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Preservice Science and Mathematics Teachers' Mathematics Anxiety and Beliefs about the Nature of Mathematics

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ABSTRACT

The aim of the research is to examine preservice science and preservice mathematics teachers' mathematics anxiety and beliefs about the nature of mathematics, as well as to reveal whether they differ according to the teacher training program. Moreover, this study investigates whether there is a relationship between beliefs about the nature of mathematics and mathematics anxiety. The study consisted of a survey research and was carried out with 213 junior and senior preservice elementary science and mathematics teachers. Data collection tools were Philosophical Thoughts about the Nature of Mathematics Scale (PTNM) and Mathematics Anxiety Scale (MAS). Both descriptive and inferential statistics were used to analyze mathematics anxiety and beliefs scores of preservice elementary teachers. The study revealed that most of the preservice teachers' scores on beliefs about the nature of mathematics were high and their mathematics anxiety scores were low. The results indicated that there were significant differences in both belief scores and mathematics anxiety scores in favor of preservice mathematics teachers. In addition, there was a high negative correlation between preservice teachers' PTNM and MAS scores.

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Introduction

It is widely accepted that teachers' competencies play an important role in increasing the quality of teaching and learning from past to present. Teacher competencies are defined as the knowledge, skills, beliefs, attitudes, and values that teachers need to have to be able to perform their teaching profession effectively and efficiently (Ministry of National Education [MoNE], 2017; Turkish Education Association [TEA], 2009). Since teachers have formally begun to develop these competencies during undergraduate education, it is important to examine the extent to which these competencies are acquired in this process. With such investigations, both the quality of the undergraduate programs will be evaluated and it will be revealed which competencies and to what extent teachers who will start their profession have. Moreover, in a context where interdisciplinary educational research has gained momentum and gained more importance in recent years, it can be said that the holistic approach and evaluation of such competencies in closely related fields such as science and mathematics has gained special importance. In a study on the integration of science and mathematics, it is stated that the preservice science teachers' conceptions about the nature of mathematics can affect both their views on science and mathematics integration and their teaching practices (Yaman et al., 2018). For this reason, science teacher candidates should have a certain level of conceptions in the discipline of mathematics, which is closely related to this subject area, as well as their own subject. Conceptions are defined as the general mental structures of an individual that includes their knowledge, beliefs, understanding,

preferences, and views (Lloyd & Wilson, 1998, p. 249). Among these structures, it is stated that their beliefs may be more determinant than the knowledge they have in understanding the differences between teachers (Ernest, 1989; Thompson, 1992). In addition, it is evaluated that teachers' mathematics anxiety as an affective domain can have a significant effect on teaching practices (Ernest, 1991; McLeod, 1992). In this context, the focus of this study was to examine preservice science and mathematics teachers' mathematics anxiety and beliefs about the nature of mathematics to evaluate their professional competencies.

Beliefs about the Nature of Mathematics

Teachers' beliefs about the nature of mathematics have a significant impact on both their teaching practices and their other beliefs within the broader belief system (Green, 1971; Philipp, 2007; Thompson, 1984). For example, these beliefs form the basis of teacher's beliefs about learning and teaching mathematics (Thompson, 1992). A teacher who sees mathematics as a subject consisting of operations and unquestionable rules related to these operations is likely to believe that learning mathematics takes place with many repetitions and practices of these operations and rules. Moreover, these beliefs can also form the basis of the teacher's belief that teaching mathematics can only be implemented by showing and telling. While it is pointed out that there may be differences between the espoused and enacted beliefs due to the limitations of the social context (Ernest, 1989), it is stated that the quality or level of teachers' beliefs can also explain these differences. Ernest (1989) classified teachers' beliefs about the nature of mathematics in three hierarchical levels. The first of these is the instrumentalist view, which is that mathematics is a set of unrelated but useful facts, rules, operations, and skills. The second is the Platonist view. A teacher who takes the Platonist view believes that mathematics is a static but unified body of certain knowledge. Mathematics is not created, it is discovered. Thirdly, there is the problem-solving view of mathematics as a dynamic, cultural product that is constantly evolving with the invention and creation of human beings. Mathematics is not a finished product, but a process of inquiry and knowing, because its results remain open to revision. It is stated that teachers can derive these beliefs from their different images regarding the foundations of mathematics (Garegae, 2016). Two different philosophical views are put forward regarding the foundations of mathematics: the absolutist view and the fallibilist view. The absolutist view holds that mathematics is a-priori, objective, absolute, certain, and incorrigible body of knowledge (Ernest, 2004, s.12; Toumasis, 1997). Mathematical truths are independent of humans, therefore it is not possible to change them, and mathematical knowledge always maintains its validity regardless of history, social environment, and situations (Baki et al., 2010). On the other hand, according to the fallibilist or quasi-experimentalist view, mathematics is a product of social processes (Ernest, 2004, p.14). The quasi-experimentalist view holds that defining mathematics as what mathematicians do, they admit that flaws can be seen in mathematics as well as in any human activity or product (Baki, 2008, p.26). Mathematical knowledge can be re-examined in terms of proof and the concepts it uses, it is open to correction and is fallible (Ernest, 2004, s. 14). Lakatos (1976) states that the validity of mathematical knowledge is tentative at best, constantly being tested more and more pragmatically, and not established once and for all by rigorous proof. In this process, the results of mathematical assumptions are investigated, just as the observational results of empirical theories are investigated in terms of both fruitfulness and falsification. Ernest (1998, p.120) states that, in the light of these views, Lakatos' views on mathematics are related to fallibilism and why it is described as "quasi-experimental". It is stated that instrumentalist and Platonist views in Ernest's (1989) classification are absolutist, and problem-solving view draws on the quasi-experimentalist philosophy (Garegae, 2016). Although it is not explicitly stated in the reform-based studies and documents in mathematics education, it is stated that the quasi-experimentalist philosophy is taken as the basis (Baki et al., 2010). For example, Toumasis (1997), in his study comparing National Council of Teacher of Mathematics (NCTM) standards with the philosophies of mathematics, states that the standards mostly adopt the quasi-experimentalist philosophy. Cooney and Wiegel (2003) support the view that a quasi-experimentalist perspective is the most efficient for guiding courses for preservice

