



EXAMINING THE RELATIONSHIP BETWEEN PRE-SERVICE MATHEMATICS TEACHERS' MATHEMATICAL THINKING LEVEL AND ATTITUDE TOWARDS MATHEMATICS COURSES

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Abstract: This study is correlational research and aims to investigate the relationship between pre-service mathematics teachers' mathematical thinking levels and attitudes for courses in mathematics. We also examined whether gender, reasons for career choice, and academic achievement lead to significant differences in pre-service teachers' attitudes and mathematical thinking levels. Participants are 109 senior pre-service mathematics teachers from three different state universities that have similar conditions. Participants are selected via convenience sampling. Seventy-nine of the participants are female, and 30 are male. "Attitude scale for courses in mathematics" and "Mathematical Thinking Scale" are used to collect data. Data were analyzed by using SPSS package program. Pre-service teachers are found to have moderate attitudes while their mathematical thinking levels are at a high-level in the sub-domains of higher-order thinking tendency, reasoning, and problem-solving and at a moderate level in the subdomain of mathematical thinking skill. Pre-service teachers' attitudes for courses in mathematics have a significant moderate relationship with higher order thinking tendency, and reasoning and have a significant and weak relationship with problem-solving.

Key words: Mathematical thinking, Attitudes, Attitudes for courses in mathematics, Pre-service mathematics teachers, Correlation

1. Introduction

The permanency and utility of learning about content depend on individuals' attitudes towards that content (Eshun, 2004; Kupari & Nissinen, 2013). Baki, Kösa, and, Berigel (2007) suggested that permanent change in behaviors may occur if positive attitudes towards the content are developed. From this viewpoint, it is possible to say that individuals' positive attitudes towards content promote their content-related success. National Council of Teachers of Mathematics (NCTM) (2000) argued that students' attitudes towards mathematics could affect their mathematical knowledge, interest, performance, and willingness to learn mathematics and their thoughts about the mathematics course. The importance of students' mathematic attitudes makes teachers' in-class behaviors more important and makes it essential to determine pre-service teachers' attitudes that can affect their future students.

Attitude towards mathematics is an essential factor that is closely related to the students' behaviors and motivation in this course. Attitudes towards mathematics are related to liking mathematics, being disposed to engage with mathematical activities, and beliefs about mathematics abilities, and mathematics value (Ma & Kishor, 1997). Students with positive attitudes enjoy mathematics and engaging with mathematics, and they believe that he/she is good at mathematics and that mathematics is useful (Kartal, 2020). On the other hand, students with negative attitudes do vice versa. Leder (1992) identifies that the fundamental purpose of mathematics should be to make students develop positive attitudes towards mathematics. Students' attitudes toward learning mathematics may play a crucial role in mathematics education (Kislenko, Grevholm & Lepik, 2005). Students who have negative attitudes towards mathematics are inclined to avoid doing mathematics and believe that they are incapable of mathematics (Aljaberi, 2014; Kargar, Tarmizi & Bayat, 2010).

Students' prior experiences related to mathematics lead to positive or negative attitudes towards learning mathematics (Beswick, 2006; Raymond, 1997). Most of the students in Turkey believe that

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mathematics is difficult to learn; they feel anxious because of the low level of self-efficacy in mathematics, and develop negative attitudes towards mathematics (Baykul, 2000; Duru, Akgün & Özdemir, 2005; Günhan & Başer, 2008; Küçük, Kahraman & İşleyen, 2013). It is known that pre-service teachers also have negative attitudes toward mathematics (Lutovac & Kaasila, 2011). Teachers with negative attitudes may prefer traditional teaching methods and reflect their feelings, such as mathematics anxiety (Pietila, 2002), or overprotect their students from unfavorable learning experiences (Gellert, 2000). Teachers' attitudes towards mathematics also significantly affect their students' attitudes (Ford, 1994). Pre-Service teachers may lead to unfavorable experiences for their students when they became teachers. Teacher educators should enhance teacher preparation programs to prevent these undesired results. Identifying pre-service teachers' attitudes and articulating the relationship between pre-service teachers' attitudes and mathematical thinking levels may be an efficient way to overcome difficulties stemming from unfavorable teacher attitudes.

