ISSN 1392-0340 (Print)
ISSN 2029-0551 (Online)
https://doi.org/10.15823/p.2024.154.4

Pedagogika / Pedagogy
2024, t. 154, Nr. 2, p. 57–79 / Vol. 154, No. 2, pp. 57–79, 2024

VYTAUTO DIDŽIOJO UNIVERSITETO ŠVIETIMO AKADEMIJA

Investigation of the Mathematical Connection Self-Efficacies of Pre-Service Teachers: A Quantitative Study From Turkey

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Annotation. This study aims to examine the mathematical connection self-efficacy beliefs of pre-service teachers who were studying at the primary mathematics, secondary mathematics, and science teaching programs of a state university in Turkey. Data were collected through survey research and analyzed quantitatively. The results show no significant differences in the total beliefs based on gender, and undergraduate program. On the other hand, grade levels were found to be effective in this context.

Keywords: *mathematical connection, self-efficacy, pre-service teachers, mathematics and science education.*

Introduction

In this fast-changing world, it is not sufficient for students to simply possess knowledge of mathematics; rather, they should be equipped with the ability to utilize mathematics effectively (Kaya, 2020). To achieve this goal, students should be able to make sense of mathematical concepts and the connections among these concepts, use and interpret them in their lives, and acquire basic mathematical skills such as connecting mathematics with different disciplines (Kinach, 2002; Vale et al., 2011; Van de Walle et al., 2019). In this respect, the mathematical connection makes it easier to

keep information in mind, and mathematics learning can be strengthened through connection (Bosse, 2003).

Mathematics relates to different disciplines and the real world, as well as being connected within itself. Also, mathematical connections are important in interdisciplinary learning (science-technology-engineering-mathematics (STEM) education) which is very widespread among today's education approaches (Yıldırım, 2021). However, for students at any grade level, it is evident that mathematics is abstract, and they struggle to make connections, resulting in difficulties with the subject matter (Rahmi et al., 2019; Ürek & Çoramık, 2022). At this point, teachers are expected to facilitate students' understanding. In addition, pre-service teacher training plays a critical role in developing future generations equipped with that skill.

Connection is an important component of mathematical work (Boaler, 2002), and the development of mathematical connection skills in students is related to classroom practices (Yavuz Mumcu, 2023). In this respect, teachers have an important role in providing students with connection skills. Thus, the necessity of increasing mathematical connection self-efficacy comes to the fore for pre-service teachers. The mathematical connection self-efficacy skill is necessary not only for mathematics teachers but also for science teachers. So, this study is expected to contribute to the literature by considering the comparison of mathematical connection self-efficacy beliefs of the pre-service teachers whose major field is mathematics and who use mathematics as an important part of their teaching process.

This study aims to examine the mathematical connection self-efficacy beliefs of pre-service teachers according to gender, grade level, and undergraduate program. By analyzing the data obtained in the research according to different variables, it is aimed to determine to what extent pre-service teachers are aware of and can use their self-efficacy beliefs when making connections in mathematics.

Research Problems

The following research questions guide this study:

1) Is there a difference in pre-service teachers' mathematical connection self-efficacy beliefs according to their gender?

2) Is there a difference in pre-service teachers' mathematical connection self-efficacy beliefs according to their undergraduate program?

3) Is there a difference in pre-service teachers' mathematical connection self-efficacy beliefs according to their grade level?

