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A mixed method research study on pre-service primary school teachers' mathematical disposition

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Abstract

This is a comprehensive study aiming to examine pre-service primary school teachers' (PPST) mathematical disposition levels in terms of various variables, and to explain the results thoroughly. It employed the explanatory sequential design among the mixed method research designs. The data were collected through Mathematics Dispositional Functions Inventory (MDFI) and semi-structured interviews. The participants consisted of 361 PPSTs in the quantitative phase, and six PPSTs in the qualitative phase. Quantitative data were analyzed with descriptive and inferential statistics, while qualitative data were analyzed with descriptive analysis. The PPSTs' mathematical disposition levels did not differ significantly in terms of grade level, high school type, area of education at high school and ability area variables; however, their scores in the attitude toward mathematics lesson factor of MDFI differed significantly in terms of area of education at high school and ability area variables. There were significant, positive, and low-level relationships between PPSTs' mathematical disposition levels and their levels of mathematics learning experience in primary, middle and high schools, and their perception level of mathematics teaching efficacy. The PPSTs' scores in attitude toward mathematics lesson factor related to ability area were consistent with their statements in the interviews. The quantitative analysis results regarding mathematics learning experience levels and mathematics teaching efficacy perception levels, defined as continuous variables, overlapped with the qualitative analysis results.

Keywords: Mathematical Disposition, Mathematics Education, Mixed-Method, Pre-Service Primary School Teacher

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Mathematics is a universal language oftentimes needed in daily life and used in the development and transfer of science and technology (Bekdemir, et al., 2008). It is essential for individuals to acquire logical, creative, analytical, and critical thinking skills that contribute to obtaining and using the information they need (Sukmadewi, 2014). Countries that attach importance to mathematics and raise individuals with high mathematical knowledge will eventually be able to compete with technologically advanced countries (Atallah, et al., 2010). Mathematical disposition (MD) is critical and occurs in primary school when the teaching of mathematics officially begins (Feldhaus, 2014). Mathematical disposition is related to the attitudes and judgements that determine positive thinking and effort in the process of learning mathematics (Ab et al., 2019) or frequent conscious steps taken to learn mathematics (Atallah et al., 2010). The concept of mathematical disposition explains individuals' approach to mathematics and their experiences related to it. It is also related to other abilities (An et al., 2014, 2015). Mathematical

disposition includes not only students but also teachers and pre-service teachers who have the responsibility for teaching mathematics (Beyers, 2012; Coppola et al., 2013; Hidayat et al., 2018). In this respect, it is important to study the issue related to teachers who have important roles in the formation of mathematical dispositions.

Mathematical disposition concept was studied on different sample except pre-service teachers (An et al., 2014, 2015; Lestari et al., 2019; Ma & Radke, 2015; Kusmaryono et al., 2019; Ulia & Kusmaryono, 2021; Ulya & Rahayu, 2021; Yaniawati et al., 2019). The mathematical disposition research in the literature conducted with pre-service primary teachers addresses pre-service teachers' approaches to mathematics (Çelik & Bindak, 2005) and mathematics teaching (Coppola et al., 2013), the relationship between mathematical disposition and mathematics teaching self-efficacy of pre-service teachers at different levels (Akar & Boz, 2011; Cruz, et al., 2019), mathematical disposition of pre-service mathematics teachers (Cruz, 2017; Kisunzu, 2008; Soltis, 2019), mathematical disposition of pre-service teachers from different branches (Yörük, 2019; Yazgan et al., 2013), and mathematical disposition of pre-service primary school teachers (PPST) (Beyers, 2008; Feldhaus, 2012; 2014; Siegfried, 2012). No study in the literature in Turkiye examined PPSTs' mathematical disposition in detail and it is recommended to investigate the mathematical dispositions of pre-service teachers (Yazgan et al., 2013).

The literature recommends investigating PPSTs' mathematical disposition since primary school teachers have a crucial role in developing students' mathematical disposition (Beyers, 2012; Cooke, 2015). Teachers with mathematical disposition believe that mathematics is a product of perseverance rather than an innate ability (Cruz, et al., 2019). Considering the PPSTs' future impact on students' first mathematics learning experiences, it is important to examine their mathematical disposition (Cooke, 2015). The current study will contribute to the field of mathematics education and basic education by giving an idea about what affects mathematical disposition and by through investigating PPST' mathematical disposition. Therefore, the current study aimed to examine PPSTs' mathematical disposition. The mixed design of the study aimed to seek an answer to the main research problem: "How do qualitative data explain the findings obtained in the examination of PPSTs' mathematical disposition" as well as the sub-problems below.

1. What is the level of PPSTs' mathematical disposition and what are their opinions regarding their levels of mathematical disposition?
2. Do PPSTs' mathematical disposition levels differ significantly in terms of various variables (grade level, graduated high school type, area of education at high school, ability) and what are PPSTs' opinions regarding whether their levels differ significantly in terms of various variables (grade level, graduated high school type, area of education at high school, ability)?
3. Is there a significant relationship between PPSTs' levels of mathematical disposition and mathematics learning experiences, and what are their opinions regarding this relationship?
4. Is there a significant relationship between PPSTs' levels of mathematical disposition and their perception of mathematics teaching efficacy, and what are their opinions regarding this relationship?

In fact, the researchers ask that what determines mathematical disposition, can mathematical disposition be explained through the variables determined?

METHODS

Research Design

This study employed the explanatory sequential design among the mixed method research designs. The mixed method is a research method analyzing quantitative and qualitative data based on the designated design (Creswell & Plano Clark, 2020). Explanatory sequential design is a mixed method research design that starts the analysis with quantitative data and follows with qualitative analysis to explain the findings obtained in the previous phase (Creswell, 2021). Employing this design, the current study first analyzed PPSTs' mathematical disposition levels quantitatively and then made a through qualitative analysis based on those findings.

The quantitative phase of the study used the survey model. The survey model is defined as "research studies, usually conducted on relatively larger samples, in which the views of the participants on a subject or event or their interests, skills, abilities, attitudes, etc. are determined" (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2012, p.177). Accordingly, this study examined PPSTs' mathematical disposition with a sample from the Central Anatolian region in Türkiye. The qualitative phase of the study involved the case study method. The case study is a research method in which one or more cases are described by collecting in-depth information from more than one source of information (Creswell, 2021). The steps of the explanatory sequential design used in the study included the following (Creswell & Plano Clark, 2020).

1. Quantitative research questions were specified.
2. The required ethical and official permissions were obtained.
3. The simple random sampling method was utilized in selecting the participants in the quantitative phase (N=361) The population size was researched from https://yokatlas.yok.gov.tr/lisans-bolum.php?b=10183 as N=2760. Then, recommended sample size was calculated min N=338 using http://www.raosoft.com/samplesize.html. calculator. So, it was reached to 361 participants.
4. Mathematics Dispositional Functions Inventory and a questionnaire were implemented.
5. The survey model was conducted. Descriptive statistics, MANOVA and Spearman Brown correlation statistics were performed.
6. The results were interpreted based on difference and correlation values.
7. The case study design was adopted in the qualitative phase.
8. Using the purposeful sampling methods, six participants were selected for the qualitative phase to explain the quantitative results.
9. With the protocols shaped by the quantitative results, the qualitative data were collected through open-ended semi-structured interviews.
10. The quantitative results were summarized and interpreted.
11. The qualitative results were summarized and interpreted.
12. The qualitative findings generally explained the quantitative results and the contrasting findings were also reported.

Participants

The participants of this study consist of pre-service teachers studying at different grade levels in primary school teaching departments at the education faculties of six universities in Central Anatolia region in Türkiye. 361 PPSTs participated in the quantitative phase (362 before the normal distribution analysis)

and six PPSTs participated in the qualitative phase.

The population was determined as Central Anatolia region of Turkiye (N=2760). The study employed the simple random sampling method (N=361) for participant selection in the quantitative phase. Pre-service teachers studying in the Department of Classroom Teaching at six universities in the Central Anatolia region were selected to represent the whole population. All units in the population have equal probability of being selected in this sampling method (Büyüköztürk et al., 2012). The frequencies regarding the participants' grade level, high school type, area of education at high school, ability they stated are presented in Table 1.

Table 1. The participants' demographic characteristics

Variable	Level	N	%
Grade level	1	110	30.5
	2	104	28.8
	3	88	24.4
	4	59	16.3
High school type	Anatolian High School	208	58.3
	Science High School	16	4.5
	Social Sciences High School	41	11.5
	Religious Vocational High School	50	14.0
	Others	46	12.7
Area of education at high school	Mathematics-Science	89	24.9
	Turkish-Mathematics	263	73.5
	Others	9	2.4
Ability	Music	26	7.2
	Visual Arts	53	14.7
	Sports	16	4.4
	Literature	13	3.6
	Intelligence Games	6	1.7
	Multiple Ability	19	5.3
	Language	6	1.7
	Other	222	61.5
Total		361	100

The participants in the qualitative phase were selected through the purposive sampling method. This is a sampling method preferred when researchers aim at obtaining detailed data with research questions about a case (Teddlie & Tashakkori, 2020). The researchers selected the participants among the PPSTs with "low", "medium" and "high" mathematical disposition levels considering the ability areas they stated regarding themselves. The responses were categorized with simple statistics by considering the mean scores of the responses. Among the selected PPSTs, five volunteered to participate in the qualitative phase of the study. A small group consisting of 4-10 participants is formed in case studies since researchers focus on collecting in-depth data from a small sample in qualitative studies (Creswell & Plano

Clark, 2020). Accordingly, the researchers held interviews with the five volunteering PPSTs. After these interviews, one more semi-structured interview was conducted because data saturation was not ensured regarding the area of education at high school variable. Thus, the number of participants for the qualitative phase was 6. Table 2 presents the information regarding the mathematical disposition scores, grade levels, high school types, area of education at high school and ability area of the PPSTs who participated in the semi-structured interviews.