Mathematical thinking is the process of finding the unknown from the known that includes assuming, gathering evidence, and generalization (Baki, 2008; Breen & O'Shea, 2010). Liu (1996) also defined mathematical thinking as the union of the prediction, induction, deduction, representation, generalization, formal and informal reasoning, and verification. It is seen that the definitions of mathematical thinking highlight higher-order thinking, reasoning, and problem-solving.

Mathematical thinking helps individuals acquire and understand the needed knowledge and problem-solving skills (Katagiri, 2006). Mathematical thinking may occur in routine and non-routine problem-solving when individuals identify the solving strategies, interpret the given information in the problem, justify the problem solution, and convince the others who think differently (Breen & O'Shea, 2010; Schoenfeld, 1992). On the other hand, the strength of attitudes affects the depth of mathematical knowledge (Ernest, 1988). Attitudes towards mathematics promote thinking about mathematical methods and content (Katagiri, 2006). Therefore, high-level mathematical thinking has the potential of developing positive attitudes towards mathematics (Kargar et al., 2010). Individuals who have positive attitudes tend to engage with mathematical activities, learn mathematics more permanently, take advanced mathematics courses, and choose a career related to mathematics (Liu & Niess, 2006). Negative attitudes restrict preservice teachers' learning experiences (Battista, 1986). It is possible to say that students' knowledge would differentiate via mathematical thinking, which would change their attitudes towards mathematics.

Trends in International Mathematics and Science Study (TIMSS) results of Turkey are below of international average even though an increase occurs. For example, Turkey is ranked 31st with 429 points in 1999, 30th with 432 points in 2007, 24th with 452 points in 2011, and 24th with 458 points (Bütüner & Güler, 2017). Programme for International Student Assessment (PISA) results also indicate Turkey is under the average of the Organisation for Economic Co-operation and Development OECD countries (Aydın, Sarier & Uysal, 2012). Teachers' negative emotions and opinions related to mathematics may be associated with these undesired results. On the other hand, pre-service teachers in Turkey have a national exam to be employed as a teacher. Secondary school pre-service mathematics teachers had a success average of 12,478 (Sd=5,219) in 50 questions in content knowledge test in 2018 (ÖSYM, 2018). The average of pre-service teachers is lower than expected. This study aims to investigate pre-service teachers' attitudes towards mathematics courses and mathematical thinking, and the relationship between these constructs. Recommendations of this study may affect pre-service teachers' academic achievement in their mathematics courses.

Researches related to pre-service teachers' attitudes towards mathematics in Turkey mostly investigates the attitudes in terms of variables such as gender and grade level (Boran, Aslaner & Çakan, 2013; Bulut, Yetkin & Kazak, 2002; Cakiroğlu & Isiksal, 2009; Celik & Bindak, 2005; Duru et al., 2005; Kandemir, 2007; Küçük et al., 2013; Memnun & Akkaya, 2012). Unlike these studies, Sarpkaya, Arık, and Kaplan (2011) examined pre-service mathematics teachers' attitudes towards mathematics and awareness of using metacognition strategies. On the other hand, there are up-to-date researches that examined the relationship between attitudes towards mathematics and achievement, motivation, and performance (Bakar et al., 2010), mathematical thinking and mathematics anxiety (Kargar et al., 2010), and problem-solving skills (Marchiş, 2013).

Researches related to mathematical thinking in Turkey focused on the development of mathematical thinking (Alkan & Bukova-Güzel, 2005; Bukova-Güzel, 2008; Kılıç, Tunç-Pekkan & Karatoprak, 2013) and mathematical thinking processes (Arslan & Yıldız, 2010; Keskin, Akbaba & Altun, 2013; Yeşildere & Türnüklü, 2007; Yıldırım & Yavuzsoy-Köse, 2017). Arslan and İlkörücü (2018) examined pre-service science and mathematics teachers' mathematical thinking. Yorulmaz, Altuntaş, and Sidekli (2017) also investigated the relationship between pre-service elementary teachers' mathematical thinking and mathematics teaching anxiety.