teachers. In their view, common teachers' beliefs that mathematics is abstract, rigid, unchanging, and not based on human experience originated from their mathematics education. They propose that these beliefs pose a major obstacle to mathematics reform in schools. In the light of all these theoretical frameworks and researches, many studies have been conducted with both teachers and preservice teachers on their beliefs about the nature of mathematics.

Raymond (1997), in her study, which examined the beliefs of mathematics teachers, examined the beliefs about the nature of mathematics in 5 levels, ranging from traditional to non-traditional, based on Ernest's categories (1989). In this study conducted with 6 math teachers in the first year of their profession, the researcher focused on Johanna's situation as a representative case, revealing that Johanna's views on the nature of mathematics are more aligned with traditional beliefs and that these beliefs are more consistent with their teaching practices than other beliefs. The study also pointed out that beliefs may have aspects that are inconsistent with practices and other beliefs, and it has been shown that deep traditional beliefs have a greater effect on practices than other non-traditional surface beliefs. Stipek et al. (2001) found that there was a correlation between the absolutist beliefs about the nature of mathematics and the practices of these teachers in their classroom in their study, in which 21 fourth through sixth-grade teachers were participants. In other words, teachers who believe that mathematics consists of a set of operations and procedures emphasized performance rather than understanding in their teaching approaches. Timmerman (2004) examined preservice elementary teachers' beliefs about the nature of mathematics, how children learn mathematics, and mathematics teaching strategies before and after the method course and revealed that there was a change in these beliefs at the end of the process. It was found that the tradition-oriented beliefs of the teacher candidates at the beginning of the process have changed towards reform-oriented beliefs. Kayan et al. (2013), in their study examining the beliefs about the nature of mathematics and mathematics learning-teaching of 584 preservice elementary mathematics teachers in 3rd and 4th grade, determined that the candidates had more constructivist beliefs. It turned out that most of the participants believed that mathematics is a dynamic discipline where new knowledge can be created. Sanalan et al. (2013) developed a belief scale to determine the philosophical thoughts of preservice teachers on the nature of mathematics and applied this scale to 520 preservice teachers. As a result of the study, it was determined that almost half of the preservice teachers had a quasi-experimentalist perspective, followed by a mixed group and very few absolutist individuals, respectively. Çelik et al. (2018) examined the mathematical beliefs of 1418 preservice elementary mathematics teachers studying in 4th grade from 21 universities. In the study, it was determined that the preservice teachers adopted the dynamic view of the nature of mathematics widely, while the static view, which reflects the traditional perspective on the nature of mathematics, was adopted at a considerable level. Ayvaz and Dündar (2014) examined the mathematics-related beliefs of 429 teacher candidates at different grade levels in elementary school mathematics and primary school teaching programs. As a result of the study, it was revealed that the "constructivist belief" levels of all candidates, regardless of their programs, increased during their faculty education, and consequently, their "traditional" belief scores decreased. Another result obtained from the study is that preservice mathematics teachers have higher levels of constructivist beliefs than primary school teacher candidates. In addition, Duru and Göl (2016) examined the beliefs of 276 preservice primary school teachers and preservice mathematics teachers about mathematics and mathematics learning-teaching. As a result of the study, it was seen that the preservice teachers generally had non-traditional beliefs about the nature of mathematics - compared to traditional beliefs - more strongly, and the preservice primary school teachers in the 4th grade had higher non-traditional beliefs than the preservice mathematics teachers in the 4th grade. Oehrtman and Lawson (2008), on the other hand, in the study group consisting of 22 science and 23 mathematics teachers, provided proof, hypothesis, theory, law, etc. examined and compared beliefs about the meanings and roles of key terms. At the end of the study, science teachers performed better than mathematics teachers in dimensions related to the nature of science, and mathematics teachers performed better than science teachers in dimensions related to the nature of mathematics. Duatepe Paksu (2008), as a result of her study examining the beliefs of the classroom, science, mathematics, and preschool teachers about mathematics, revealed that teachers