Table 2. Demographic Characteristics and Mathematical Disposition Scores of the PPSTs in the Interviews

Participants	Grade Level	High School Type	Area of Education at High School	Area of Ability Stated	Mathematical Disposition Score	Scores Gathered from Subscales of Mathematical Disposition			
						Thoughts and beliefs on the nature of mathematics	The importance of the usefulness perception mathematics	Attitude toward Mathematics lesson	Mathematics anxiety
P1	3	Anatolian H.S.	TM	Multiple ability	90	39	19	20	12
P2	3	Open Education H. S.	-	Multiple ability	121	44	28	32	17
P3	3	Anatolian H. S.	TM	Literature	64	21	16	17	10
P4	1	Anatolian H. S.	TM	Intelligence games	103	40	19	32	12
P5	1	Religious Vocational H. S.	TM	Literature	127	45	29	35	18
P6	3	Anatolian H. S.	MS	None	111	45	26	35	5

Data Collection

The quantitative data in the study were collected using the Mathematics Dispositional Functions Inventory (MDFI), developed by Beyers (2008) and adapted to Turkish by Yörük (2019). MDFI is a 5-point Likert-type scale and includes 26 items, gathered under the factors of thoughts and beliefs on the nature of mathematics (F1), the importance of the usefulness perception mathematics (F2), attitude toward mathematics lesson (F3), Mathematics anxiety (F4) (Yörük, 2019). The reliability and validity of measurement tools are important in terms of the reliability of the results obtained through scientific research (Seçer, 2017). For this reason, it was paid attention to the validity and reliability studies of the measurement tool used in the research. The validity and reliability studies of the scale belonging to Yörük (2019) were carried out by the researcher. Since this scale was developed to measure the mathematical dispositions of pre-service teachers, it is suitable for the purpose of the research and the participant group. To ensure the internal validity of the research, care was taken to select the appropriate analysis technique to be used in determining the relationship between variables correctly (Creswell & Plano Clark, 2020). In order to ensure the external validity of the study, attention was paid to sample selection. In this direction, pre-service teachers at different levels studying in the Department of Primary Teaching at different universities in the Central Anatolia Region were reached. The Cronbach Alpha

reliability coefficient of the scale applied within the scope of the study, calculated by the researchers, is ".90".

Some categorical (independent) variables were added to the instrument. These include grade level, area of education at high school (TM: Turkish and Mathematics, MS: Mathematics and Science, and others), area of ability, level of mathematics education experience, and level of mathematics teaching efficacy perception. The data regarding the categorical variables were collected through a questionnaire.

In the qualitative phase, semi-structured interviews were held with volunteering students among those who responded to MDFI. The interviews were recorded upon the participants' consent. After the procedure of ethical permission, quantitative and qualitative data were collected from the specified participants.

Data Analysis

The dependent variable of the study was PPSTs' mathematical disposition scores (thoughts and beliefs on the nature of mathematics, the importance of the usefulness perception mathematics, attitude toward Mathematics lesson, Mathematics anxiety) and the independent variables included grade level, university, area of education at high school (MF, MS, and others), perception of mathematics teaching efficacy, and level of mathematics education experience. Parametric tests were used to analyze. It is recommended while the data are continuously using Likert scale, parametric statistics are applicable (Bishop & Herron, 2015). The multivariate ANOVA (MANOVA) difference test was used to identify whether the mathematical disposition scores differed significantly in terms of the independent variables. MANOVA is the analysis technique in which more than one dependent variable are tested (Seçer, 2017). The analyses were performed in SPSS 25.0 program.

MANOVA requires normal distribution assumptions and hence Kolomogorov-Smirnov and Mahalanobis distance coefficients were calculated (Seçer, 2017). The mathematical disposition score was regarded as a single variable and the normality assumptions were tested for this variable ($p<.05$). The Mahalonobis value was 22.98(>18.47) and based on Pearson and Hartley's (1958) recommendation, the 190th participant's data was excluded from the data set and the analysis was conducted with 361 participants. All other Mahalonobis values were below the recommended values, and the normality assumptions were met.

The qualitative data in the study was analyzed using the descriptive analysis method. In descriptive analysis, the data in the study are organized under pre-determined themes and the researchers reveal results based on the date in these themes. These results are interpreted by the researchers and presented to readers including some quotes from the data (Yıldırım & Şimşek, 2018, p. 239-240). Accordingly, the interviews, held with the PPSTs whose mathematical disposition varied based on the descriptive statistics and difference analysis obtained in the previous phase, were analyzed using this method. The qualitative data were analyzed on MAXQDA 2020 program. The participants statements were visualized with MAXmap.

RESULTS AND DISCUSSION

PPSTs' Levels of Mathematical Disposition

The descriptive statistics of the PPSTs' mathematical disposition scores and qualitative findings are presented below regarding the research question "What is the level of PPSTs' mathematical disposition and what are their opinions regarding their levels of mathematical disposition?".

Table 3. The descriptive statistics for the participants' scores in the instrument

	N	Min.	Max.	$\bar{X}$	sd
F1	361	19.00	45.00	35.56	4.82
F2	361	7.00	30.00	21.03	4.38
F3	361	7.00	35.00	25.13	5.91
F4	361	4.00	20.00	11.57	4.64

As is present in Table 3, in MDFI, participants had the highest score in the F1 dimension and the lowest score in the F4 dimension. This shows that they do not consider themselves as anxious about mathematics. On the other hand, they agreed with the statements about the nature of mathematics.

The analysis of the interviews with the PPSTs indicated that the participants' perceived mathematical disposition levels were grouped as low level, medium level, and high level. Three participants thought that they had high-level mathematical disposition, one thought that s/he had medium level mathematical disposition, and one stated that s/he had mathematical disposition between medium level and high level. P5, who stated that s/he thought s/he had a high-level mathematical disposition, had the highest mathematical disposition score in MDFI with 127 points (max=130) among the participants in the qualitative phase. P5 stated: "I think I have mathematical disposition at a high level. I am very interested in mathematics." P5's this statement demonstrated that s/he had a positive opinion in the thoughts and beliefs on the nature of mathematics factor: "In fact, mathematics is the language of the nature. Wherever we look in our daily life, we can see math. In all sciences...". That she had positive thoughts in the importance of the usefulness perception mathematics factor was evident in his/her statement: "Nowadays, mathematics seems to be an undesirable subject for young people because it is only understood as the mathematics course. When it is compulsory, I guess it is not liked by students. But the truth of the matter is that all sciences exist on mathematics, and we live in a universe based on mathematics. Therefore, mathematics is inevitable." Another participant who though that s/he had high-level mathematical disposition was P2 ($\bar{X}$=121). P2 stated: "I think my mathematical disposition is high". P2 stated her/his thoughts regarding the thoughts and beliefs on the nature of mathematics factor, saying: "numbers and symbols come to my mind, it is like a language". P2 mentioned that mathematics was a necessity in relation to the importance of the usefulness perception mathematics factor. P1, who had a medium level mathematical disposition with 90 points, stated regarding her/his mathematical disposition level: "I think my mathematical disposition is between medium and high level". P1's statement: "Mathematics was like a dark and deep well for me. But as I started to think differently and my anxiety level decreased, I realized that mathematics was like a fun journey" demonstrated his/her positive thoughts on the nature of mathematics. His/her statement "mathematics is a necessity; it is a need for me" showed s/he had positive thoughts on the importance of the usefulness perception mathematics. Besides, P1 told that s/he had medium level attitude toward mathematics lesson.

P6 ($\bar{X}$=111) was among the PPSTs who had the highest level of mathematical disposition scores. P6 said: "I think I have a high mathematical disposition; I enjoy doing mathematics". P4 told: "I can say that my mathematical disposition is medium level. I think I have disposition". P4 ($\bar{X}$=103) was also among the PPSTs who had the highest level of mathematical disposition scores. P4 told that we need mathematics in our lives and this statement demonstrated her/his positive thoughts regarding the thoughts and beliefs on the nature of mathematics factor. P4's positive attitude towards mathematics

lesson can be understood from this statement: “Mathematics lesson is fun. It is a bit difficult to understand, but when you try, you can get good results”. P3 was the participant with the lowest level of mathematical disposition among the ones who participated in the interviews. The researchers observed P3’s mathematics anxiety in her/his gestures and mimics while answering questions about mathematics. It was considered that P3 had a low-level perception regarding her/his mathematical disposition level and P3 stated: “Low”. Based on P3’s statements, we could deduce that P3 had negative thoughts regarding all the factors of mathematical disposition. The researchers observed that the scores the participants obtained from MDFI and their opinions regarding their mathematical disposition levels were consistent. The participants’ quantitative mathematical disposition scores and the qualitative data on their thoughts regarding mathematical disposition levels supported each other.

Examination of Mathematical Disposition Levels in Terms of Various Variables

The findings regarding the research question “Do PPSTs’ mathematical disposition levels differ significantly in terms of various variables (grade level, graduated high school type, area of education at high school, ability) and what are PPSTs’ opinions regarding whether their levels differ significantly in terms of various variables (grade level, graduated high school type, area of education at high school, ability)?” are presented below. The MANOVA findings regarding analysis of PPSTs’ mathematical disposition in terms of grade level variable are provided in Table 4.

Table 4. One-way MANOVA (Grade level and mathematical disposition)

	Dependent Variable	Sum of Means	df	Square of Means	F	p	η2
Grade Level	F1	15.066	3	5.022	.214	.886	.002
	F2	45.509	3	15.170	.786	.502	.007
	F3	44.565	3	14.855	.423	.737	.004
	F4	40.299	3	13.433	.621	.601	.005

The assumptions of MANOVA analysis were checked and the homogeneity assumption of the distribution matrix according to the Box’s M test was met (p>.05). Table 4 shows that the PPSTs’ scores in the thoughts and beliefs on the nature of mathematics, the importance of the usefulness perception of mathematics, attitude toward mathematics and mathematics anxiety factors, did not differ significantly in terms of grade level variable at the level of p=.05.