Literature Review

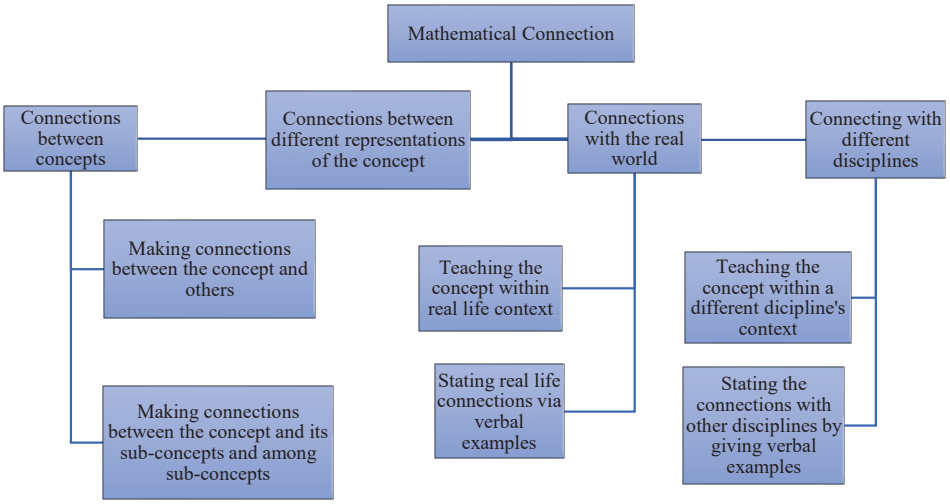
Mathematical Connection

In the literature, there are multiple definitions of mathematical connection. Eli (2009) defines mathematical connection as a bridge or link in mathematical ideas. Through mathematical connection, students can use mathematical concepts and knowledge effectively (NCTM, 2000). Van de Walle et al. (2019) state that there are two distinct drivers for making connections. The first is the relationship within and between mathematical ideas, and the second is the representation of mathematics' relationships with the real world and other disciplines.

Regarding mathematics education, connection is categorized into two main fields as comprehension and skills. First, the concept of comprehension is divided into two sub-concepts: relational comprehension and procedural comprehension (Bingölbali & Coşkun, 2016). From these concepts, relational comprehension is defined as the comprehension of the applied mathematical operation together with its reason (Skemp, 1978), while procedural comprehension is the focus on step-by-step operations and skills without specific references for mathematical ideas (Ashlock, 2001). Coxford (1995) describes connection skills as the ability to link relational and procedural comprehension, to use mathematics with other subjects, to use mathematics in relating to the real world, and to know the connections between subjects within mathematics itself. Figure 1 demonstrates connection skills under four titles as identified by Bingölbali and Coşkun (2016) based on the relevant literature (NCTM, 2000).

There are various studies conducted with pre-service teachers regarding their mathematical connections. For example, Bal (2015) detected that pre-service classroom teachers had positive opinions toward real-life-based problems that involved mathematical connections. On the other hand, their achievement level was lower in real-life-based problems when compared to routine problems. In another study, Eli et al. (2013) determined that pre-service middle-grade teachers' mathematics knowledge for teaching geometry was below average. However, they could make various mathematical connections during the tasks given to them. Also, several studies identified pre-service primary mathematics teachers' (Özgen, 2013) and classroom teachers' opinions (Yorulmaz & Çokçalışkan, 2017) toward connecting mathematics in itself as well as connecting it to different disciplines and daily life. In addition, Özturan Sağırlı et al. (2016) found that real-life-based implementations had a positive influence on pre-service primary mathematics teachers' mathematical connection abilities.

Figure 1
Mathematical Connection Skill Concept Framework



In the literature, several studies have also investigated pre-university level students' mathematical connection abilities. The studies conducted with elementary school (Kenedi et al., 2019) and junior high school students (Rahmi et al., 2019) indicated insufficiencies in this respect. In addition, Lubis et al. (2019) identified a significant impact of the problem-solving model on high school students' mathematical connection ability.

The results in the literature imply that insufficiencies of pre-university students might continue during their undergraduate education. To facilitate student learning and make students construct mathematical connections, teachers should possess a sufficient level of self-efficacy beliefs. In many studies on mathematical learning, the phenomenon of learning is explained by connection processes (Yavuz Mumcu, 2023). As mathematical connection skills increase, self-efficacy also increases (Trihatun & Jailani, 2019). Within this scope, self-efficacy can be used to predict an individual's teaching responsibilities and behaviors (Yenilmez & Kakmacı, 2008). In this context, mathematical self-efficacy beliefs emerge as an important concept for pre-service teachers.

Mathematical Self-Efficacy Beliefs

Self-efficacy is defined as the ability of individuals to organize and carry out the activities necessary to achieve their goals (Bandura, 1986). According to Zimmerman (2000), self-efficacy belief is the mediation of students' personally determined learning methods and performance, communication styles, and academic success. Individuals should be able to use their abilities along with their beliefs and self-efficacy to achieve

the goals they have set (Ural, 2015). Therefore, individuals with high self-efficacy beliefs can cope with a difficult problem situation, are persistent, set higher goals towards the situation, are success-oriented, and think positively about their future.