generally have an instrumentalist perspective, which is traditionally described. In addition, in the study, it was determined that there was no significant difference in the beliefs of mathematics teachers and teachers in other branches about the nature of mathematics, which is a sub-dimension of mathematical beliefs. Sağlam and Dost (2014) compared the beliefs of preservice science and mathematics teachers about mathematical problem-solving. In the study, it was revealed that the preservice mathematics teachers' beliefs about problem-solving were higher than the preservice science teachers and there was a significant relationship between them. Yaman et al. (2018) also analyzed the views on the nature of mathematics and science in his study, in which he consulted a group of preservice science and mathematics teacher on the integration of science and mathematics research. In the study, most of both science and mathematics teacher candidates thought that mathematics is a discipline that includes symbols and formulas and has a direct relationship with daily life. In addition, a result in favor of preservice mathematics teachers emerged in the number of candidates who stated that the source of mathematical knowledge is human and nature. In some other studies conducted with teachers, students, and preservice teachers, researchers pointed out that individuals may have multiple beliefs about the nature of mathematics at the same time (Grigutsch & Törner, 1998, p.5; Op't Eynde & De Corte, 2003; Yang & Leung, 2015). For example, Yang and Leung (2015) revealed that preservice mathematics teachers believed in mathematics both as a rule and procedure and as a research process. As stated before, an important element of the affective domain, which has an impact on teachers' teaching practices at least as much as beliefs, is mathematics anxieties, which are also related to their attitudes towards mathematics. In addition, attitudes can be considered as responses of individuals to belief structures (Liljedahl & Oesterle, 2020). That is, attitudes are manifestations of beliefs (Liljedahl 2005).

Mathematics Anxiety

Mathematics anxiety is characterized by feelings such as fear, panic, and tension when faced with mathematics (McLeod, 2012). Richardson and Suinn (1972) defined mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). The origin of people's mathematics anxiety is attributed to their negative mathematics experiences in mathematics classes in the formal education process (Bekdemir, 2010; Harper & Daane, 1998; Hembree, 1990; Jackson & Leffingwell, 1999; Kutluca et al., 2015). Many studies show that teacher candidates bring these anxieties until their faculty years and that these anxieties continue even at the graduation stage (Brady & Bowd, 2005; Bursal & Paznokas, 2006; Hembree, 1990; Jackson & Leffingwell, 1999). In addition, it is stated that teachers carry these anxieties to their students through their teaching practices when they start their profession, and this vicious cycle continues (Brady & Browd, 2005; Wood, 1988).

There are studies that examine the mathematics anxieties of teacher candidates on their own, as well as many studies that examine the relationship of these anxieties with different variables (Bursal & Pzanokas, 2010; Hembree, 1990; Swars et al., 2006; Philipp, 2007). For example, Swars et al. (2006) examined the relationship between mathematics anxiety and mathematics teaching efficacy beliefs in their study with prospective teachers. As a result of the study, it was found that teacher candidates with a low level of mathematics anxiety generally had a high level of mathematics teaching efficacy. Sloan et al. (2012) found a significant relationship between preservice teachers' mathematics anxiety and learning styles in their study with 72 preservice mathematics teachers; high-level global learning style (right-brain dominant) is associated with high-level anxiety. Bursal and Pzanokas (2010), on the other hand, in their study examining preservice teachers' mathematics anxiety and science and mathematics teaching efficacy beliefs, revealed that candidates with low mathematics anxiety are more confident in mathematics and science teaching. In addition, a negative correlation was found between the mathematics anxiety scores of the candidates and their mathematics teaching confidence scores. Peker and Ertekin (2011) examined the relationship between mathematics anxiety and mathematics teaching anxiety of 316 preservice teachers in primary school, elementary, and secondary mathematics teaching