The qualitative findings regarding the examination of PPSTs’ mathematical disposition in terms of grade level variable are presented in Figure 1. According to Figure 1, in line with some of the views expressed by the participants, it can be stated that they think that getting university education has contributed to them and that they think that they have made positive progress in mathematics with the contributions of the mathematics teaching course they took at the university. The participants’ views on this are as following: "After I started to receive education in the field of primary school teaching, my thoughts about mathematics changed. I can even say something like this; my willingness to study mathematics lessons in the first year is different from my willingness to study in the third year. I seem to be more inclined towards mathematics now. I think that my university lecturer influenced this. (P1)", "My ideas and skills about mathematics have changed positively since I started university. (P3)" Considering these statements, it can be concluded that they started to form positive thoughts about mathematics as

their grade level progressed. The other PPSTs' stated: "I think that I need to add something to myself every year in primary school teaching due to my profession. I will be more adapted/successful in terms of mathematics in the following years (P2)", "I think that the grade level has an effect on mathematical disposition. Since we are now teaching rather than learning, I think that we gain different perspectives and improve ourselves (P6)" These statements suggest that the participants were more proficient and ready on mathematics teaching as their grade level increased. Considering PPSTs' statements, we can conclude that they think that their mathematical dispositions differ in terms of the grade level variable. Their statements in the interviews are not in the same direction with the quantitative analysis results. Regarding the grade level variable, P1, P2, P3 and P6 expressed their opinions, but the other participants did not express their opinions.

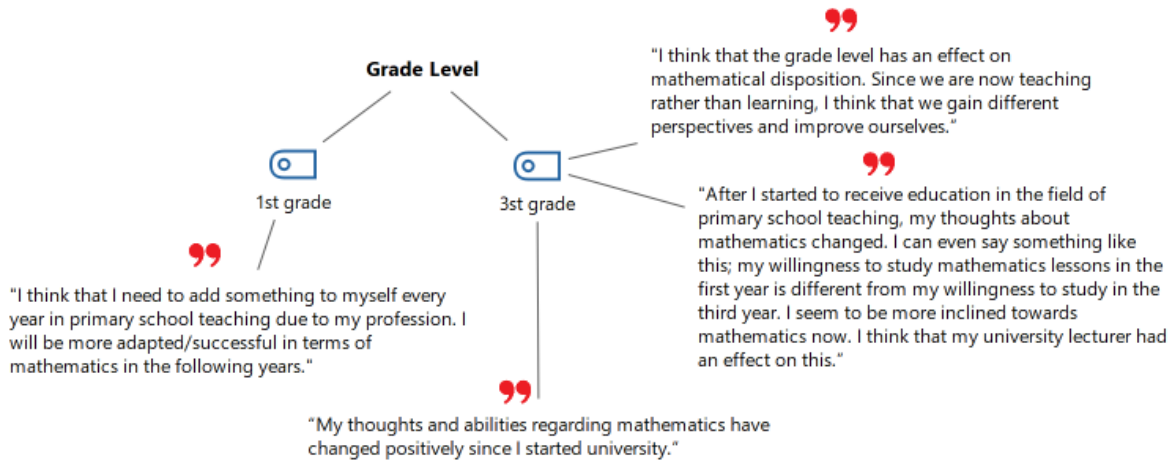

Figure 1. The participants' statements regarding the grade level variable

The MANOVA findings regarding analysis of PPSTs' mathematical disposition in terms of high school type variable are provided in Table 5.

Table 5. One-way MANOVA (High school type and mathematical disposition)

	Dependent Variable	Sum of Means	df	Square of Means	F	p	η2
High School Type	F1	136.152	4	34.038	1.520	.196	.017
	F2	34.725	4	8.681	.446	.775	.005
	F3	19.577	4	4.894	.138	.968	.002
	F4	109.712	4	27.428	1.280	.278	.014

Table 5 demonstrates that the PPSTs' scores in the factors of thoughts and beliefs on the nature of mathematics), the importance of the usefulness perception of mathematics (attitude toward mathematics lesson and mathematics anxiety did not differ significantly in terms of high school type variable (Anatolian High School, Science High School, Social Sciences High School, Religious Vocational High School, Others) at p=.05 level. This result suggests that high school type is not a factor that affects PPSTs' mathematical disposition levels significantly.

The quantitative findings of the study revealed that mathematical disposition did not differ

significantly in terms of high school type; however, the participants' opinions in the interviews revealed different results. The PPSTs who participated in the interviews thought that the type of their high schools affected their mathematical disposition. Figure 2 presents some participants' opinions.

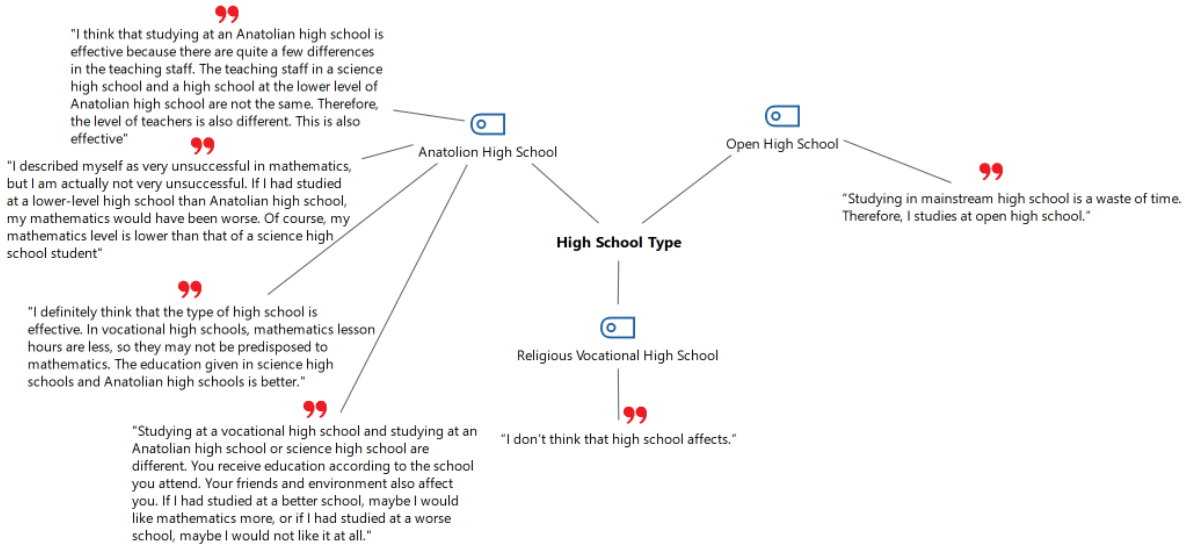

Figure 2. The participants' statements regarding the high school type variable

Regarding the high school type, the participants stated: "I think that studying at an Anatolian high school is effective because there are quite a few differences in the teaching staff. The teaching staff in a science high school and a high school at the lower level of Anatolian high school are not the same. Therefore, the level of teachers is also different. This is also effective" (P1), "I described myself as very unsuccessful in mathematics, but I am actually not very unsuccessful. If I had studied at a lower-level high school than Anatolian high school, my mathematics would have been worse. Of course, my mathematics level is lower than that of a science high school student" (P3), "Studying at a vocational high school and studying at an Anatolian high school or science high school are different. You receive education according to the school you attend. Your friends and environment also affect you. If I had studied at a better school, maybe I would like mathematics more, or if I had studied at a worse school, maybe I would not like it at all." (P4), "I definitely think that the type of high school is effective. In vocational high schools, mathematics lesson hours are less, so they may not be predisposed to mathematics. The education given in science high schools and Anatolian high schools is better." (P6). These statements reveal that the quantitative findings on high school type variable are different from the qualitative findings. On the other hand, a religious vocational high school graduate, P5 stated: "I don't think that high school affects". P2 told that s/he graduated from open high school and thought that studying in mainstream high school was a waste of time. All in all, the qualitative findings are not in line with the quantitative findings.

The MANOVA findings regarding analysis of PPSTs' mathematical disposition in terms of area of education at high school variable (TM, MS, Others) are provided in Table 6. As provided in Table 6, the PPSTs' scores in the factors of thoughts and beliefs on the nature of mathematics the importance of the usefulness perception of mathematics and mathematics anxiety did not differ significantly in terms of area of education at high school variable at p=.05 level. However, there was a significant difference in the attitude toward mathematics lesson factor. This shows that the area of education variable can determine the attitude of mathematics factor.

Table 6. One-way MANOVA (Area of education at high school and mathematical disposition)

	Dependent Variable	Sum of Means	df	Square of Means	F	p	η2
Area of education at high school	F1	0.43	2	.021	.001	.999	.000
	F2	6.729	2	3.365	.173	.841	.001
	F3	282.294	2	141.147	4.092	.017	.023
	F4	87.232	2	43.616	2.037	.132	.011

As a matter of fact, the attitude scores of pre-service teachers towards mathematics are in favor of pre-service teachers who graduated from departments with numerical emphasis. Post-hoc test was performed to identify between which group or groups the differentiation in this factor was. The results are presented in Table 7.

Table 7. Post – hoc analysis

Source of variance	Sum of squares	df	Mean of squares	F	p	Difference
Mathematical disposition (Attitude toward mathematics lesson)	282.294	2	141.147	4.092	.017	MS-TM

According to Table 7, the score PPSTs obtained in the attitude toward mathematics lesson factor was significantly higher in favor of MS in the comparison between MS ($\bar{X}$=26.68, sd= 5.42) and TM ($\bar{X}$=24.63, sd=6.04) (p<.05). This result suggests that PPSTs who graduated from MS area at high school had higher levels of positive attitudes toward mathematics lesson when compared to those who graduated from TM area at high school.

Figure 3 presents the participants' statements regarding the area of education at high school.