Self-efficacy belief is an important part of the affective domain in mathematics teaching (Dede, 2008). Accordingly, mathematical self-efficacy is the person's beliefs and attitudes about his/her skills and successful completion of tasks in mathematics (Adal & Yavuz, 2017). The literature indicates that there is a relationship between mathematical self-efficacy and academic achievement (Ayotola & Adedeji, 2009; Grigg et al., 2018; Liu & Koirala, 2009; Schweinle & Mims, 2009; Uzar, 2010; Valentine et al., 2004). Another important result for teachers and pre-service teachers is that high mathematical self-efficacy perception reduces anxiety towards teaching mathematics (Ural, 2015), and increasing mathematical connection self-efficacy decreases mathematics teaching anxiety (Karaman & Çil, 2021).

Mathematical self-efficacy beliefs have attracted the attention of researchers in recent years (Demirci, 2023; Karaman & Çil, 2021; Kaya, 2020; Yılmaz, 2022). The related studies address the effect of gender (Britner & Pajares, 2006; Huang, 2013; İpek, 2019; Uzar, 2010) and grade level (İpek, 2019; Uzar, 2010) on mathematical self-efficacy beliefs. Other variables that are effective on mathematical self-efficacy are school type (Uzar, 2010), parental education level, family socio-economic level, having a room of their own, attending school mathematics courses, and taking private mathematics courses (İpek, 2019). In addition, students' prior mathematics interest positively predicted subsequent mathematics self-efficacy (Grigg, et al., 2018).

Methods

Research Design

This study is based on the survey model, which is one of the quantitative research methods. The survey model, which is usually conducted on relatively larger samples than other studies, is a type of study in which the views of the participants on a subject or event or their interests, skills, abilities, and attitudes are determined (Büyüköztürk et al., 2020).

Participants

The participants of the study included a total of 434 pre-service teachers studying at the primary mathematics, secondary mathematics, and science teaching programs of an education faculty at a state university in the west part of Turkey. The sample involved 319 female (FM) pre-service teachers and 115 males (M). The programs of the participants were abbreviated as PMT for primary mathematics teaching, SMT for

secondary mathematics teaching, and ST for science teaching students in the tables presented in this paper.

Table 1 shows the distribution of the participants regarding the grade level and gender considering their undergraduate programs.

Table 1

Demographic Information of Pre-Service Teachers

	Undergraduate Programs					
	PMT		**SMT**		**ST**	
Grade Level	f	%	f	%	f	%
1	57	27.0	24	30.8	39	26.9
2	54	25.6	18	23.1	41	28.3
3	51	24.2	20	25.6	35	24.1
4	49	23.2	16	20.5	30	20.7
Total	211	100.0	78	100.0	145	100.0
Gender	f	%	f	%	f	%
Female	157	74.4	45	57.7	117	73.5
Male	54	25.6	33	42.3	28	26.5
Total	211	100.0	78	100.0	145	100.0

As can be seen in Table 1, there are three groups of participants in the study. All these participants receive four years of training in the education faculty. PMT students are trained to teach mathematics to the fifth, sixth, seventh, and eighth graders in middle school. SMT students are trained to teach mathematics to the ninth, tenth, eleventh, and twelfth graders in high school. ST students are trained to teach science courses to the fifth, sixth, seventh, and eighth graders in middle school. All these pre-service teachers take three groups of courses during their education. These courses are general culture courses (such as history, language, computer skills, and several electives), teaching profession courses (such as classroom management, special education, assessment, and evaluation), and field courses. Field courses are specific to the program. In this context, several field courses which are taken by PMT students include analysis, geometry, algebra, and probability. Besides, SMT students take analysis, Euclidean geometry, probability, and differential equations. Also, ST students take physics, chemistry, biology, mathematics, astronomy, and geology.

The study sample was determined with the simple random sampling method. The surveys were implemented in the autumn term of the 2023–2024 academic year based on the voluntariness of the participants. Also, the ethical board permission was taken from the institution of the researchers and ethical considerations were followed in the study.