Mathematical thinking and attitudes towards mathematics affect academic achievement, and teachers' attitudes play an essential role in students' attitudes. Given these results, we can say that it is essential to examine the relationship between pre-service mathematics teachers' mathematical thinking and attitudes towards mathematics courses. Only one study (Aljaberi, 2014) has examined the relationship between pre-service elementary school teachers' mathematical thinking and attitudes towards mathematics. This study has considered attitudes towards mathematics courses that pre-service teachers take in their undergraduate education, and this special consideration distinguishes this study from the mentioned study. The research questions are specified as follows:

1. Do senior pre-service mathematics teachers' attitudes towards mathematics courses differ significantly in terms of gender, their reasons for career choice, and their academic achievement?
2. Do senior pre-service mathematics teachers' mathematical thinking differ significantly in terms of gender, their reasons for career choice, and their academic achievement?
3. Is there a relationship between senior pre-service mathematics teachers' attitudes towards mathematics courses and mathematical thinking?

2. Methodology

2.1. Research design

This study that investigates the relationship between pre-service secondary school mathematics teachers' attitudes towards mathematics courses and mathematical thinking is correlational research. Researchers aim to reveal the relationship between two or more variables without manipulating or intervening in individuals' experiences and behaviors in correlational research (Fraenkel, Wallen & Hyun, 2011; Plano-Clark & Creswell, 2015). Correlational research also seeks how a change in one of the variables affects the other variable's change. This study examines what kind of a change in attitudes towards mathematics courses may occur when a change in mathematical thinking occurs.

2.2. Participants

At least 30 subjects selected via convenience sampling is enough for correlational research (Fraenkel et al., 2011). A sample size of more than 30 can provide less error variance and can support to have propositions that would explain the relationships better (Creswell, 2012).

Senior pre-service mathematics teachers participated in the study because senior pre-service teachers have taken all the mathematics courses in their undergraduate education. Their mathematical thinking level may be regarded as enough to reveal the relationship with attitudes towards mathematics courses. Participants are 109 senior pre-service secondary school mathematics teachers from three different universities in Turkey in the 2018-2019 academic year. Pre-service mathematics teachers must receive a bachelor's degree to be employed as a mathematics teacher. Besides, teacher preparation programs admit students based on the results of a national examination called Higher Education Institutions Entrance Exam. The universities from which data was collected require similar national exam-based results to enter a mathematics teacher preparation program, and have similar physical and technical conditions. Additionally, mathematics teacher preparation programs follow a similar curriculum proposed by the Higher Education Council. Seventy-nine of the participants are female, and 30 are male.

2.3. Data collection tools

Attitude Scale for Courses in Mathematics and *Mathematical Thinking Scale* were used to collect data. Detailed information about these scales is given below.

2.3.1. Attitude Scale for Courses in Mathematics. The scale is developed by Turanlı, Karakaş, and Keçeli (2008), and it aims to examine pre-service mathematics teachers' attitudes towards mathematics courses. This five-point Likert scale consists of 20 items; 11 are positively worded, and nine are negatively worded. The Cronbach's Alpha was reported as .93 in the original article. We calculated the reliability coefficient for this study with the data obtained from 109 pre-service teachers and found the coefficient as .934, indicating high reliability.

2.3.2. Mathematical Thinking Scale. The scale is developed by Ersoy and Başer (2013) to examine senior pre-service mathematics teachers' mathematical thinking levels. This five-point Likert scale consists of 25 items and four factors. Twenty items are positively worded, while 5 of them are negatively worded. The factors are high order thinking tendency (6 items), reasoning (4 items), mathematical thinking skill (8 items), and problem-solving (7 items). The maximum score is 125, and the minimum is 25 for the scale. The total score obtained from items is used for data analysis. A higher total score means a higher level of mathematical thinking (Ersoy & Başer, 2013). The Cronbach's alpha is reported as .78 in the original form, and calculated as .759 in this study.

There are three types of evidence of validity researchers should consider; content-related evidence of validity, criterion-related evidence of validity, and construct-related evidence of validity. Expert review (asking knowledgeable people to assess items of the instrument in terms of content and format) is a way to obtain content-related evidence of validity. Researchers reported that experts judged items of both instruments used in this study to clarify they have the appropriate content and format to measure mathematical thinking and attitudes towards mathematics courses (Ersoy & Başer, 2013; Turanlı et al., 2008). The criterion-related evidence was obtained by comparing the participants' scores of the mathematical thinking scale and the attitude scale for mathematics courses with their academic achievement as an independent criterion (Fraenkel et al., 2011). Lastly, the think-aloud strategy was used to ensure construct validity (Bowles, 2010). Three pre-service teachers from different participant universities were asked to read, think, and answer the items in the instruments aloud to determine how pre-service teachers understand the items.