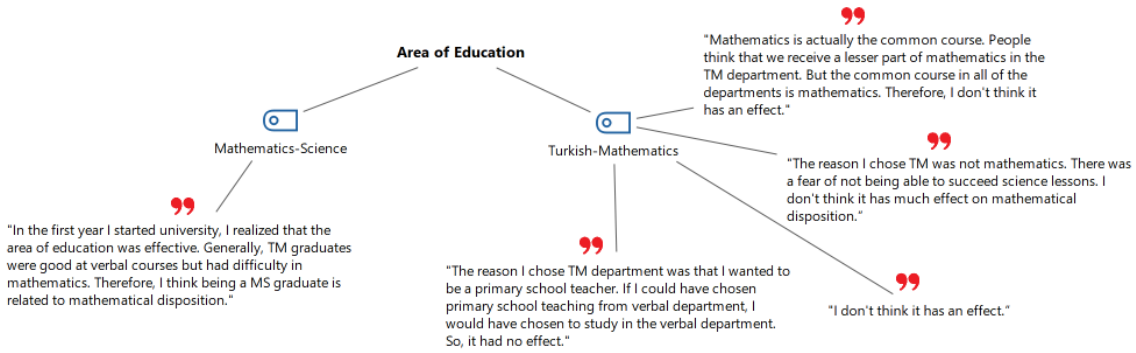

Figure 3. The participants' statements regarding the area of education at high school

The statements of the participants in the interviews, as shown in Figure 3, demonstrate that they thought that the area of education at high school variable did not influence their mathematical disposition. They expressed their opinions as following: "Mathematics is actually the common course. People think that we receive a lesser part of mathematics in the TM department. But the common course in all the departments

is mathematics. Therefore, I don't think it has an effect (P1)", "The reason I chose TM department was that I wanted to be a primary school teacher. If I could have chosen primary school teaching from verbal department, I would have chosen to study in the verbal department. So, it had no effect. (P3)", "The reason I chose TM was not mathematics. There was a fear of not being able to succeed science lessons. I don't think it has much effect on mathematical disposition (P4)", "I don't think it has an effect. (P5)". Different from the other participants, P6 stated: "In the first year I started university, I realized that the area of education was effective. Generally, TM graduates were good at verbal courses but had difficulty in mathematics. Therefore, I think being a MS graduate is related to mathematical disposition."

The qualitative findings were different from the quantitative findings. Among the PPSTs, only P6 stated that area of education at high school had effect on their mathematical disposition. P1, P3, P4, and P5 thought that the area of education at high school did not affect their mathematical disposition. Considering that there was a significant difference in favor of MS department regarding the area of education at high school department, P6's opinion was in consistency with the quantitative result. That P6 studies in MS department at high school may have affected her/his opinion in this regard. The analysis results with respect to the area of education at high school variable reveal that the quantitative results did not overlap with the qualitative results. Only one PPST expressed an opinion overlapping with the qualitative analysis results.

Another variable of examination was the effect of ability area on PPSTs' mathematical disposition levels. We asked questions to PPSTs regarding their ability areas to reveal this. Their ability areas were coded based on their responses to these questions. Accordingly, the PPSTs stated that they had abilities in the areas of music, visual arts, sports, literature, intelligence games and language. The PPSTs who stated that they had more than one ability area among these areas were coded as multiple ability. For example, the ability area of the PPSTs who stated that they had ability in the areas of intelligence games, sports and literature were coded as multiple ability.

The MANOVA findings regarding analysis of PPSTs' mathematical disposition in terms of ability variable are provided in Table 8.

Table 8. One-way MANOVA (Ability and mathematical disposition)

	Dependent Variable	Sum of Means	df	Square of Means	F	p	η2
Ability	F1	207.599	7	29.657	1.282	.258	.025
	F2	162.413	7	23.202	1.209	.297	.023
	F3	552.999	7	79.000	2.316	.025	.044
	F4	162.847	7	23.264	1.081	.375	.021

Table 8 reveals that the PPSTs' scores in the factors of thoughts and beliefs on the nature of mathematics, the importance of the usefulness perception of mathematics, and mathematics anxiety did not differ significantly in terms of the ability variable. On the other hand, there was a significant difference in the attitude toward mathematics lesson factor. This finding indicates that ability type affects mathematical disposition scores. Post-hoc test was performed to identify between which group or groups the differentiation in this factor was. The results are presented in Table 9.

Table 9. Post-hoc analysis

Source of variance	Sum of squares	df	Mean of squares	F	p	Difference
Mathematical disposition (Attitude toward mathematics lesson)	552.999	7	79.00	2.316	.025	Intelligence games-Literature

According to Table 9, the score PPSTs obtained in the attitude toward mathematics lesson factor was significantly higher in favor of intelligence games ($\overline{X}$=31.50, sd=3.20) in the comparison between intelligence games and literature (F=2.316, p<.05). This result suggests that PPSTs who had ability in intelligence games had higher levels of positive attitudes toward mathematics lesson when compared to those who had ability in literature. The participants' statements regarding the ability area variable are presented in Figure 4.

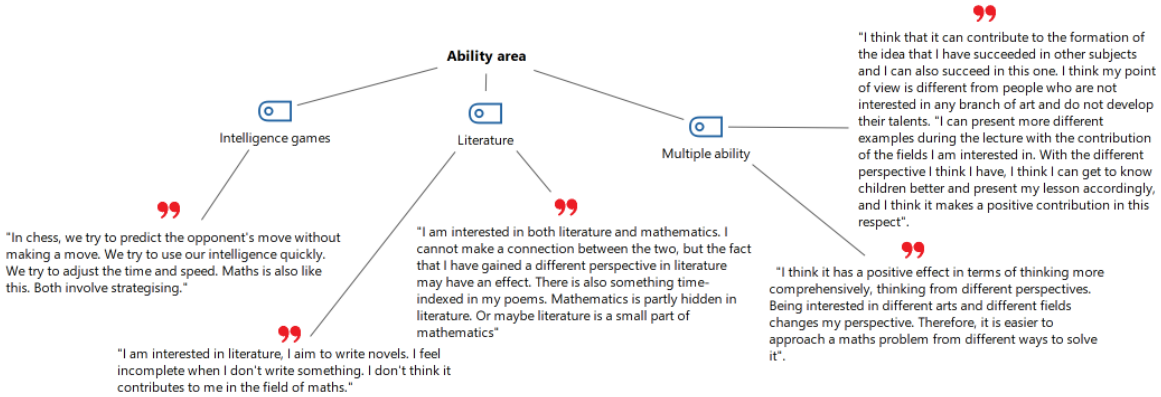

Figure 4. The participants' statements regarding ability

The participants' statements regarding ability area, presented in Figure 4, were interpreted in line with the quantitative results presented in Table 9. The PPSTs who participated in the semi-structured interviews had stated that they had ability in the areas of literature and intelligence games. P6 stated that s/he did not have any ability. P3's statements were not in line with the quantitative results. P3's statement: "I am interested in literature; I aim to write novels. I feel incomplete when I don't write something. I don't think it contributes to me in the field of math." shows that P3 thinks that s/he is talented in literature, but she does not think that this ability has any effect on her/his mathematical disposition positively or negatively. The other participants had different opinions than P3. P1, who reported having multiple ability, told that her/his ability area influenced her/him positively. On this, P1 said: "I think it has a positive effect in terms of thinking more comprehensively, thinking from different perspectives". P1 thought that her/his ability areas contributed positively to her/his attitude toward mathematics lesson, as apparent in her/his statement: "Being interested in different arts and different fields changes my perspective. Therefore, it is easier to approach a maths problem from different ways to solve it". Considering what P1 reported about her/his experiences in the first periods of her/his education life, it can be interpreted that s/he had experiences that caused her/him to have a negative attitude towards mathematics lesson, and that s/he started to have a positive attitude towards mathematics lesson thanks to the skills s/he added to

herself/himself through positive experiences and her/his abilities, replacing her/his negative attitude over time with the contribution of her/his skills.

P2 stated that s/he had multiple ability areas. P2 added that having different areas of ability contributed positively to her/him in mathematics. S/he stated that s/he overcame her/his anxiety about being able to do something by succeeding in playing a musical instrument and painting. P2 said: "I think that it can contribute to the formation of the idea that I have succeeded in other subjects, and I can also succeed in this one", and s/he added: "I think my point of view is different from people who are not interested in any branch of art and do not develop their talents". S/he has the belief that having a different perspective and the belief of being successful thanks to her/his areas of ability will contribute to her/him in learning and teaching mathematics. On this, P2 said: "I can present more different examples during the lecture with the contribution of the fields I am interested in. With the different perspective I think I have, I think I can get to know children better and present my lesson accordingly, and I think it makes a positive contribution in this respect". P4 argued that s/he had ability in intelligence games. P4 stated that s/he thought that this ability area contributed to her/him in mathematics. P4, who stated that s/he was a good chess player and had championships in chess, conveyed the contribution of chess to her/him in mathematics with the following sentences: "In chess, we try to predict the opponent's move without making a move. We try to use our intelligence quickly. We try to adjust the time and speed. Math is also like this. Both involve strategizing." P4's thoughts that the strategies she used in chess and the skills she acquired through chess contributed to her mathematical skills can be understood from the following sentences: "We try to find the previous or next move. We try to checkmate and win. That's why I think it is effective in terms of mathematical disposition. I think they are related. They both require intelligence and effort."

P5, who stated that s/he had ability in literature, was indecisive bout whether her/his area of ability had a positive or negative effect on her/his mathematical disposition. P5 stated that s/he lived in a family where the oral literature tradition was maintained that s/he learnt this tradition from the elders of the family, and that her/his interest in literature may have been formed in this way. P5, who had a high mathematical disposition score, liked learning and teaching mathematics, and thought that mathematics had an important place in life, stated that s/he had a different perspective thanks to literature, literature improved her/his ability to understand, and that this may have positively affected her/his mathematical skills. P5's statement "I am interested in both literature and mathematics. I cannot make a connection between the two, but the fact that I have gained a different perspective in literature may have an effect. There is also something time-indexed in my poems. Mathematics is partly hidden in literature. Or maybe literature is a small part of mathematics" summarizes her/his opinion on whether her/his ability in literature contributed to her/his mathematical disposition. Based on the opinions of most of PPSTs, it can be inferred that ability areas contribute positively to the formation of a positive attitude towards mathematics lesson.

Relationship between PPSTs' Levels of Mathematical Disposition and Mathematics Learning Experiences

The findings regarding the research question, "Is there a significant relationship between PPSTs' levels of mathematical disposition and mathematics learning experiences, and what are their opinions regarding this relationship?", are presented below.

The Spearman correlation analysis findings to reveal whether there was a relationship between PPSTs' mathematical disposition and their levels of mathematics learning experiences (primary school, middle school, high school) are presented in Table 10.