Data Collection Instruments

In the study, a Demographic Information Form was used to determine the gender, undergraduate program, and grade level of the pre-service teachers. In addition, the Mathematical Connection Self-Efficacy Scale was utilized to investigate the mathematical connection self-efficacy beliefs of the participants. This scale was developed by Özgen and Bindak (2018) and consists of 22 items, six of which are negative. The scale also has five sub-dimensions (SDs) as difficulty (SD1), using mathematics (SD2), connecting mathematics within itself (SD3), connecting mathematics with the real world (SD4), and connecting mathematics with different disciplines (SD5). The 5-point Likert-type scale was scored from 1 to 5 points for the responses never, rarely, sometimes, often, and always. A reverse coding was made for the negative items. The lowest score which can be obtained from the scale is 22, whereas the highest score is 110. Özgen and Bindak (2018) calculated the Cronbach alpha internal consistency reliability coefficient of the scale as .85 for the total scale and .76 for difficulty, .70 for using mathematics, .74 for connecting mathematics within itself, .66 for connecting with the real world, and .62 for connecting with different disciplines sub-dimensions.

Data Analysis

In the current study, data obtained from the participants were analyzed with the SPSS 20.0 package program. Firstly, data were analyzed descriptively. Then, normality analysis was performed to determine the tests to be used in the analysis. In this case, the Shapiro-Wilk test was used for the groups that were smaller than 50 individuals, and the Kolmogorov Smirnov (K-S) test was used for the groups larger than 50 (Büyüköztürk, 2023). All the analyses were conducted for $p = .05$ significance level. For comparisons, parametric tests (Independent Samples t-test and ANOVA) were used for normally distributed data sets. Non-parametric tests (Mann Whitney U test and Kruskal Wallis H test) were used for data sets that were not normally distributed.

In the normality analysis of the scores based on gender, the results of the K-S test were considered. It was seen that the total scores and the scores obtained from the sub-dimensions indicated distributions that differed significantly from normal distribution ($p < .05$). Hence, the Mann Whitney U-test was utilized to make comparisons on the scores about gender. In addition, similar analyses were also conducted for data sets obtained from males and females in each undergraduate program. As a result, due to the difference from a normal distribution ($p < .05$), male and female pre-service primary mathematics teachers' scores were compared with the Mann-Whitney-U test from non-parametric tests. On the other hand, for the data obtained from pre-service secondary mathematics and science teachers confirming normal distribution ($p > .05$), the comparisons were conducted with the Independent Samples t-test from parametric tests.

Second, the normality of the scores was examined based on the participants' undergraduate programs. The results of the K-S test indicated that the distributions of data obtained from pre-service primary mathematics teachers differed significantly from a normal distribution ($p < .05$). Accordingly, the Kruskal Wallis H test from non-parametric tests was used to compare the participants' scores based on the undergraduate program. When the analyses were conducted for sub-dimensions, it was found that data were not normally distributed for pre-service primary mathematics teachers, secondary mathematics teachers, and science teachers for the first dimension ($p < .05$). In the second dimension, pre-service primary mathematics and science teachers' scores were not normally distributed ($p < .05$). In the third, fourth, and fifth dimensions, all undergraduate program scores showed that they were not normally distributed ($p < .05$). Consequently, the Kruskal Wallis H test was used to make comparisons among the undergraduate programs in terms of the sub-dimensions as well as the total scale scores.

Third, the normality of pre-service teachers' mathematical connection self-efficacy belief scores was examined based on their grade level. According to the results, K-S tests of both the total score and the sub-dimension scores did not show a normal distribution for the participants ($p < .05$). Therefore, the Kruskal Wallis H test from non-parametric tests was used to compare the scores based on grade level. When data sets were investigated in each undergraduate program, the Kruskal Wallis H test from non-parametric tests was used to make comparisons among different grade levels' scores for pre-service primary mathematics teachers ($p < .05$). On the other hand, K-S tests indicated normal distributions for pre-service secondary mathematics and science teachers ($p > .05$). So, one-way analysis of variance (ANOVA), one of the parametric test techniques, was used to compare their scores based on the grade levels.

For the reliability analysis of this study, Cronbach's alpha internal consistency reliability coefficient was calculated as .90 for the total scale. For the sub-dimensions, Cronbach's alpha values were calculated as .79 for difficulty, .79 for using mathematics, .82 for connecting mathematics within itself, .78 for connecting with the real world, and .72 for connecting with different disciplines.