programs. The research showed that there was a positive moderate relationship between preservice teachers' mathematics teaching anxiety and mathematics anxiety. Swars et al. (2009), in their longitudinal research, examined the changes in mathematics-related beliefs, mathematics efficacy beliefs, and mathematics anxiety of the candidates in the innovative courses in the faculty. As a result of the study, it was revealed that there was a positive change in all these dimensions, as well as a significant relationship between the candidates' beliefs scores and their mathematics anxiety scores. Hacıömeroğlu (2013) investigated whether there is a relationship between the preservice mathematics teachers' mathematics anxiety and their mathematical beliefs. In the study, it was revealed that there was a small negative significant relationship between mathematical anxiety and mathematical beliefs scores of preservice teachers. Uysal and Dede (2016), on the other hand, in their study examining the mathematics teaching beliefs and mathematics anxieties of preservice elementary mathematics teachers, found that the preservice teachers' mathematics anxiety levels were generally low and their scores on the beliefs scale were high. In addition, it was found in the study that there was no significant relationship between the preservice teachers' mathematics anxiety and child-centeredness beliefs. Austin et al. (1992) showed that mathematical beliefs have no effect on mathematics anxiety.

In the light of all these studies on beliefs about the nature of mathematics and mathematics anxiety, several salient points that lead the way in the execution of this study come to the fore. First, there has been a lot of research done on in-service/preservice mathematics teachers' beliefs about the nature of mathematics, while very little work has been done in the discipline of science education. As stated in the introduction, preservice science teachers must have a certain level of knowledge and belief in the discipline of mathematics, which is closely related to their subject matter. Therefore, this study aimed to contribute to filling this gap by examining the preservice science teacher beliefs about the nature of mathematics. Secondly, there are almost no studies in science teaching in researches on mathematics anxiety, which has an important effect on teachers / preservice teachers teaching practices and teaching efficacy beliefs. In this sense, examining the mathematics anxiety of preservice science teachers will contribute to academic studies about their competencies in the affective domain. As a natural reflection of these two prominent points in the academic studies, a third deficiency is that the number of comparative studies focused on these dimensions among science and mathematics teacher candidates is quite low. Comparative studies will both contribute to interdisciplinary research and help evaluate preservice teacher education programs for these disciplines. Finally, in many studies examined, there was a tendency to investigate teachers 'and preservice teachers' beliefs as a whole (such as beliefs about the nature of mathematics, beliefs about learning mathematics, and teaching mathematics). It is thought that this situation may be valuable in terms of revealing the relationships between belief structures, but since it does not have a special focus, it may cause researchers to have difficulties in interpreting their results and associating them with the results of other studies. Moreover, beliefs about the nature of mathematics are accepted as the source of beliefs about mathematics learning and teaching. For these reasons, it can be said that examining the preservice teachers' beliefs about the nature of mathematics as a special focus is a priority and fundamental issue.

Purpose of the Research

The purpose of this study was to investigate the preservice science and mathematics teachers' mathematics anxiety and beliefs about the nature of mathematics with respect to their programs. Another purpose was to describe the relationships between preservice teachers' mathematics anxiety and beliefs about the nature of mathematics. The problems of this research can be stated as follows:

1. What are the preservice science and mathematics teachers' beliefs levels about the nature of mathematics?
2. Is there any significant difference in the preservice teachers' beliefs about the nature of mathematics according to the program?
3. What are the preservice science and mathematics teachers' mathematics anxiety levels?

4. Is there any significant difference in the preservice teachers' mathematics anxiety levels in terms of the program?

5. Is there any significant correlation between the preservice teachers' mathematics anxiety and beliefs about the nature of mathematics?

Methods

The research design of the study was a correlational survey design. In this study, the opinions of the participants about a particular issue or topic were examined and the relationship between these opinions was tried to be revealed, so both survey and correlation design were used together (Fraenkel et al., 2012).

Participants

The participants in this study, selected using the convenience sampling method, were 213 preservice teachers (105 mathematics, and 98 science teacher candidates) in science and mathematics teacher education programs of three different universities in Turkey. At the time of the study, these preservice teachers were in the second semester of the 3rd and 4th grades. The reason why teacher candidates were selected from 3rd and 4th grades is that they have completed their education processes in the faculty to a great extent. Student teachers in both programs have taken most of both content and pedagogical content courses. The table regarding the distribution of the participants in the grades is presented below:

Table 1

Preservice Teachers' Grades

Program	Mathematics		Science	
Level	Junior	Senior	Junior	Senior
N (%)	55 (52,4)	50 (47,6)	31 (31,6)	67 (68,4)
Total	105 (51,7)		98 (48,2)	