Table 10. The relationship between mathematical disposition and level of mathematics learning experience

Variable	N	r
Mathematics learning experience level in primary school /Mathematical disposition	361	.220**
Mathematics learning experience level in middle school /Mathematical disposition	361	.294**
Mathematics learning experience level in high school /Mathematical disposition	361	.120*

** Correlation is significant at 0.01 level (p<.01)

As Table 10 presents, there is a significant, positive and low-level relationship between PPSTs' mathematical disposition and their levels of mathematics learning experience in primary school (r = .220** ,p <.01), a significant, positive and low-level relationship between PPSTs' mathematical disposition and their levels of mathematics learning experience in middle school (r = .294** ,p <.01), and a significant, positive and low-level relationship between PPSTs' mathematical disposition and their levels of mathematics learning experience in high school (r = .120* , p <.05).

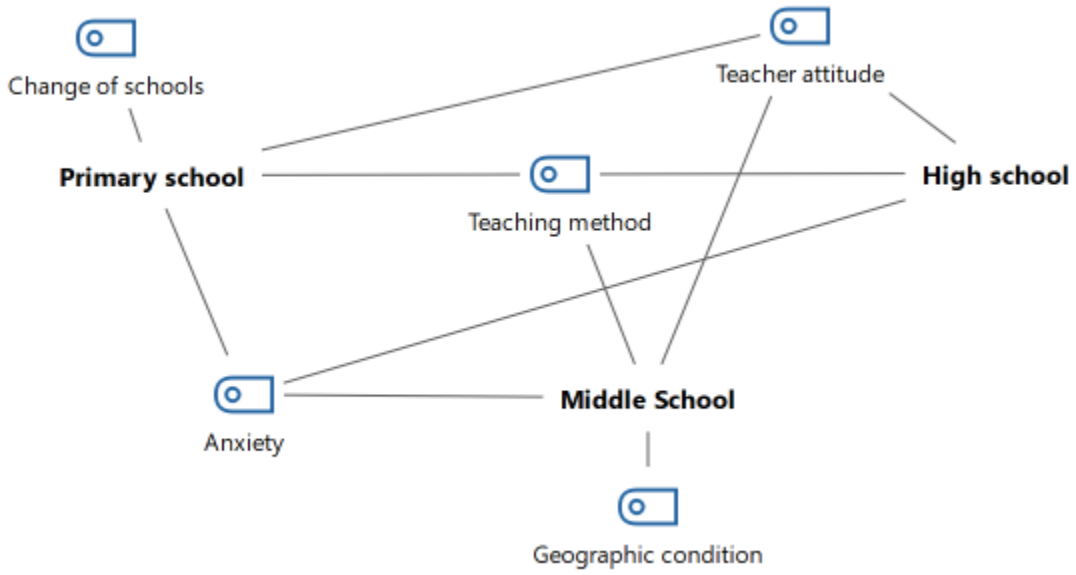

Figure 5. Categories of mathematics learning experience

Cohen (1988) and Huck (2008) state that the r value obtained as a result of correlation analysis between .10 and .29 indicates a low-level relationship, between .30 and .49 indicates a medium level relationship and between .50 and 1.0 indicates a high level relationship (cited in: Seçer, 2017). Therefore, when the tables of the relationship analysis are interpreted in general, it is revealed that the relationship between mathematical disposition and the level of mathematics learning experience in middle school is

at a higher level. The relationship between mathematical disposition and level of mathematics learning experience in high school is at the lowest level. Again, there is a low level- significant relationship between PPSTs' mathematical disposition and their mathematics learning experience in primary school. Information about the categories of mathematics learning experience is given in Figure 5.

As Figure 5 presents, the PPSTs' mathematics learning experience were investigated at primary, middle and high school levels, and it is seen that the themes of teacher attitude and teaching method were expressed in common by the participants. The statements and categories that emerged in line with the answers given by the PPSTs regarding their school mathematics experience levels are shown in Figure 6, Figure 7, and Figure 8 separately under the titles of primary school, middle school, and high school.

Mathematics Learning Experience in Primary School

In Figure 6, it was determined that PPSTs' mathematical disposition scores and opinions overlapped with each other according to the participant statements regarding the mathematics learning experience in primary school. Only P5 and P6's mathematical disposition scores and their opinions on their mathematics learning experiences in primary school did not overlap.

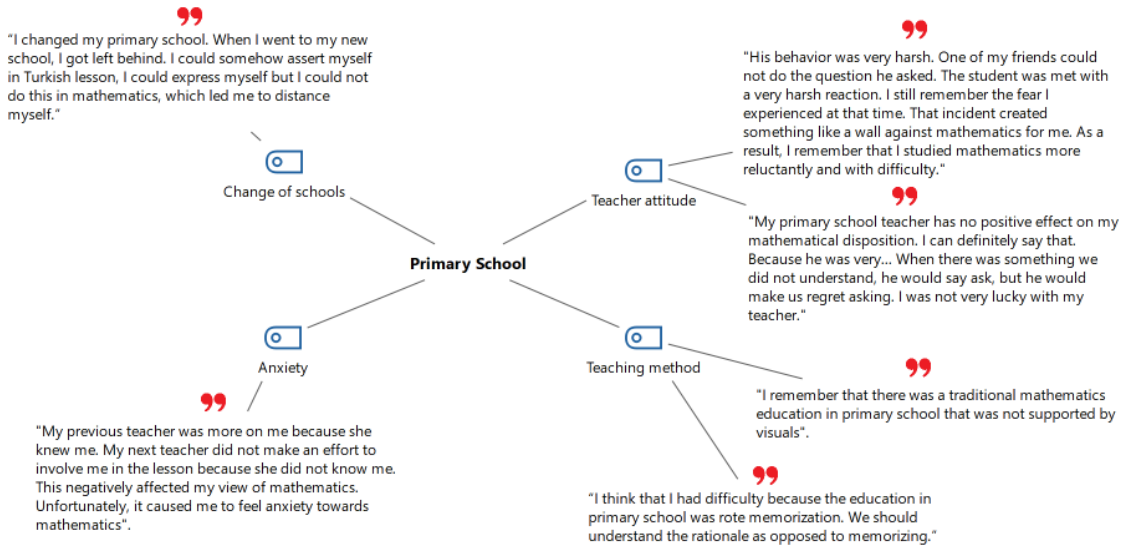

Figure 6. The participants' statements regarding their mathematics learning experience in primary school

P1 had a medium-level mathematical disposition score ($\bar{X}$=90). When asked about his/her mathematics learning experience in primary school, s/he mentioned some negative memories. P1 told that s/he was negatively affected by her/his primary school teacher's behavior towards another student in the class and continued her/his words as follows "His behavior was very harsh. One of my friends could not do the question he asked. The student was met with a very harsh reaction. I still remember the fear I experienced at that time. That incident created something like a wall against mathematics for me. As a result, I remember that I studied mathematics more reluctantly and with difficulty." Despite this negative experience and the resulting negative attitude, P1's having a moderate level of mathematical disposition can be accounted for by the support s/he received from her/his father during primary school. P1's sentence "My father has been very supportive in this regard, we used to practice mental operations like playing games with him" reveals the support s/he received from her/his father.

P2 had a high-level of mathematical disposition score ($\bar{X}$=121). When P2 was asked about her/his experiences in learning mathematics in primary school, s/he said that he did not have any negative experiences. The statement "I was a successful student in mathematics and Turkish lessons in primary school" shows that s/he had a high level of experience during her primary school mathematics education. P2 stated that the only thing s/he remembered as negative at this point was that s/he was assigned by his teacher to help his friends with lower achievement during breaks because s/he was a successful student.

P3 had a low level of mathematical disposition score ($\bar{X}$=64). P3 stated that s/he had difficulties due to the school change during her/his primary school years, and that s/he was especially distanced from mathematics. P3 added that s/he had difficulty in mathematics from the beginning, but the teacher at the first school helped her/him because he knew her/his situation, and that s/he was ignored by the teacher at the school s/he went to after the school change. P3 said: "My previous teacher was more on me because she knew me. My next teacher did not try to involve me in the lesson because she did not know me. This negatively affected my view of mathematics. Unfortunately, it caused me to feel anxiety towards mathematics". This statement also shows that P3's level of mathematics learning experience in primary school was at a low level.

P4 had a high level of mathematical disposition score ($\bar{X}$=103). P4 expressed that s/he had positive experiences in primary school and that her/his teacher contributed a lot to her. P4 mentioned that s/he had a primary school teacher who taught mathematics and other subjects in a pleasant way. P4 described her/his experience as follows: "He was a person I took as a role model; I still keep in touch with him. He was not a person who just taught information and left. That's why he is one of the people I take as an example who made me love the lessons". P4 also added: "I see mathematics as something I have to do because of lessons and exams, I don't like it much. I would like to learn it not because I feel obliged but because I like it. It is a lesson I would learn with more pleasure if there were no exams".

P5 had the highest level of mathematical disposition score among the participants ($\bar{X}$=127). P5 stated that s/he did not remember much about mathematics learning in primary school. S/he briefly expressed her/his opinion on this issue as "I remember that there was a traditional mathematics education in primary school that was not supported by visuals". From this point of view, we cannot conclude that P5's mathematical disposition score and her/his experience level of mathematics learning in primary school are in the same direction.

P6 was one of the participants with a high level of mathematical disposition score ($\bar{X}$=111). Considering P6's statements, it can be interpreted that her/his level of mathematics learning experience in primary school is low. P6 told: "My primary school teacher has no positive effect on my mathematical disposition. I can say that. Because he was very... When there was something, we did not understand, he would say ask, but he would make us regret asking. I was not very lucky with my teacher." It was observed that P6's mathematical disposition score and her/his level of mathematics learning experience in primary school were inconsistent.

We can deduce that the PPSTs had different experiences related to mathematics learning in the primary school period and these experiences had positive or negative effects. Therefore, the PPSTs' mathematics learning experience levels differed. From the responses of the participants, we understand that teachers have influenced this difference.