Results

In this section, the analysis results obtained from the pre-service teachers' mathematical connection self-efficacy beliefs are presented. Table 2 gives the descriptive statistical values obtained from preservice teachers for the total scale and its sub-dimensions.

Table 2

The Descriptive Statistics Regarding the Total Scale and Its Sub-Dimensions

Scale/SDs	n	$\bar{X}$	sd	min	max
Total Scale	434	82.4	9.9	46	110
SD1	434	22.6	3.5	7	30
SD2	434	18.0	2.9	5	25
SD3	434	19.4	2.8	5	25
SD4	434	11.2	1.8	3	15
SD5	434	11.2	1.9	3	15

According to Table 2, the total mean score of pre-service teachers' mathematical connection self-efficacy beliefs is 82.4 with a standard deviation of 9.9. While the minimum score was found to be 46, the maximum score was 110. Considering the mean score ($\bar{X}$ = 82.4), it can be stated that their mathematical connection self-efficacy beliefs are positive. Also, the means of the sub-dimensions varied between 11.2 and 22.6.

Results Regarding the Gender of the Participants

The first question of the research considers pre-service teachers' mathematical connection self-efficacy beliefs according to their gender. The analysis results obtained from Mann-Whitney U tests are presented in Table 3.

Table 3

Comparison of Pre-service Teachers' Mathematical Connection Self-Efficacy Beliefs According to Their Gender

Scale/SDs	Gender	n	Mean Rank	Sum of Ranks	U	p
Total Scale	FM	319	213.5	68097.5	17057.5	.26
	M	115	228.7	26297.5		
SD1	FM	319	218.1	69591.0	18134.0	.86
	M	115	215.7	24804.0		
SD2	FM	319	211.6	67502.0	16462.0	.10
	M	115	233.8	26893.0		
SD3	FM	319	215.6	68788.0	17748.0	.60
	M	115	222.7	25607.0		
SD4	FM	319	210.9	67267.5	16227.5	.06
	M	115	235.9	27127.5		
SD5	FM	319	212.4	67745.0	16705.0	.15
	M	115	231.7	26650.0		

According to Table 3, there was no significant difference among pre-service teachers regarding their gender both in the scores of the total scale (U = 17057.5, p = .26) and its sub-dimensions (SD1: U = 18134.0, p = .86; SD2: U = 16462.0, p = .10; SD3: U = 17748.0, p = .60; SD4: U = 16227.5, p = .06; SD5: U = 16705.0, p = .15). To examine the data in detail, the participants' mathematical connection self-efficacy belief scores were analyzed in terms of the gender variable in each undergraduate program. Accordingly, Mann-Whitney U test results obtained from pre-service primary mathematics teachers are displayed in Table 4.

Table 4

Comparison of Pre-Service Primary Mathematics Teachers' Total Mathematical Connection Self-Efficacy Beliefs According to Their Gender

Program	Gender	n	Mean Rank	Sum of Ranks	U	p
PMT	FM	157	102.6	16101.5	3698.5	.16
	M	54	116.0	6264.5		

Table 4 shows that there was no significant difference between male and female pre-service primary mathematics teachers considering their total mathematical connection self-efficacy belief scores (U = 3698.5, p = .16).

Table 5 shows the analysis results obtained from the comparison of the scores of pre-service secondary mathematics teachers based on their gender using the Independent Samples t-test.

Table 5

Comparison of Pre-Service Secondary Mathematics Teachers' Total Mathematical Connection Self-Efficacy Beliefs According to Their Gender

Program	Gender	n	$\bar{X}$	sd	df	t	p
SMT	FM	117	81.1	10.9	143	0.01	.99
	M	28	81.1	9.6			

The results in Table 5 show that there was no significant difference between male and female participants considering total scores among pre-service secondary mathematics teachers (t(143) = 0.01, p = .99).

Table 6 demonstrates the comparison of the scores of pre-service science teachers regarding their gender with the Independent Samples t-test.

Table 6

Comparison of Pre-Service Science Teachers' Total Mathematical Connection Self-Efficacy Beliefs According to Their Gender

Program	Gender	n	$\bar{X}$	sd	df	t	p
ST	FM	45	82.4	10.8	76	0.21	.83
	M	33	82.8	9.1			

As in the previous analysis results based on the gender variable, Table 6 demonstrates that there was no significant difference among male and female pre-service science teachers in terms of their total mathematical connection self-efficacy belief scores (t (76) = 0.21, p = .83).