Plano-Clark and Creswell (2015) suggested that mentioning the other research that used the same instruments, asking experts to review the instrument's content, and revealing relationships between the scores from the instruments and other variables are good validity indicators. The results of the study may be considered valid because of having all these indicators.

2.4. Data collection process

Threats to internal and external validity were attempted to minimize in the data collection process. Data were collected in one session via different data collectors. Administering the data instruments in one session may support to preclude the threat of instrument decay. On the other hand, different data collectors may also overcome the bias derived from only one data collector's characteristic (Fraenkel et al., 2011). Data were collected in three different universities. The conditions of universities were similar, and this has affected our choice of universities. This choice is important because similar characteristics of different locations may minimize the threats to internal validity (Creswell, 2012). Lastly, collecting data face to face from participants has been expected to minimize data loss (mortality) (Fraenkel et al., 2011). Assigning individuals randomly to collect data and encouraging as many participants as possible to respond may also increase the opportunity to generalize our results to the population of senior pre-service mathematics teachers.

2.5. Data analysis

Data collected from pre-service teachers were analyzed by using the SPSS packet program. We first entered the data into the SPSS environment and then controlled whether missing data exists or not. SPSS used the mean as an estimate for missing data. Both data collection tools consist of negatively

worded items. These items were reverse-coded ranging from 1 (completely agree) and 5 (completely disagree). After these adjustments, the normality of the data was investigated.

Non-parametric tests were utilized in data analysis because data is significantly different from the normal distribution. Mann-Whitney U test was used to determine whether there is a significant difference in pre-service teachers' attitudes towards mathematics courses and their mathematical thinking in terms of gender. Besides, the Kruskal-Wallis test was also employed to identify a significant difference in pre-service teachers' attitudes towards mathematics courses and their mathematical thinking in terms of reasons for career choice and academic achievement. In case of revealing a significant difference from the Kruskal-Wallis test, the Mann-Whitney U test was performed again by selecting groups in twos to determine the source of the significant difference (Field, 2009).

Correlation analysis was conducted to reveal the relationship between pre-service teachers' attitudes towards mathematics and mathematical thinking. Correlation analysis is a statistical test used to identify the trend or the pattern between two variables or two data sets (Creswell, 2012). Spearman's Rho (ρ) was used to interpret results as data does not have a normal distribution. The Correlation coefficient (ρ) gives the degree of the relationship between variables, while the square of correlation coefficient (ρ^2) gives the strength of the relationship. In other words, it is the extent to which the variance in a variable is explained by another variable. If the correlation coefficient is less than 0.30, the relationship is considered as weak; if the coefficient is in the range of .30-.70, the relationship is considered as moderate; and if the correlation is more than .70, the relationship is considered as strong (Büyüköztürk, 2011).

Table 1 was used to interpret the levels of pre-service teachers' mathematical thinking and its sub-domains and attitudes towards mathematics courses. Maximum and minimum scores that can be obtained from scales and sub-scales were identified, and the minimum score has been subtracted from the maximum score. The result was divided into three because we considered three levels as low, moderate, and high.

Table 1. Ranges used to interpret mathematical thinking and attitude levels

		Low	Moderate	High
The Sub-Domains of Mathematical Thinking Scale	Higher-order thinking tendency	6-13.,33	13.34-21.67	21.68-30
	Reasoning	4-8.66	8.6-14.33	14.34-20
	Mathematical thinking skill	8-18	19-29	30-40
	Problem-solving	7-15.66	15.67-25.33	25.34-35
Mathematical Thinking Scale	Total score	5-44.33	44.34-84.67	84.68-125
Attitude Scale for Courses in Mathematics	Total score	20-46	47-73	73-100

3. Findings

Kolmogorov-Smirnov test was employed to examine whether the data obtained from the mathematical thinking scale and attitude scale for mathematics courses had a normal distribution or not. Table 2 indicates the Kolmogorov-Smirnov test results and the levels of pre-service teachers' levels of mathematical thinking and attitudes.