Mathematics Learning Experience in Middle School

According to Figure 7, the mathematical disposition scores of the participants and their statements about their mathematics learning experience in middle school period supported each other. P1 clarified that s/he had slightly more positive experiences in mathematics than in primary school with the following statement: "In middle school, our teacher preferred a teaching style in which we were active. He trusted us a lot in problem solving. The situation was a little more positive in middle school". We can interpret that P1 had an intermediate level of mathematics learning experience. P1's medium level mathematical disposition score overlapped with her/his level of mathematics learning experience in middle school. While talking about her/his experiences related to mathematics learning in middle school, P2 stated that s/he remembered her/his experiences with teachers more than the lessons. P2 mentioned that s/he was negatively affected by the harsh temperament of her/his mathematics teacher in middle school. P2 told that s/he experienced negative teacher behaviors with this statement: "He was very angry. He made us feel that he was not doing his job well. We were teenagers and he was always snapping at us. We made a complaint about him. He had a negative effect on my view of mathematics". P2 was affected negatively. On this P2 said: "I think that teacher may have been effective in my anxiety at that time". P2 stated that her/his mathematics learning was at a good level despite the negative experiences s/he had. The pre-service teacher's statement in this direction and the mathematical disposition score were consistent.

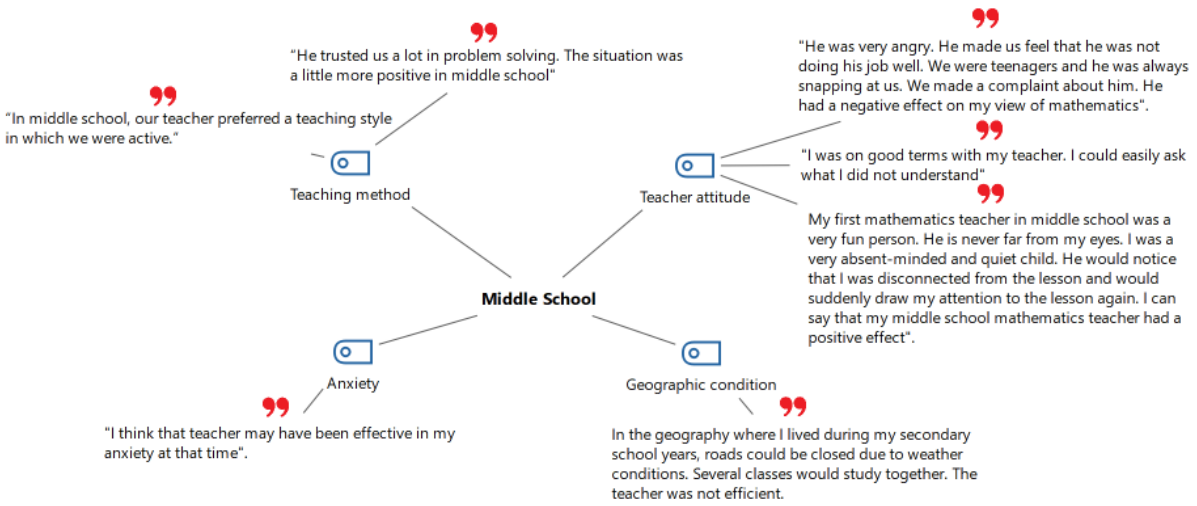

Figure 7. The participants' statements regarding their mathematics learning experience in middle school

Regarding mathematics learning experience in middle school, P3 explained the fact that s/he did not like her/his teacher affected her/him negatively. P3 stated: "I didn't like him very much. That's why I didn't like listening to his lectures and being interested in lesson." During the interview with P3, who stated that the mathematics education s/he received in middle school was poor, the negative effects of her/his experiences in mathematics and her/his low mathematical disposition because of these experiences were observed. P3's answers and mathematical disposition score overlapped with each other.

P4 reported that s/he did not have any negative experiences in primary and middle school and that the mathematics education she received in middle school was good. P4 said: "I was on good terms with my teacher. I could easily ask what I did not understand", which shows that her/his middle school mathematics education experience was at a high level. The opinions of P4, who had a high mathematics disposition score, were consistent with the quantitative results.

P5 explained that s/he studied in a multigrade class, it was difficult, and it was sometimes hard to access to school due to geographic conditions. Therefore, s/he could not receive qualified mathematics education in middle school. She reported: "In the geography I lived in during middle school, schools could be closed due to weather conditions. Several classes used to study together. The teacher could not be efficient", which suggests that P5's mathematics learning experience was low in middle school. An examination of the participants' opinions and mathematical disposition scores reveals that the qualitative results differed from the quantitative results.

P6 informed that s/he had positive experiences about her middle school period and mentioned the positive effect of her/his teacher as follows: "My first mathematics teacher in middle school was a very fun person. He is never far from my eyes. I was a very absent-minded and quiet child. He would notice that I was disconnected from the lesson and would suddenly draw my attention to the lesson again. I can say that my secondary school mathematics teacher had a positive effect". P6's mathematical disposition score and her/his mathematics learning experience overlapped with each other.

Mathematics Learning Experience in High School

As can be seen in the statements summarized in Figure 8, it was determined that the participants had different experiences. P1 had a medium level mathematical disposition score. P1 stated her/his opinions on mathematics learning experience in high school as following: "Our education processes have always been based on theory and rote learning. We experienced this a lot in high school. The teaching in high school was as follows; when our teacher started a new subject, when we needed to learn a new concept, he would explain it himself without giving us the opportunity, and it was result-oriented". P1 stated that they did not receive an education that would enable them to make sense of the subject and form relationships, and that s/he had negative experiences with her/his teacher. P1 had a medium level mathematical disposition score, but it was concluded that her/his level of mathematics learning experience in high school was low.

P2 explained that s/he completed her/his high school education in open education high school with the idea that continuing formal education would be a waste of time. Therefore, s/he did not have any mathematics education experience in high school. P2 disclosed that s/he tried to close the gap in mathematics in high school by taking private lessons during the preparation period for the university exam, and that s/he made positive progress in mathematics thanks to the private tutor. S/he stated that the teacher's instruction was effective and permanent and that the lessons were very enjoyable. We can say that P2, whose high school education level we could not comment on, developed a positive attitude towards the mathematics lesson during the university preparation process. That s/he had a high level of mathematical disposition supports this interpretation.

P3 pointed out that her/his high school teachers supported her/him and helped her/him to overcome her/his deficiencies. Based on P3's statement, "My high school mathematics teacher made me think a little more positively about mathematics. It prevented me from hating it completely", we can conclude that the teacher had a positive effect. However, s/he mentioned that after an exam, s/he tried to get a passing grade from her/his teachers. S/he expressed her/his mathematics anxiety in high school with the following words: "When I was in high school, we used to take exams, and all of my close friends were good at maths. They would ask questions to the teacher. I could never ask them. I was a student who was anxious about maths." Therefore, we can interpret that the level of mathematics learning experience was at low. Accordingly, we can argue that P3's mathematical disposition score and level of mathematics learning experience in high school were consistent.

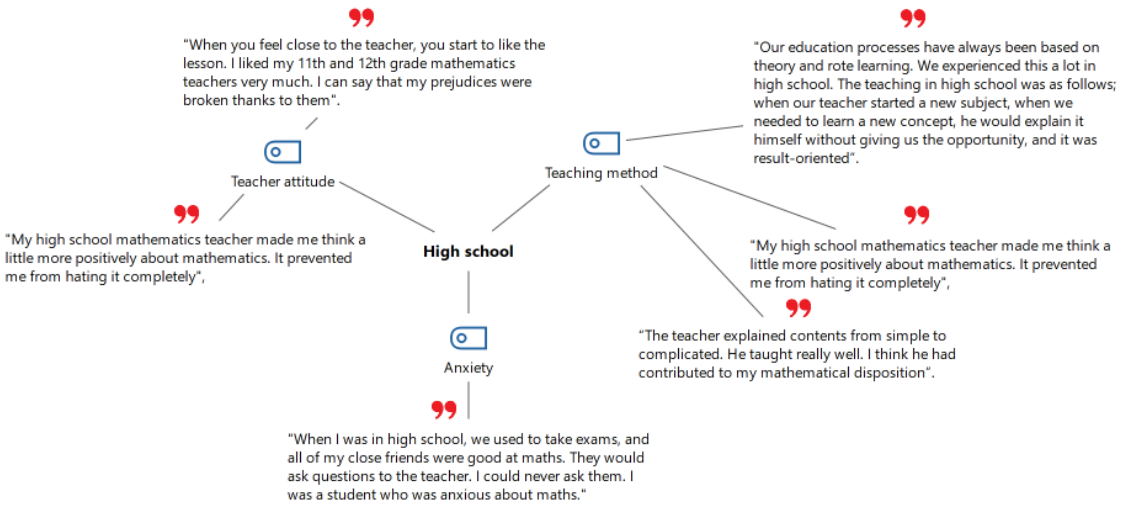

Figure 8. The participants' statements regarding their mathematics learning experience in high school

P4 stated that it is necessary to like the teacher before liking a lesson, and that s/he was negatively affected in mathematics because of the teacher s/he did not like at the beginning of her/his high school years. Later, s/he she started to like mathematics thanks to the mathematics teacher s/he met and liked during high school. On this, P4 stated: "When you feel close to the teacher, you start to like the lesson. I liked my 11th and 12th grade mathematics teachers very much. I can say that my prejudices were broken thanks to them". P4's mathematical disposition score was at a high level, and we can conclude that P4's mathematics learning experience in high school was at a high level, which demonstrates that the quantitative and qualitative findings for this participant were consistent.

P5, who had a high mathematical disposition score, told that s/he started to like mathematics lessons more thanks to her/his mathematics teacher in high school and that s/he changed her/his field of study in high school. P5 explained that she transferred from verbal department to TM department. We can deduce that her/his level of mathematics learning experience in high school was high, based on her/his following statement: "I love maths. In high school, there was a teacher who came to our maths class. He explained the lesson so beautifully and fun...". P5's mathematical disposition score was also at a high level and hence, the qualitative and quantitative findings overlapped for this participant.

Relationship between Mathematical Disposition and Perception of Mathematics Teaching Efficacy

The findings regarding the research question, "Is there a significant relationship between PPSTs' levels of mathematical disposition and their perception of mathematics teaching efficacy, and what are their opinions regarding this relationship?", are presented in Table 11.

