Table 5, Table 6 and Table 7.

Table 4

Result of Multiple Regression Analysis for Prediction of Content Knowledge

Variables	B	Std. Error	B	t	p
(Constant)	37.822	2.283		16.568	.000
TK	-.304	.078	-.288	-3.875	.000
PK	.163	.084	.166	1.935	.054
CK	-.437	.090	-.392	-4.842	.000
TPK	.004	.114	.003	.031	.975
TCK	-.068	.128	-.042	-.532	.595
PCK	-.173	.126	-.128	-1.369	.172
TPCK	.178	.081	.201	2.211	.028
Contexts	-.178	.114	-.108	-1.564	.119

a.Predictors: (Constant), TK, PK, CK, TPK, TCK, PCK, TPCK, Contexts

b.The Dependent Variable: The anxiety originated from content knowledge

When the table is examined, it is seen that the TK, CK and TPCK sub-dimensions are significant (F_{268}=11.849; p<.05) predictors of mathematics teaching anxiety (R= .511; R^2=.239), and these sub-dimensions all together explain 24% of the total variance in teaching anxiety. TK, CK and TPCK are the predictor variables according to the standardized regression coefficients. The relative importance of these variables on "the anxiety originated from content knowledge" are CK (β = -0.392), TK (β = -0.288) and TPCK (β = 0.201) respectively. In other words, the CK sub-dimension explains "the anxiety originated from content knowledge" in highest level.

Table 5

Result of Multiple Regression Analysis for Prediction of Self-Efficacy

Variables	B	Std.Error	B	t	p
(Constant)	25.801	1.506		17.129	.000
TK	-.241	.052	-.351	-4.651	.000
PK	.010	.056	.015	.171	.864
CK	-.213	.060	-.293	-3.568	.000
TPK	.077	.075	.088	1.026	.306
TCK	-.087	.085	-.083	-1.027	.305
PCK	-.032	.083	-.037	-.389	.698
TPCK	.097	.053	.169	1.829	.068
Contexts	-.093	.075	-.086	-1.231	.219

a.Predictors: (Constant), TK, PK, CK, TPK, TCK, PCK, TPCK, Contexts

b.The Dependent Variable: The anxiety originated from self-efficacy

When the table is examined, it is seen that the TK and CK sub-dimensions are significant (F_{268}=10.602; p<.05) predictors of "the anxiety originated from self-efficacy" (R= .490; R^2=.218), and these sub-dimensions all together explain 22% of the total variance in "the anxiety originated from self-efficacy". TK and CK are the predictor variables according to the standardized regression coefficients. The relative importance of these variables on "the anxiety

originated from self-efficacy" are TK (β=-0.351) and CK (β=-0.293) respectively. In other words, the TK sub-dimension explains "the anxiety originated from self-efficacy" in highest level.

Table 6

Result of Multiple Regression Analysis for Prediction of the Attitude Toward Mathematics Teaching

Variables	B	Std. Error	B	t	p
(Constant)	15.755	.970		16.241	.000
TK	-.038	.033	-.088	-1.144	.254
PK	-.064	.036	-.157	-1.779	.076
CK	-.099	.038	-.216	-2.591	.010
TPK	.032	.048	.057	.654	.514
TCK	-.048	.054	-.071	-.872	.384
PCK	-.007	.054	-.013	-.134	.894
TPCK	.044	.034	.120	1.287	.199
Contexts	-.134	.048	-.197	-2.777	.006

a.Predictors: (Constant), TK, PK, CK, TPK, TCK, PCK, TPCK, Contexts

b.The Dependent Variable: The anxiety originated from the attitude toward mathematics teaching

When the table is examined, it is seen that the CK and Contexts Knowledge sub-dimensions are significant (F_{268}=9.322; p<.05) predictors of "the anxiety originated from the attitude toward mathematics teaching" (R=.467; R^2=.194), and these sub-dimensions all together explain 19% of the total variance in "the anxiety originated from the attitude toward mathematics teaching". CK and Contexts Knowledge are the predictor variables according to the standardized regression coefficients. The relative importance of these variables on "the anxiety originated from the attitude toward mathematics teaching" are CK (β=-0.216) and Contexts Knowledge (β=-0.197) respectively. In other words, the CK sub-dimension explains "the anxiety originated from the attitude toward mathematics teaching" in highest level.