Table 2. One sample Kolmogorov-Smirnov test results for the subdomains of mathematical thinking scale and attitude scale for courses in mathematics

	n	\bar{X}	Sd	Level	p
Higher-order thinking tendency	109	25.100	2.759	High	0.005*
Reasoning	109	17.588	2.083	High	0.000*
Mathematical thinking skill	109	29.752	3.113	Moderate	0.004*
Problem-solving	109	26.624	2.808	High	0.007*
Mathematical Thinking Scale Total Score	109	99.064	8.040	High	0.200
Attitude for Courses in Mathematics	109	71.266	14.108	Moderate	0.010*

Table 2 indicates that pre-service secondary school mathematics teachers have a high level of higher-order thinking tendency, reasoning, problem-solving, and a moderate level of mathematical thinking skill. Considering the overall scale of mathematical thinking results, we can say that participants have a high level of mathematical thinking. However, pre-service teachers' attitude level for mathematics courses is found to be at a moderate level.

Normality test results reveal that data obtained from the attitude scale and the subdomains of mathematical thinking tendency, reasoning, mathematical thinking skill, and problem-solving have significantly differed from a normal distribution ($p < .05$). In other words, data does not have a normal distribution, and for this reason, non-parametric tests were utilized in data analysis.

3.1. Findings related to the first research question

Mann-Whitney U test was employed to examine whether pre-service teachers' attitudes for mathematics courses differ in terms of gender, and Table 3 shows the results.

Table 3. Pre-service teachers' attitudes for courses in mathematics in terms of gender

Groups	N	Mean Rank	Sum of ranks	M-Whitney U	Z	P
Male	30	59,12	1773.50	1061.50	-0.838	0.402
Female	79	53,44	4221.50			

* $p < .05$

Table 3 presents that male pre-service teachers have more positive attitudes for courses in mathematics than female pre-service teachers. However, this difference between the means of males and females is not statistically significant ($p = 0.402 > .05$).

Pre-service teachers' attitudes for courses in mathematics were examined in order to reveal whether there is a significant difference in terms of their reasons for career choice. For this purpose, the Kruskal-Wallis test was utilized, and the results are given in Table 4.

Table 4. Pre-service teachers' attitudes for courses in mathematics in terms of the reason for career choice

Reasons for career choice	N	Mean Rank	χ^2	p
Intrinsic reasons	78	60.28	8.200	0.017*
Family guidance	18	45.31		
Other	13	36.77		

* $p < .05$

Pre-service teachers' attitudes differ significantly in terms of the reasons for career choice. Mann-Whitney U test was performed by selecting groups in twos to determine the source of the significant difference. Mann-Whitney U test results indicate that pre-service teachers who chose to teach as a

career with intrinsic reasons have significantly more positive attitudes than those who chose this career for other reasons such as a teacher or peer guidance ($U=283,000$; $p=.011 < .05$).

Whether there was a significant difference in pre-service teachers' attitudes for courses in mathematics in terms of academic achievement was investigated by utilizing the Kruskal-Wallis test (Table 5).

Table 5. Pre-service teachers' attitudes for courses in mathematics in terms of academic achievement

Academic Achievement	N	Mean Rank	χ^2	p
1.51-2.00	6	19.92	17.695	0.001*
2.01-2.50	25	40.94		
2.51-3.00	53	60.17		
3.01-3.50	20	64.08		
3.51-4.00	5	76.30		

* $p < .05$

Table 5 indicates that pre-service teachers' attitudes have differed significantly in terms of academic achievement ($\chi^2=17,695$; $p < .05$). The groups that were arranged based on academic achievement were selected in twos, and the Mann-Whitney U test was utilized to examine the source of the significant difference. Pre-service teachers who are at an academic level between 1,51-2,00 have been found to have less positive attitudes than those who are at an academic level between 2,01-2,50 ($U=32,500$; $p=.033 < .05$), between 2,51-3,00 ($U=49,500$; $p=.006 < .05$), and between 3,51-4,00 ($U=1,000$; $p=.011 < .05$). Pre-service teachers whose achievement level is between 2,51-3,00 have been seen to have more positive attitudes than those whose achievement level is between 2,01-2,50 ($U=425,000$; $p=.011 < .05$) and pre-service teachers whose achievement level is between 3,51-4,00 have been seen to have more positive attitudes than those whose achievement level is between 3,01-3,50 ($U=14,500$; $p=.007 < .05$).