Instrument and Data Collection Procedure

To determine the preservice teachers' beliefs about the nature of mathematics, "Philosophical Thoughts about the Nature of Mathematics Scale (PTNM)" developed by Sanalan et al. (2013) was used. The instrument includes 25 items in a five-point Likert-type ranging from "strongly agree" to "strongly disagree". Within this instrument, PTNM includes 4 broad dimensions: Daily life (DL), Problem-solving (PS), Structure of mathematics (SM), and Mathematical thinking (MT). The reliability coefficient for the overall instrument was calculated as .854. The Cronbach Alpha reliability coefficients of the dimensions of this scale were calculated as 0.814 for DL, 0.650 for PL, 0.633 for MT, and 0.703 for SM. To examine the preservice teachers' mathematics anxiety, the "Mathematics Anxiety Scale (MAS)" developed by Akçakın et al. (2015) was used. This instrument, which was developed as a result of adapting the scale developed by Bai et al. (2009) for measuring mathematics anxiety (MAS-R) into the Turkish language, consists of 14 items with positive (6 items) and negative factors (8 items). In this study, the negative factor and positive factor were labeled as NF and PF, respectively. The items in the scale are structured in a five-point Likert type ranging from "strongly agree" to "strongly disagree". The internal consistency coefficient of the overall scale was .91, and the reliability coefficient for the sub-factors of the scale was .90 for the first factor (for the negative factor) and .84 for the second factor (for the positive factor).

In the first stage of the application of the instruments, both scales were transferred to the web environment with the help of Google Forms. Later, the google form link was shared with the academicians from the science and mathematics education programs of the three universities, and these scales were applied to the preservice teachers. The researcher, on the other hand, applied the scales to the preservice teachers at his own university with the help of the academicians in the program. The scales were mostly filled in online courses to reduce the likelihood of others from the targeted teacher candidate groups filling this form. It was also stated in the google form that preservice teachers should fill the instruments voluntarily.

Data Analysis

Both descriptive and inferential statistics were used to examine preservice teachers' mathematics anxiety levels and their beliefs about the nature of mathematics. Before starting the data analysis, the coefficients of skewness and kurtosis in the overall and sub-dimensions of both scales were examined to control whether the data was normally distributed. If the ratio of the coefficient of skewness (kurtosis) to the coefficient of the standard error of skewness (kurtosis) is staying between -1,96 and +1.96, the distribution of the data is considered as normally distributed (Field, 2009). The normality of the data obtained from both scales is presented in Table 2:

Table 2

The Normality Distribution of the Data

Program	Instrument	Skewness	Std Error	Skewness /Std Error	Kurtosis	Std Error	Kurtosis /Std Error
Science	DL	.291	.244	1.19	.845	.483	1.74
	PS	.225	.244	.922	.572	.483	1.18
	SM	-.449	.244	-1.84	.301	.483	.623
	MT	-.056	.244	-.229	-.436	.483	-.902
	PTNM	.095	.244	.389	.423	.483	.875
	NF	.460	.244	1.88	.867	.483	1.79
	PF	.190	.244	.778	.296	.483	.612
	MAS	.334	.244	1.36	.699	.483	1.44
Mathematics	DL	.185	.236	.783	.742	.467	1.58
	PS	.089	.236	.377	.323	.467	.691
	SM	-.180	.236	-.762	.814	.467	1.74
	MT	-.303	.236	-1.28	-.227	.467	-.486
	PTNM	.041	.236	.173	.919	.467	1.96
	NF	-.042	.236	-.177	.501	.467	1.07
	PF	.442	.236	1.87	.505	.467	1.08
	MAS	.288	.236	1.22	.615	.467	1.31

Both of the instruments and their subscales, data were considered to be normally distributed. For that reason, the independent sample t-test was used to determine the differences between scores of preservice science and mathematics teachers. In the analysis of the scores obtained by preservice teachers on the PTNM instrument, these scores were divided into three intervals. The lowest score that can be obtained from the instrument is 25, and the highest score is 125. The score ranges and the corresponding the PTNM groups are presented in Table 3:

Table 3

The Group Labels for Interpreting Preservice Teachers' PTNM Scores

Score	Group Labels (Level)
25-75	Absolutist Group (AG)
76-94	Mixed Group (MG)
95-125	Quasi-experimentalist Group (QEG)

In the analysis of preservice teachers' mathematics anxiety levels, the scores obtained from the MAS instrument were graded as in Table 4. Positive 6 items in the scale were scored in reverse, so higher scores indicate a higher level of mathematics anxiety.

Table 4

Levels for Interpreting Preservice Teachers' MAS Scores.

Score	Mathematics Anxiety Level
1.00-1.79	Very low
1.80-2.59	Low
2.60-3.39	Moderate
3.40-4.19	High
4.20-5.00	Very high

In addition, the Pearson product correlation coefficients of the scores of PTNM and MAS were calculated to determine the possible relationship between the variables.

Findings

What are the preservice science and mathematics teachers' beliefs about the nature of mathematics?

Table 5 indicates the descriptive analysis of the PTNM levels for preservice science and mathematics teachers.