Table 7

Result of Multiple Regression Analysis for Prediction of the Pedagogical Content Knowledge

Variables	**B**	**Std. Error**	**β**	**t**	**p**
(Constant)	11.802	.718		16.435	.000
TK	-.043	.025	-.133	-1.736	.084
PK	-.044	.027	-.147	-1.670	.096
CK	-.027	.028	-.079	-.950	.343
TPK	.043	.036	.103	1.188	.236
TCK	-.032	.040	-.065	-.789	.431
PCK	-.040	.040	-.098	-1.018	.310
TPCK	.022	.025	.080	.861	.390
Contexts	-.123	.036	-.243	-3.436	.001

a.Predictors: (Constant), TK, PK, CK, TPK, TCK, PCK, TPCK, Contexts

b. The Dependent Variable: The anxiety originated from pedagogical content knowledge

When the table is examined, it is seen that the Contexts Knowledge sub-dimension is significant (F_{268}=9.463; p<.05) predictor of "the anxiety originated from pedagogical content knowledge" (R=.467; R^2=.194), and this sub-dimension explain 20% of the total variance in "the anxiety originated from pedagogical content knowledge".

Conclusion and Discussion

Results Related to the First Sub-Problem

The first sub-problem of the study was looked for an answer to the question "Is there a relationship between TPACK levels of pre-service mathematics teachers and mathematics teaching anxiety levels?". According to the findings of the study, the sub-dimensions of TPACK-Math and MATAS have a positive correlation with medium level in itself. The sub-dimensions of the TPACK-Math and the sub-dimensions of the MATAS have a negative and moderate correlation. In addition, all correlations were statistically significant.

A significant and inverse intermediate relationship between TPACK sub-dimensions and mathematics teaching anxiety sub-dimensions can be regarded as a sign that mathematics teaching anxiety will decrease as technological pedagogical content knowledge increases. In the study conducted by Tatar, Zengin, and Kağızmanlı (2015), it is obtained as a finding that if the pre-service teachers' perceptions related to the use of technology increases, mathematics teaching anxieties will decrease and this finding supports the results of our research with at least the technology aspect. This situation can be interpreted as effective education to be given to the pre-service teachers in the subjects such as the use of technology in teacher training institutions and how to integrate technology into content education will reduce teaching anxiety.

When the correlation values between TPACK-Math and MATAS sub-dimensions were taken into consideration, the highest correlation was found between PK and CK sub-dimensions. The fact that there is a higher level of relationship between PK and CK sub-dimensions can be explained by the necessity of having an advanced content knowledge and pedagogy knowledge in order to teach a subject. As a matter of fact, in the study conducted by Türnüklü and Yeşildere (2007), they obtained the finding that an in-depth content knowledge is necessary but not sufficient for mathematics teaching and it supports this situation.

In addition, when we look at the correlation values of the sub-dimensions, the lowest correlation was found between the TPACK-Math sub-dimension Contexts Knowledge and the MATAS sub-dimension "the anxiety originated from self-efficacy". This result can be explained as follows:

- Contexts Knowledge mostly contains information about educational environments.
- However, "the anxiety originated from self-efficacy" is about the person himself/herself.

Results Related to the Second Sub-Problem

The second sub-problem of the study was looked for an answer to the question "Does TPACK level of pre-service mathematics teachers predict mathematics teaching anxiety?".