Table 11. The relationship between participants' mathematical disposition and perception of mathematics teaching efficacy levels

Variable	N	r
Perception of mathematics teaching efficacy level	361	.323**
Mathematical disposition		

** Correlation is significant at 0.01 level (p<.01)

As presented in Table 11, The Spearman correlation analysis, which was performed to reveal whether there was a significant relationship between mathematical disposition scores and perception of mathematics teaching efficacy levels, demonstrated that there was a significant, positive, and medium level relationship (r = .323**, p <.01). The participants' statements regarding their levels of mathematics teaching efficacy perception in the interviews are provided in Figure 9.

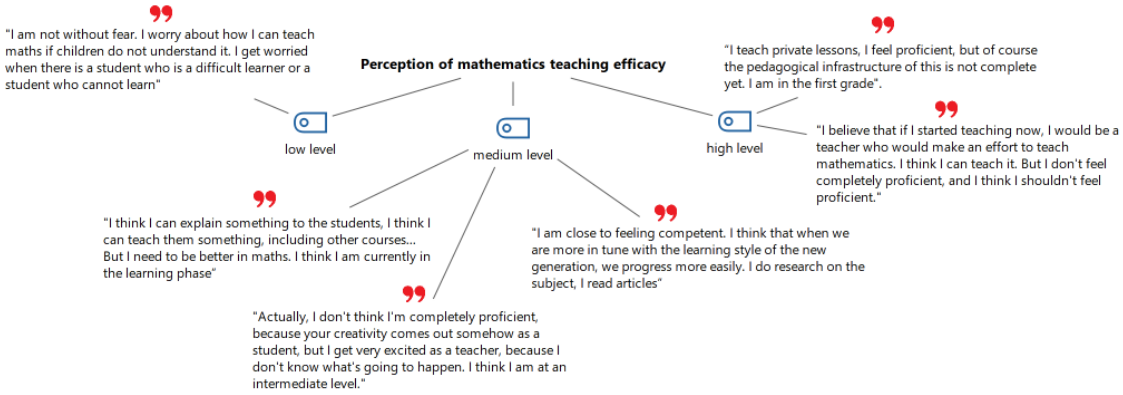

Figure 9. The participants' statements regarding perception of mathematics teaching efficacy

Based on the relationship between the participants mathematical disposition levels and their opinions as summarized in Figure 9, we attempted to put forth a stance regarding whether mathematical disposition influences this issue. Then we concluded that the participants' mathematical disposition scores and perception of mathematics teaching efficacy were consistent.

It was observed that P3, whose mathematical disposition score was at a low level, was concerned about mathematics teaching. On this, P3 stated: "I am not without fear. I worry about how I can teach maths if children do not understand it. I get worried when there is a student who is a difficult learner or a student who cannot learn". Although s/he had these concerns, s/he stated that the mathematics teaching course s/he had taken at the university had contributed a lot to her/him and that this had a positive effect on her/him. It was determined that the pre-service primary school teacher (P1) with medium level mathematical disposition score felt less competent than the candidates with high mathematical disposition but had the motivation to try to become competent. P1 stated: "I am close to feeling competent. I think that when we are more in tune with the learning style of the new generation, we progress more easily. I do research on the subject, I read articles". It can be interpreted that the PPSTs with high mathematical disposition (P2, P4, P5) were more self-confident based on the observation results and the opinions they expressed during the interview. Related to this, P2 stated: "I believe that if I started teaching now, I would be a teacher who would make an effort to teach mathematics. I think I can teach it. But I don't feel completely proficient, and I think I shouldn't feel proficient." P4 said: "I think I can explain something to the students, I think I can teach them something, including other courses... But I need to be better in maths. I think I am currently in the learning phase". P5, who considered herself/himself competent in mathematics teaching, wanted to confirm this by saying that she taught private lessons. It is thought that giving private lessons strengthened the participant's perception of self-efficacy in mathematics teaching. We can interpret that s/he considers herself/himself competent but is open to improvement based on her/his following statement: "I teach private lessons, I feel proficient, but of course the pedagogical infrastructure of this is not complete yet. I am in the first grade".

Another pre-service teacher P6, who had a high mathematical disposition score, stated that s/he was aware of how important it was to gain a student and that s/he would try to be better. P6 told that s/he considered herself/himself at an intermediate level in mathematics teaching. P6 stated: "Actually, I don't think I'm completely proficient, because your creativity comes out somehow as a student, but I get very excited as a teacher, because I don't know what's going to happen. I think I am at an intermediate level." We can conclude that although this participant had a high-level mathematical disposition, s/he does not consider herself/himself fully competent in mathematics teaching.

The current study comprehensively investigated mathematical disposition of pre-service primary school teachers, studying at different grade levels in the faculties of education at various universities in Türkiye, in terms of various variables. The quantitative analysis revealed that the PPSTs' mathematical disposition levels did not differ significantly in terms of grade level variable; however, the participants in the semi-structured interviews argued that their opinions and knowledge on mathematics improved positively with the education they got as their grade level progressed at university. A study examining the grade level variable, like the current study, revealed no significant differences (Yazgan et al., 2013). Another study reported that PPSTs' mathematical disposition scores differed significantly as their grade levels increased (Cruz et al., 2019).

This study also demonstrated that the PPSTs' mathematical disposition scores did not differ significantly in terms of high school type variable. On the other hand, the participants stated that the high school they had graduated had an influence on their levels of mathematical disposition. The quantitative and qualitative findings were not in line with each other for this variable. In parallel with the opinions of the participants who were involved in the qualitative phase of this study, a research study found that PPSTs' attitudes toward mathematics lesson differed significantly in terms of high school type (Akar & Boz, 2011). Another variable addressed in the present study was the area of education at high school. The quantitative findings noted that PPSTs' mathematical disposition scores did not differ significantly in terms of the area of education at high school. However, in the attitude toward mathematics lesson factor of mathematical disposition, there was a significant difference between TM and MS areas, in favor of MS area. The findings of the interviews held to better understand the quantitative findings noted that the participants thought that the area of education in their high school did not influence their mathematical disposition in parallel with the quantitative findings. Among the participants, only P6 who studied in MS area at high school stated that the area of education at high school affected mathematical disposition. Çelik and Bindak (2005) investigated PPSTs' attitudes toward mathematics and found that the area of education at high school affected the scores of attitudes toward mathematics, and graduates of MS area had higher levels of attitude toward mathematics scores. This result lends its support to the quantitative results of the current study.

In terms of ability areas, the PPSTs' mathematical disposition scores did not differ significantly; however, in the attitude toward mathematics lesson factor, there was a significant difference between intelligence games and literature ability areas in favor of intelligence games. The interview analyses demonstrated that, except for one pre-service teacher, all the participants believed the ability areas contributed positively to their mathematical disposition. They disclosed that the areas they thought they had ability in improved them regarding feeling of success, time management, strategy development, gaining different perspectives, and prediction. Considering the participants' opinions, and the high level of mathematical disposition scores and attitude toward mathematics factor, we can conclude that the ability areas positively influenced individuals from the academic perspective. The ability area is also noteworthy in the findings of studies on teaching mathematics through integrating it with other areas (An

et al., 2014, 2015). Accordingly, the participants' opinions supported the finding that ability area affected mathematical disposition with respect to attitude toward mathematics lesson factor. Participants in a study, conducted to demonstrate that workers in different fields may have a positive mathematical disposition, involving employees in the packaging, design and store departments of an art company thought that their work was full of mathematical reasoning (Ma & Radke, 2015). Therefore, in the teaching of mathematics, the skills that individuals' areas of ability contribute to them can be utilized and their mathematical disposition can be developed positively by providing learning environments that will attract students' attention, increase their communication and active participation. There are interesting things to explore in this regard. Are mathematical dispositions influenced by ability or vice versa or influence each other? That is, the ability area makes a positive contribution to the mathematical disposition, but conversely it can also happen that the mathematical disposition makes a positive contribution to the ability area.

This study also investigated the relationship between PPSTs' mathematical disposition scores and their levels of mathematics learning experience in primary, middle and high schools. There was a significant and positive relationship between PPSTs' levels of mathematical disposition and their levels of mathematics learning experience in primary, middle and high schools. The interviews, held to better explain this finding, revealed that the PPSTs provided responses that overlapped with their mathematical disposition scores. Generally, the pre-service teachers with high mathematical disposition scores had positive mathematics learning experiences, while pre-service teachers with low mathematical disposition scores had negative mathematics learning experiences. An analysis of the opinions of PPSTs on this issue highlights the teacher factor. The participants stated that their negative experiences with their teachers left a mark on them and caused indifference and anxiety towards the lesson. On the other hand, pre-service teachers who had positive experiences with their teachers conveyed positive feelings towards the mathematics lesson. Their experiences with their primary school teachers are also noteworthy. There are other studies that found that primary school teachers influence pre-service teachers (Feldhaus, 2014). Feldhaus (2014) argues that the experiences in primary school are effective in the positive or negative mathematical disposition. The PPSTs mentioned that besides the teacher's attitude, factors such as the use of traditional methods, lack of connection with daily life, and rote learning also had a negative effect on their attitudes towards mathematics. These statements of pre-service teachers are supported by the studies that report the finding that students' mathematical disposition levels improve positively because of teachers' using different methods in mathematics lessons (Lestari et al., 2019; Sukmadewi, 2014; Ulya & Rahayu, 2021; Yaniawati et al., 2019).

This study reports a significant and positive relationship between the PPSTs' mathematical disposition levels and their perception of mathematics teaching efficacy. The analyses of the interviews with the PPSTs supported the quantitative findings. The qualitative analyses revealed that the PPSTs with high level mathematical disposition had higher levels of mathematics teaching efficacy perception. The PPSTs with medium level mathematical disposition had lower perception levels of mathematics teaching efficacy when compared to those with higher mathematical disposition levels. The PPSTs with low level of mathematical disposition had a low level of mathematics teaching efficacy perception and had a high level of anxiety about teaching mathematics. In parallel with this finding, a study reported a strong association between mathematical disposition and mathematics teaching efficacy perception (Cruz et al., 2019).

CONCLUSION

This study attempted to highlight the significance of PPSTs' mathematical disposition and reveal the factors associated with their level of mathematical disposition. It revealed that the PPSTs' mathematical disposition levels are associated with their earlier experiences related to mathematics and these experiences are also linked to their attitude toward mathematics lesson. This study once again highlighted the significance of mathematics experiences in schools on individuals' mathematics achievement as well as the effect of teacher factor. The study was limited to PPSTs and the specified variables.