Table 5

Descriptive Analysis of Preservice Science and Mathematics Teachers' PTNM Levels

Program	N	%	Level
	0	0	AG
Mathematics	19	18	MG
	86	82	QEG
	2	2	AG
Science	38	39	MG
	58	59	QEG

Considering the scores of the preservice mathematics teachers from the PTNM scale in Table 5, it is seen that a great majority (82%) are in the QEG, which is the highest level. It is also striking in the data in the table that none of the preservice mathematics teachers were included in the AG. On the other hand, it is seen that more than half of the preservice science teachers are included in the QEG, although their percentage is lower than the preservice mathematics teachers. Considering the average scores of the PTNM scale, it was revealed that 39% of the preservice science teachers were in MG, only a small portion of them, 2%, were in AG. All these indicators show that the belief scores of both groups of preservice teachers about the nature of mathematics are generally middle-upper level.

Is there any significant difference in the preservice teachers' beliefs about the nature of mathematics according to the program?

The mean scores, standard deviations, and independent samples t-test results of the PTNM scale and the sub-dimensions of this scale are presented in Table 6.

Table 6

Independent Sample t-test Result of Preservice Teachers' PTNM Scores

Instrument	Program	N	Mean	Std. Deviation	t	p
DL	Mathematics	105	32.31	2.73	3.408	.001
	Science	98	30.67	3.96		
PS	Mathematics	105	24.35	2.28	3.583	.000
	Science	98	23.08	2.76		
SM	Mathematics	105	28.40	2.69	2.364	.019
	Science	98	27.41	3.21		
MT	Mathematics	105	16.24	2.09	2.063	.040
	Science	98	15.61	2.29		
PTNM	Mathematics	105	101.31	7.94	3.523	.001
	Science	98	96.78	10.15		

$p<.05$

Table 6 shows that there is a statistically significant difference in favor of preservice mathematics teachers when the total scores from the PTNM scale are taken into account ($t = 3.523$, $p <.05$). There is also a significant difference in favor of preservice mathematics teachers in all sub-dimensions of the scale.

What are the preservice science and mathematics teachers' mathematics anxiety levels?

Table 7 indicates the descriptive analysis of the MAS instrument scores for both preservice science and mathematics teachers.

Table 7

Descriptive Analysis of Preservice Teachers' MAS Instrument

Subscale	Preservice Mathematics Teachers			Preservice Science Teachers		
	Mean	Std. Deviation	Level	Mean	Std. Deviation	Level
NF	2.17	.49	Low	2.35	.73	Low
PF	1.76	.52	Very low	2.14	.61	Low
MAS	2.00	.43	Low	2.26	.63	Low

Table 7 shows that the total MAS scores of both preservice science and mathematics teachers are at a low level. In addition, in the PF and NF subscales of MAS, the mean scores of both programs are very low and low.

Is there any significant difference in the preservice teachers' mathematics anxiety levels in terms of the program?

Table 8 presents the preservice science and mathematics teachers' averages, standard deviations, and independent sample t-test results of the MAS scale and the scores of the sub-dimensions of this scale.

Table 8

Independent Sample t-test Result of Preservice Teachers' MAS Scores

Instrument	Program	N	Mean	Std. Deviation	t	p
NF	Mathematics	105	2.17	0.49	-2.019	.045
	Science	98	2.35	0.73		
PF	Mathematics	105	1.76	0.52	-4.649	.000
	Science	98	2.14	0.61		
MAS	Mathematics	105	2.00	0.43	-3.384	.001
	Science	98	2.26	0.63		

Note. p<.05

Table 8 shows that there is a significant difference in favor of preservice mathematics teachers when the total scores obtained from the MAS scale are taken into account (t = -3.384, p <.05). In addition, a significant difference was found in the NF and PF sub-dimensions of the scale in favor of preservice mathematics teachers.

Is there any significant correlation between the preservice teachers' mathematics anxiety and beliefs about the nature of mathematics?

The Pearson correlation coefficient calculated to determine whether there is a significant relationship between preservice teachers' beliefs about the nature of mathematics and their level of mathematics anxiety is presented in Table 9:

Table 9

The Pearson Correlation Coefficients for MAS and PTNM

Variables	**N**	**R**	**P**
PTNM and MAS	203	-.682**	.000

Note. **p < .001

As seen in Table 9, it was revealed that there is a negative high significant difference between the PTNM and MAS scores of the preservice teachers (R = -. 682; p <.001). In other words, it can be said that as the level of beliefs about the nature of mathematics increases, mathematics anxiety decreases, or as the level of beliefs about the nature of mathematics decreases, mathematics anxiety increases. Considering the coefficient of determination (R=-.682, $\mathbf{R^2}$=.465), %46,5 of the differences in MAS scores can be attributed to the differences in their PTNM scores.