3.2. Findings related to the second research question

Research question 2 is related to the existing significant differences in pre-service teachers' levels in the subdomains of mathematical thinking scale in terms of gender, the reasons for career choice, and academic achievement.

Table 6 indicates the results of the Mann Whitney U test that was employed to investigate whether there were significant differences in participants' levels of higher-order thinking tendency, reasoning, mathematical thinking skill, and problem-solving in terms of gender.

Table 6. Pre-service teachers' levels in the subdomains of mathematical thinking scale in terms of gender

	Groups	N	\bar{X}	Mean Rank	Sum of Ranks	M-Whitney U	Z	P
Higher-order thinking tendency	Male	30	25.500	59.42	1782.50	1052.500	-.905	.365
	Female	79	24.950	53.32	4212.50			
Reasoning	Male	30	17.667	55.90	1677.00	1158.000	-.186	.852
	Female	79	17.557	54.66	4318.00			
Mathematical thinking skill	Male	30	30.033	57.95	1738.50	1096.500	-.604	.546
	Female	79	29.646	53.88	4256.50			
Problem-solving	Male	30	27.233	63.28	1898.50	936.500	-1.696	.090
	Female	79	26.392	51.85	4096.50			

It is seen from Table 6 that male pre-service teachers have higher levels in all the subdomains than female teachers. The differences between total scores of males and females are not found to be statistically significant ($U=1052,500; p=.365 > .05$; $U=1158,000; p=.852 > .05$; $U=1096,500; p=.546 > .05$; $U=936,500; p=.090 > .05$).

Table 7 gives the results of the Kruskal-Wallis test that was utilized to reveal whether the reasons for career choice lead to significant differences in pre-service teachers' higher-order tendency, reasoning, mathematical thinking skills, and problem-solving.

Table 7. Pre-service teachers' levels in the subdomains of mathematical thinking scale in terms of the reasons for career choice

		N	\bar{X}	Mean Rank	χ^2	P
Higher-order thinking tendency	Intrinsic reasons	78	24.910	53.06	3.483	0.175
	Family guidance	18	24.889	52.39		
	Others	13	26.539	70.23		
Reasoning	Intrinsic reasons	78	17.577	55.16	1.025	0.599
	Family guidance	18	17.944	59.39		
	Others	13	17.153	47.96		
Mathematical thinking skill	Intrinsic reasons	78	29.488	52.57	5.732	0.057
	Family guidance	18	31.222	70.81		
	Others	13	29.308	47.69		
Problem-solving	Intrinsic reasons	78	26.577	54.54	0.790	0.674
	Family guidance	18	27.222	60.25		
	Others	13	26.077	50.46		

*p < .05

Table 7 presents no significant differences in the mathematical thinking scale subdomains in terms of the reasons for career choice.

The last analysis for research question 2 examined whether academic achievement results in a significant difference in the mathematical thinking scale's subdomains. For this purpose, the Kruskal-Wallis test was conducted, and the results were given in Table 8.

Table 8. Pre-service teachers' levels in the subdomains of mathematical thinking scale in terms of academic achievement

	Academic Achievement	N	\bar{X}	Mean Ranks	χ^2	P
Higher-order thinking tendency	1.51-2.00	6	25.333	56.50	4.640	0.326
	2.01-2.50	25	24.040	43.52		
	2.51-3.00	53	25.359	57.57		
	3.01-3.50	20	25.500	59.65		
	3.51-4.00	5	25.800	64.80		
Reasoning	1.51-2.00	6	17.500	49.50	3.015	0.555
	2.01-2.50	25	17.000	46.52		
	2.51-3.00	53	17.774	58.39		
	3.01-3.50	20	17.700	56.35		
	3.51-4.00	5	18.200	62.70		
Mathematical thinking skill	1.51-2.00	6	28.167	37.00	3.384	0.496
	2.01-2.50	25	29.280	52.80		
	2.51-3.00	53	30.076	57.04		
	3.01-3.50	20	30.200	60.25		
	3.51-4.00	5	28.800	45.00		
Problem-solving	1.51-2.00	6	26.167	49.50	4.301	0.367
	2.01-2.50	25	25.920	47.68		
	2.51-3.00	53	26.793	56.40		
	3.01-3.50	20	27.050	60.20		

	3.51-4.00	5	27.200	62.60		
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* $p < .05$

As seen from Table 8, there were no significant differences in pre-service teachers' levels of higher order thinking tendency ($\chi^2=4,640$; $p=0,326 > .05$), reasoning ($\chi^2=3,015$; $p=0,555 > .05$), mathematical thinking skill ($\chi^2=3,384$; $p=0,496 > .05$), and problem-solving ($\chi^2=4,301$; $p=0,367 > .05$) in terms of academic achievement.