This study sheds light on some variables that can explain mathematical disposition for researchers and practitioners in the field of mathematics education. Interpreting the results of this study with studies shaped with different problem statements can contribute to the literature on mathematical disposition. Further research on PPSTs and mathematical disposition is needed. Future research may address in-service teachers' mathematical disposition as well as pre-service teachers, and their levels of mathematical disposition needs to be investigated. Studies revealing what can be done to improve students' mathematical disposition starting from primary school may be guiding for pre-service and in-service teachers. This study examined the variables of ability area and area of education at high school that may affect mathematical disposition, and the relationship between mathematical disposition and mathematics learning experience was investigated. Examining various other variables associated with mathematical disposition using different methods may contribute to mathematics education literature.

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HC: Conceptualization, data analyzing, visualization, and review.

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REFERENCES

Ab, J. S., Margono, G., & Rahayu, W. (2019). The logical thinking ability: mathematical disposition and self-regulated learning. *Journal of Physics: Conference Series*, *(Vol. 1155, p. 012092). IOP Publishing.*https://doi.org/10.1088/1742-6596/1155/1/012092

Akar, H., & Boz, N. (2011). Sınıf öğretmeni adaylarının matematiğe yönelik tutumları, matematiğe karşı öz-yeterlik algıları ve öğretmen öz-yeterlik inançları arasındaki ilişkilerin incelenmesi. *Türk Eğitim Bilimleri Dergisi*, *9*(2), 281–312. https://dergipark.org.tr/en/pub/tebd/issue/26100/275000

An, S. A., Tillman, D. A., Boren, R., & Wang, J. (2014). Fostering elementary students' mathematics disposition through music-mathematics integrated lessons. *International Journal for Mathematics Teaching & Learning*, 19.

An, S. A., Zhang, M., Flores, M., Chapman, J. R., Tillman, D. A., & Serna, L. (2015). Music Activities as an Impetus for Hispanic Elementary Students' Mathematical Disposition. *Journal on Mathematics Education*, *8*.

Atallah, F., Lynne Bryant, S., & Dada, R. (2010). A research framework for studying conceptions and dispositions of mathematics: A dialogue to help students learn. *Research in Higher Education Journal*, *7*(1).

Bekdemir, M., Çiltaş, A., & Işık, A. (2008). Matematik eğitiminin gerekliliği ve önemi. *Ataturk Universitesi Kazım Karabekir Egitim Fakultesi Dergisi*. https://www.academia.edu/25863769/Matematik_E%C4%9Fitiminin_Gereklili%C4%9Fi_Ve_%C3%96nemi

Beyers, J. E. R. (2008). *Development and evaluation of an instrument to measure prospective teachers' dispositions with respect to mathematics*. https://www.proquest.com/dissertations-theses/development-evaluation-instrument-measure/docview/304632697/se-2?accountid=159111

Beyers, J. E. R. (2012). An examination of the relationship between prospective teachers' dispositions and achievement in a mathematics content course for elementary education majors. *SAGE Open*, *2*(4), 1–15. https://doi.org/10.1177/2158244012462589

Bishop, P. A., & Herron, R. L. (2015). Use and misuse of the Likert item responses and other ordinal measures. *International Journal of Exercise Science, 8(3), 297-302*. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4833473/

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2012). Bilimsel araştırma yöntemleri (11th ed.). Pegem Akademi.

Çelik, H. C., & Bindak, R. (2005). Sınıf öğretmenliği bölümü öğrencilerinin matematiğe yönelik tutumlarının çeşitli değişkenlere göre incelenmesi | TR Dizin. *Gazi Üniversitesi Kastamonu Eğitim Dergisi*, *13*(2), 427–436. https://app.trdizin.gov.tr/makale/TVRFM01UZ3lNZz09

Cohen, J. (1988). Set correlation and contingency tables. *Applied psychological measurement*, *12*(4), 425-434. https://doi.org/10.1177/014662168801200410

Cooke, A. (2015). Considering pre-service teacher disposition towards mathematics. *Mathematics Teachers Education and Development*, *17*(1), 1–11. https://espace.curtin.edu.au/handle/20.500.11937/47462

Coppola, C., Martino, P. di, Pacelli, T., & Sabena, C. (2013). Primary teachers' beliefs and emotional disposition towards mathematics and its teaching. *Mathematıcs Educatıon In A Globalızed Envıronment: Proceedings of CIEAEM 65*, 217–226. https://arpi.unipi.it/handle/11568/532073

Creswell, J. W. (2021). Karma Yöntem Araştırmalarına Giriş (M. Sözbilir, Ed.; 3rd ed.). Pegem Akademi Yayıncılık. https://doi.org/10.14527/9786053184720.

Creswell, J. W., & Plano Clark, V. L. (2020). Karma Yöntem Araştırmaları Tasarımı ve Yürütülmesi (Y. Dede ve S. B. Demir, Eds.; 4th ed.). Anı Yayıncılık.

Cruz, J. M. (2017). *Investigating the mathematical dispositions and self-efficacy for teaching mathematics of preservice teachers* [The University of Texas Rio Grande Valley]. https://www.proquest.com/dissertations-theses/investigating-mathematical-dispositions-

Cruz, J. M., Wilson, A. T., & Wang, X. (2019). Connections between pre-service teachers' mathematical dispositions and self-efficacy for teaching mathematics. *International Journal of Research in Education and Science*, *5*(2).

Feldhaus, C. A. (2012). *How mathematical disposition and ıntellectual development ınfluence teacher candidates' mathematical knowledge for teaching in a mathematics*. https://www.proquest.com/dissertations-theses/how-mathematical-disposition-intellectual/docview/1098535239/se-2?accountid=159111

Feldhaus, C. A. (2014). How pre service elementary school teachers' mathematical dispositions are ınfluenced by school mathematics. *American International Journal of Contemporary Research*, *4*(6). www.aijcrnet.com

Hidayat, W., Wahyudin, & Prabawanto, S. (2018). The mathematical argumentation ability and adversity quotient (aq) of pre-service mathematics teacher. *Journal on Mathematics Education*, *9*(2), 239–248. https://eric.ed.gov/?id=EJ1193588

Huck, S.W. (2008). Reading statistics and research (5rd edition). New York: Addison Wesley Longman

Kisunzu, P. K. (2008). Teacher instructional practices, student mathematical dispositions, and mathematics achievement [Northern Illinois University]. In *ProQuest Dissertations and Theses*. https://www.proquest.com/dissertations-theses/teacher-instructional-practices-student/docview/304541001/se-2?accountid=159111

Kusmaryono, I., Suyitno, H., Dwijanto, D. & Dwidayati, N. (2019). The effect of mathematical disposition on mathematical power formation: Review of dispositional mental functions. *International Journal of Instruction*, *12*(1). https://doi.org/10.29333/iji.2019.12123a

Lestari, S. D., Kartono, & Mulyono. (2019). Mathematical literacy ability and mathematical disposition on team assisted ındividualization learning with RME approach and recitation. Unnes Journal of Mathematics Education Research, 8(2), 2019–2157.

Ma, J. & Radke, S. (2015). *Interplay of artistic identities and mathematical dispositions at an art crating company* (S. Mukhopadhyay ve B. Greer, Eds.). MES8.

Pearson, E.S. & Heartley, H.O. (1958). Biometrika tables for statistician. New York: Cambridge University Press

Seçer, İ. (2017). *SPSS ve LISREL ile Pratik Veri Analizi Analiz ve Raporlaştırma* (3rd ed.). Anı Yayıncılık.

Siegfried, J. Z. M. (2012). *The hidden strand of mathematical proficiency: defining and assessing for productive disposition in elementary school teachers' mathematical content knowledge* [University of California, San Diego]. https://www.proquest.com/dissertations-theses/hidden-strand-mathematical-proficiency-defining/docview/1081482546/se-2?accountid=159111

Soltis, L. A. (2019). *Mathematical dispositions of novice upper-elementary teachers: a phenomenological study* [Liberty University]. https://www.proquest.com/dissertations-theses/mathematical-dispositions-novice-upper-elementary/docview/2355994782/se-2?accountid=159111

Sukmadewi, S. T. (2014). Improving students' mathematical thinking and disposition through probing and pushing questions. *Journal Matematika Integratif*, *10*(2), 127–137.

Teddlie, C. & Tashakkori, A. (2020). *Karma yöntem araştırmalarının temelleri* (Y. Dede & S. B. Demir, Eds.; 2nd ed.). Anı Yayıncılık.

Ulia, N., & Kusmaryono, I. (2021). Mathematical disposition of students', teachers, and parents in distance learning: A survey. *Premiere Educandum: Jurnal Pendidikan Dasar Dan Pembelajaran*, *11*(1), 147–159. https://doi.org/10.25273/pe.v11i1.8869

Ulya, H., & Rahayu, R. (2021). Mathematical disposition of students in open-ended learning based on ethnomathematics. *Journal of Education Technology*, *5*(3), 339–345. https://doi.org/10.23887/JET.V5I3.33535

Yaniawati, R. P., Indrawan, R. & Setiawan, G. (2019). Core model on ımproving mathematical communication and connection, analysis of students' mathematical disposition. *International Journal of Instruction*, *12*(4), 639–654. https://doi.org/10.29333/iji.2019.12441a

Yazgan, Y., Akkaya, R. & Memnun, D. S. (2013). Matematiksel yatkınlık: ilkokul ve ortaokul öğretmen adaylarının yatkınlık düzeylerinin çeşitli değişkenler açısından incelenmesi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, *13*(2). http://acikerisim.ibu.edu.tr/xmlui/handle/20.500.12491/382

Yıldırım, A. & Şimşek, H. (2018). Sosyal bilimlerde nitel araştırma yöntemleri (11th ed.). Seçkin Yayıncılık.

Yörük, S. K. (2019). *Matematiksel yatkınlık ölçeği uyarlama çalışması*. http://dspace.balikesir.edu.tr/xmlui/handle/20.500.12462/6149