It was found that TK, CK and TPACK sub-dimensions were significant predictors of "the anxiety originated from content knowledge". In addition, these variables, which are predictors according to the standardized regression coefficients, have been found to have the relative importance on "the anxiety originated from content knowledge" as CK, TK and TPACK respectively. In other words, the CK sub-dimension explains "the anxiety originated from content knowledge" in highest level. The findings of Battista (1986) that lack of knowledge in pre-service teachers prevented

them from using effective methods in mathematics teaching as well as subsequent mathematics learning is also confirmed in the context of our research.

On the other hand, it is noteworthy that technology information has a relatively second place among these sub-dimensions. As a matter of fact, in the study conducted by Türnüklü and Yeşildere (2007), the finding that pre-service teachers who have a positive perception about the use of technology has lower mathematics teaching anxiety supports this importance.

It was found that TPACK-Math sub-dimensions TK and CK were significant predictors of "the anxiety originated from self-efficacy". In addition, these variables, which are predictors according to standardized regression coefficients, have been found to have the relative importance on "the anxiety originated from self-efficacy" as TK and CK respectively. In other words, the TK sub-dimension explains "the anxiety originated from self-efficacy" at a higher level than the CK sub-dimension. The results indicate that lack of TK and CK are two important components that lead to "the anxiety originated from self-efficacy". On the other hand, the fact that technology knowledge explains mathematics teaching anxiety at a higher level than content knowledge can be considered as an indicator that it is seen that having technology knowledge is more important than content knowledge for pre-service teachers.

It was found that TPACK-Math sub-dimensions CK and Contexts Knowledge were significant predictors of "the anxiety originated from the attitude toward mathematics teaching". In addition, these variables, which are predictors according to standardized regression coefficients, have been found to have the relative importance on "the anxiety originated from the attitude toward mathematics teaching" as CK and Contexts Knowledge respectively. In other words, the CK sub-dimension explains "the anxiety originated from the attitude toward mathematics teaching" at a higher level than the Contexts Knowledge sub-dimension. Similarly, Umay (2002) stated that a teacher who is not adequately equipped in his field cannot be expected to give his students a sense of trust and create a discipline based on respect in the classroom. Therefore, the teacher's inadequacy in his / her field may affect his / her attitude towards teaching the course. It may also have a negative impact on students' learning.

It was found that the TPACK-Math sub-dimension Contexts Knowledge was a significant predictor of "the anxiety originated from pedagogical content knowledge". This situation can be interpreted as "the anxiety originated from pedagogical content knowledge" in pre-service teachers stems from lack of experience related to educational environments. According to Grossman (1988), Contexts Knowledge is the knowledge of the region where the teacher works and the positive and negative aspects of this region, contextual factors that may affect teaching in school, school culture, students' past experiences, interests, strengths and weaknesses.

Suggestions

Teacher training programs should allow pre-service teachers to be trained in accordance with the requirements of the technology era we live in. Therefore, TPACK-based education and teaching should be planned during the university education and it should be aimed to improve pre-service teachers in the types of knowledge that constitute TPACK. It should be taken into consideration that pre-service teachers should use this knowledge both through micro education applications and through school experience and teaching practice lessons. Priority should be given to the integration of technology into the lesson. Furthermore, more emphasis should be given to TPACK-based courses related to the teaching practices and mathematics teaching in the undergraduate period. Thus, it will be possible to reduce the teaching anxiety with the increasing teaching experiences of the pre-service teachers.

This study, which is carried out only with pre-service teachers, can be repeated with the teachers who have just started to the profession and/or have different professional experience and the results can be compared. In the new researches, data can be gathered from more pre-service teachers/teachers so that the working group can be expanded. In addition, this study conducted with pre-service teachers studying in two different departments of a single university can be repeated with various comparisons as a result of increasing the number of universities. Finally, a qualitative study can be planned for the pre-service teachers with high mathematics teaching anxiety to reveal the reasons of their anxiety.

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