3.3. Findings related to the third research question

Correlation analysis was performed to reveal the relationship between pre-service teachers' attitudes for courses in mathematics and the subdomains of the mathematical thinking scale. Table 9 indicates the results of the correlation analysis.

Table 9. The Spearman's Rho Correlation between attitudes for courses in mathematics and subdomains of the mathematical thinking scale

	Attitudes for courses in mathematics
Higher-order thinking tendency	.363*
Reasoning	.320*
Mathematical thinking scale	.164
Problem-solving	.273*

* Correlation is significant at the .001 level

The Spearman's Rho correlation is .363 with the significance level of .001, which means that there is a significant positive moderate correlation between higher-order thinking tendency and attitudes. The Spearman's Rho correlation is .320 with the significance level .001, which means that there is a significant positive moderate correlation between reasoning and attitudes. Finally, the Spearman's Rho correlation is .273 with the significance level .001, which means that there is a significant positive moderate correlation between problem-solving and attitudes. The correlation between the subdomain titled mathematical thinking skill and attitudes was also weak and not statistically significant.

Considering the significant and positive correlations between attitudes for courses in mathematics and higher-order thinking tendency, reasoning, and problem-solving, it was found that 13.17% ($\rho^2=[0.363]^2$) of variance in attitudes can be explained by higher-order thinking tendency, 10.24% ($\rho^2=[0.320]^2$) by reasoning, and 7.45% ($\rho^2=[0.273]^2$) by problem-solving.

4. Conclusion and Discussion

This research aims to investigate (i) whether pre-service secondary school mathematics teachers' attitudes for courses in mathematics differ in terms of gender, reasons for career choice, and academic achievement, (ii) whether pre-service secondary school mathematics teachers' mathematical thinking levels differ in terms of gender, reasons for career choice, and academic achievement, and (iii) the relationship between pre-service teachers' attitudes and mathematical thinking levels.

Participants have been found to have a moderate level of attitudes for courses in mathematics. Some researches report pre-service teachers' moderate level of mathematics attitudes (Kargar et al., 2010; Rech, Hartzell, & Stephens, 1993) and a high level of attitudes (Boran et al., 2013; Bulut et al., 2002; Cakiroglu & Isiksal, 2009; Duru et al., 2005; Kandemir, 2007). Ma and Kishor (1997) suggested that individuals' levels of mathematics attitudes may decrease via an increasing number of mathematical experiences even if they started school with positive attitudes. Similarly, Philippou and Christou (1998) reported that students' mathematics attitudes might have a trend to diminish because of the increasing level of the difficulties in mathematical activities and the increasing level of the pressure that these activities put on the students as their grade levels increase. In a way that supports these findings, Kaasila, Hannula, Laine, and Pehkonen (2008) reported negative mathematics attitudes of pre-service teachers, while Malik (2018) found negative attitudes in college students.

Male pre-service mathematics teachers had more positive attitudes for courses in mathematics than female pre-service teachers. However, the difference between the means of males and females is not

statistically significant. Researchers (Awofala, 2016; Cakiroglu & Isiksal, 2009; Duru et al., 2005; Sarpkaya et al., 2011) mostly found no significant differences in mathematics attitudes in terms of gender. However, a few researchers (Bulut et al., 2002; Boran et al., 2013; Küçük et al., 2013) found significant differences in favor of females. On the other hand, Fennema and Sherman (1976; 1978) findings are consistent with this study.