Discussion, Conclusion and Implications

The first of the aims of this study was to determine the science and mathematics teachers' beliefs about the nature of mathematics. The first result obtained for this purpose is that considering the average scores of both science and mathematics teacher candidates from the PTNM scale, most of them are included in the QEG. Another remarkable result is that there were no candidates in AG in both groups, except for two science teacher candidates. When these results are taken together, it can be said

that the espoused beliefs held by preservice science and mathematics teachers are compatible with the philosophy of mathematics education reform documents (Baki et al., 2010; Toumasis, 1997) and reform based curriculums. Furthermore, these results may show that beliefs about the nature of mathematics either did not change or changed positively during the preservice teacher education process. If the preservice teachers' beliefs about the nature of mathematics are absolutist when they come to the faculty, it can be said that these beliefs change positively. On the other hand, when it is accepted that the candidates come to the faculty with fallibilist beliefs, it can be inferred that these beliefs do not change negatively. In both possibilities, it can be said that preservice teacher education programs that preservice teachers are involved in positively affect their beliefs about the nature of mathematics. Of course, longitudinal researches will be required to reach a clearer conclusion on this issue. However, given the emphasis that many of the teacher candidates enter the faculty as the products of traditional mathematics classes (Cady et al., 2006) and that their beliefs about the nature of mathematics can remain unchanged and resistant to change during the faculty process (Kagan, 1992; Raymond, 1997), this positive opinion about the quality of teacher education programs is supported. On the other hand, in many studies about the mathematical beliefs of preservice teachers, especially in recent years, it has been revealed that, in accordance with the results of this study, candidates advocate beliefs that are described as fallibilist, constructivist, dynamic, non-traditional, child-centeredness (Dede & Karakuş, 2014; Duru & Göl, 2016; Çelik et al., 2018; Kayan et al., 2013; Köğce, 2017; Sanalan et al., 2013, Uysal & Dede, 2016). Although these results are limited to the context of espoused beliefs by the candidates (Ernest, 1989), they are important and promising for the future. Because, preservice teachers' future classroom teaching practices, although there are sometimes inconsistencies, will basically be shaped within the framework of these beliefs (Thompson, 1992). This study also revealed that there were a considerable number of teacher candidates whose beliefs about the nature of mathematics were included in MG in line with the results found in Sanalan et al (2013). It was noteworthy that 39% of the science teacher candidates' beliefs were in this group. This result can be interpreted in two different ways. The first is the possibility that these candidates adopted both quasi-experimentalist and absolutist views while marking the PTNM scale. In some studies, it has been pointed out that individuals may have multiple beliefs about the nature of mathematics that contradict each other (Grigutsch & Törner, 1998, p.5; Op't Eynde & De Corte, 2003; Yang & Leung, 2015). The second possibility is that the candidates may have adopted the items on the PTNM scale at medium or close to medium level. This situation can be evaluated as an indicator of their degree of defense of their beliefs. Which of these two possibilities are more valid may be the focus of future research. In these researches, a detailed examination of the candidates' individual markings on the belief scale and interviewing the candidates regarding these markings when necessary will help us better understand the complex nature of their beliefs.

The second of the aims of this study was to examine whether there was a significant difference in the preservice teachers' beliefs about the nature of mathematics according to their programs. In the study, considering both the total PTNM scores and in all sub-dimension of the scale, it was observed that a significant difference emerged in favor of the mathematics teacher candidates. This result has also been reached in some studies comparing the mathematical beliefs of teachers and teacher candidates from different branches (Ayvaz & Dündar, 2014; Duru & Göl, 2016; Oehrtman & Lawson, 2008; Sağlam & Dost, 2014; Yaman et al., 2018). On the other hand, the significant differentiation of belief scores in favor of preservice mathematics teachers can be considered as an indirect positive reflection of the effectiveness of the mathematics teacher education programs and courses at the faculty. In order to evaluate the faculty programs more effectively and to reveal the effects of these programs on the candidates' beliefs about the nature of mathematics, it may be suggested to examine these beliefs longitudinally during the faculty process. Studying the same individuals in the process will also help us better understand the complex nature of their beliefs and the change in these beliefs.

Another aim of this study was to determine the mathematics anxiety levels of preservice science and mathematics teachers. The study revealed that both science and mathematics teacher candidates had low levels considering the total average of MAS scores. In addition, it was determined that the mean scores of the mathematics teacher candidates in the PF and NF subscales of MAS were very low and low, respectively, and the science teacher candidates were at low levels in both subscales. Overall, these results posited that preservice teachers in both programs felt less anxious about mathematics. Considering that individuals with low mathematics anxiety are more self-confident in teaching, their mathematics teaching anxiety is low, their mathematics teaching effectiveness beliefs are higher, and these feelings may also affect their learning styles (Bursal & Pzanokas, 2006; Peker & Ertekin, 2011; Swars et al., 2006; Sloan et al., 2002), this results can be considered as a positive indicator of the quality of their affective domain competencies. On the other hand, the fact that the mathematics anxiety levels of the candidates in both programs are generally low rather than very low indicates that the candidates have these anxieties, albeit partially. Philippou and Christou (1998) reported that preservice teachers' deeply rooted mathematics anxieties remained unchanged throughout the faculty. Based on the results of this study, it can be said that the mathematics anxiety of the candidates in both programs did not change negatively in the faculty period. In future studies, the validity of this inference can be demonstrated more robustly by determining with which mathematics anxiety levels teacher candidates come to the faculties and examining the same candidates at regular intervals throughout the process.

In this study, it was also aimed whether there is a significant difference between the programs in terms of the mathematics anxiety of the candidates. Considering both the total scores of the MAS scale and the sub-dimensions PF and NF scores, it was revealed that there was a significant difference in favor of the mathematics teacher candidates. As in beliefs about the nature of mathematics, such a difference between programs in mathematics anxieties can be considered reasonable for similar reasons stated above. In addition, the significant differentiation of the anxiety of mathematics teacher candidates from the anxiety of preservice science teachers may be due to the structure and qualities of the programs and courses applied in the faculty. Mathematics teacher candidates have more opportunities to confront and change their deeply-rooted mathematics anxieties in both content and pedagogical content courses compared to preservice science teachers. Considering the fact that preservice teachers may come to the faculties with their ongoing deeply rooted mathematics anxieties (Hembree, 1990; Jackson & Leffingwell, 1999; Brady & Bowd, 2005), reducing these anxieties in content and teaching methods lesson designs in science undergraduate programs should be supported with conscious initiatives. In this context, it is thought that especially interdisciplinary studies and the collaboration of science and mathematics teacher education experts in lesson and content designs may be beneficial.

Finally, another aim of this study was to determine whether there was a significant relationship between preservice teachers' mathematics anxiety and beliefs about the nature of mathematics. In the study, it was revealed that there is a negative high significant difference between PTNM and MAS scores of prospective teachers. It was also determined that having high-level beliefs about the nature of mathematics significantly predicts low-level mathematics anxiety. Hacıömeroğlu (2013) revealed that there is a significantly negative but small relationship between mathematical beliefs and mathematics anxiety, in line with the results of this study. In addition, Swars et al. (2009) showed that there is a significant relationship between the preservice teachers' beliefs about learning and teaching mathematics and their mathematics anxiety. On the other hand, some research results inconsistent with the results obtained in this study were also reported. Uysal and Dede (2016) stated that there is no significant relationship between mathematical beliefs and mathematics anxiety and Austin et al. (1992) found that mathematical beliefs do not have a significant effect on mathematics anxiety. Unlike these studies, this study specifically focused on the relationship between mathematics anxiety and beliefs about the nature of mathematics, and as a result, a high-level significant relationship was found. In other words, the more the teacher candidates believe that mathematics is a dynamic, cultural product

that is constantly evolving with the invention and production of human beings and that it can be seen in any human activity or product, the less anxious about mathematics. Conversely, it can be said that a person who views mathematics as a-priori, a static subject consisting of unrelated exact truths, procedures, and rules, about which there can be no doubts, will have a higher level of math anxiety. So if we want to reduce mathematics anxiety, which is shown as an important obstacle to mathematics learning and teaching, we need to change their absolutist beliefs about the nature of mathematics. Since this change will not happen spontaneously, we must first ensure that prospective teachers confront these beliefs at the faculty and design courses that will allow them to change them. Thus, we can increase their potential to positively influence the mathematical beliefs and anxieties of students in their class in the future.

The results of this study were obtained from the data from two Likert type questionnaire surveys applied to preservice teachers. Although questionnaire surveys are useful for obtaining data from large sample groups, they are limited as they are based only on self-reports. Especially when examining preservice teachers' beliefs about the nature of mathematics, in-depth interviews and classroom observations (for enacted beliefs) together with these data will help us to understand the complex structure of these beliefs. Especially the Teaching Practice course may be a suitable context for collecting observational data on these beliefs. Similar to this study, the beliefs of preservice mathematics and preservice science teachers' beliefs about the nature of science can also be examined in future studies. Thus, it will be possible to compare the beliefs of the candidates about the nature of science and mathematics. The results of this study imply an important task for both science and mathematics teacher educators and those who design teacher education programs. This task includes the development of more interdisciplinary courses and practices in the structure of both programs. Thus, preservice teachers will have the opportunity to compare their beliefs about the nature of different disciplines, and this will be a suitable context for their beliefs to be solidly structured/modified. In addition, as revealed in this study, the change in beliefs may also help reduce anxiety about learning and teaching-related disciplines.

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