Pre-service mathematics teachers' attitudes who chose to teach for intrinsic reasons differed significantly from those who chose to teach with family guidance or teacher and peer guidance. Research shows that teachers who chose to teach for intrinsic reasons are more open-minded about learning and have higher intrinsic motivation (Aktürk, 2012), and have more positive attitudes towards teaching as a career (Özder, Konedralı & Zeki, 2010). Pre-service teachers' attitudes are also related to their efficacy beliefs (Kartal, 2020). Pre-service teachers with more positive attitudes may feel more efficacious in mathematics. We think that pre-service teachers who chose to teach for intrinsic reasons feel qualified and willing to solve mathematics course problems. For this reason, they may study harder, and therefore their attitudes improved significantly from others. This assumption can be explained by research in the literature. Liking mathematics is a common factor that occurs in pre-service teachers' reasons in career choice (Boz & Boz, 2008; İncikabı, Mercimek, Biber & Serin, 2016; Kartal & Kıymaz, 2020; Papanastasiou & Papanastasiou, 1997; Sinclair, 2008; Tataroğlu, Özgen & Alkan, 2011) and this factor may explain the significant difference in attitudes.

Pre-service teachers whose academic achievement is between 1,51-2,00 and 2,01-2,50 have lower attitudes for courses in mathematics than pre-service teachers with higher academic achievement. This finding is consistent with the researches that specify that attitude is a predictor of academic performance (Aljaberi, 2014; Bakar et al., 2010; Papanastasiou, 2000). Pre-service teachers' academic achievement level should be at least 2,00 in order to graduate. It may not be wrong to consider pre-service teachers whose academic achievement is 2,50 and above as successful. Since pre-service teachers who had an achievement level above 2,50 may be accepted as successful, there may not be significant differences in their attitudes in terms of academic achievement.

Participants have a high level of mathematical thinking, considering the full scale. They also had high levels in the subdomains of higher-order thinking tendency, reasoning, and problem-solving and a moderate level in mathematical thinking skills. Yorulmaz, Çoççalışkan, and Çelik (2018) and Arslan and İlkörücü (2018) found that the pre-service teachers' mathematical thinking levels are high while Kargar and colleagues (2010), and Aljaberi (2014) reported moderate levels of mathematical thinking. Aljaberi (2014) also concluded that pre-service teachers' mathematical thinking improved as their grade levels increased. From this finding, it is possible to say that participants' mathematical thinking levels are high because they are seniors.

Many researchers investigated the affect (such as attitude, anxiety, and belief) in mathematical thinking (Aljaberi, 2014; Hannula, 2004; Kargar et al., 2010; Zan, Brown, Evans & Hannula, 2006). Individuals with negative attitudes towards mathematics may avoid doing mathematics and may not gain thinking skills such as reasoning and problem-solving (Aljaberi, 2014; Kargar et al., 2010). On the other hand, individuals who cannot think mathematically and fail in mathematical activities are likely to develop negative attitudes towards mathematics. This study investigated the relationship between pre-service teachers' attitudes and mathematical thinking levels. The correlation analysis indicated a moderate positive relationship between attitudes and the higher-order thinking tendency and the reasoning, and a weak positive relationship between attitudes and problem-solving. The relationships between attitudes and higher-order thinking tendency and reasoning may be stronger because undergraduate mathematics courses may employ higher-order thinking tendency and reasoning more frequently than problem-solving.

The findings of this study revealed the relationships between attitudes and mathematical thinking. The importance of developing positive mathematics attitudes in pre-service teachers is seen again (Marchiş, 2013) considering the effect of teachers' positive attitudes on their students' attitudes (Küçük et al., 2013). Therefore, pre-service teachers' mathematics attitudes should be measured periodically during their teacher preparation programs to make arrangements conducive to developing positive attitudes. One of the findings in this study is that pre-service teachers who chose to teach for

intrinsic reasons have more positive attitudes than others. It is known that these pre-service teachers have higher levels of intrinsic motivation. It may be suggested to organize activities that improve pre-service teachers' intrinsic motivation who did not choose to teach with intrinsic reasons. Making pre-service teachers engaging in activities that require higher-order thinking and reasoning and making them believe that they would be successful may help pre-service teachers develop positive attitudes. It is essential to state that the subdomain of higher-order thinking tendency and reasoning explains 23% of the variance in the attitudes for courses in mathematics.

This study has investigated the relationship between senior pre-service teachers' attitudes for courses in mathematics and mathematical thinking levels. Further research may investigate these variables and the relationship between these two variables in all grade levels and examine whether grade level leads to significant differences or not. The relationships between mathematical thinking and affective factors such as motivation, beliefs, and values may also be explored.

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