Results Regarding the Undergraduate Program of the Participants

The second question of the research deals with the differentiation of pre-service teachers' mathematical connection self-efficacy beliefs obtained from the total scale and its sub-dimensions based on their undergraduate program. In this context, the results of the Kruskal Wallis H test are presented in Table 7.

Table 7

Comparison of Pre-Service Teachers' Mathematical Connection Self-Efficacy Beliefs According to Their Undergraduate Programs

Scale/SDs	Program	n	Mean Rank	df	χ^2	p
Total Scale	PMT	211	226.5	2	3.17	.20
	SMT	78	220.9			
	ST	145	202.6			
SD1	PMT	211	221.5	2	0.95	.62
	SMT	78	221.9			
	ST	145	209.3			
SD2	PMT	211	212.6	2	2.02	.36
	SMT	78	208.7			
	ST	145	229.3			
SD3	PMT	211	235.5			
	SMT	78	225.3			
	ST	145	187.1	2	13.53	.001*
SD4	PMT	211	226.7			
	SMT	78	229.4	2	5.71	.06
	ST	145	197.7			
SD5	PMT	211	237.3			
	SMT	78	221.1	2	13.53	.001*
	ST	145	186.8			

In Table 7, it is seen that there was no significant difference among pre-service teachers from three undergraduate programs considering their mathematical connection self-efficacy beliefs ($\chi2 = 3.17$, $p = .20$). Also, it is seen that there was no significant difference among the undergraduate programs in terms of the sub-dimensions of difficulty ($\chi2 = 0.95$, $p = .62$), using mathematics ($\chi2 = 2.02$, $p = .36$) and connecting mathematics with the real world ($\chi2 = 5.71$, $p = .06$). On the other hand, there was a significant difference among the undergraduate programs in terms of the sub-dimensions of connecting mathematics within itself ($\chi2 = 13.53$, $p = .001$), and connecting mathematics with different disciplines ($\chi2 = 13.53$, $p = .001$). Examining the mean ranks, it is seen that pre-service primary mathematics generally teachers possessed the highest scores, whereas pre-service science teachers possessed the lowest scores.

Results Regarding the Grade Level of the Participants

The third question of the research focuses on the differentiation of pre-service teachers' mathematical connection self-efficacy beliefs according to their grade level. In this respect, the results of the Kruskal Wallis H test are given in Table 8.

Table 8

Comparison of Pre-Service Teachers' Total Mathematical Connection Self-Efficacy Beliefs According to Their Grade Level

Grade Level	n	Mean Rank	df	χ2	p
1	120	199.5	3	15.06	.002*
2	113	208.1			
3	106	208.9			
4	95	261.0			

When Table 8 is examined, a significant difference was found among pre-service teachers' mathematical connection self-efficacy beliefs based on their grade levels ($\chi2 = 15.06$, $p = .002$). When the mean ranks are considered, the fourth graders had the highest scores, whereas the first graders had the lowest scores.

When the comparisons are conducted for each sub-dimension of the scale, the results obtained from the Kruskal Wallis H test are presented in Table 9.

Table 9

Comparison of Pre-Service Teachers' Sub-Dimensional Scores According to Their Grade Level

SDs	Grade Level	n	Mean Rank	df	χ^2	p
SD1	1	120	232.9	3	3.81	.28
	2	113	202.4			
	3	106	212.2			
	4	95	221.9			
SD2	1	120	202.9	3	19.17	.001*
	2	113	204.3			
	3	106	203.7			
	4	95	266.9			
SD3	1	120	197.7	3	10.00	.02*
	2	113	213.7			
	3	106	214.4			
	4	95	250.5			
SD4	1	120	186.4	3	26.37	.001*
	2	113	215.6			
	3	106	207.2			
	4	95	270.7			
SD5	1	120	200.6	3	10.63	.01*
	2	113	211.4			
	3	106	211.6			
	4	95	252.8			

According to Table 9, there was no significant difference in the mathematical connection self-efficacy beliefs of pre-service teachers among the grade levels only in the difficulty sub-dimension ($\chi 2 = 3.81$, $p = .28$). However, significant differences were found in the sub-dimensions of using mathematics ($\chi 2 = 19.17$, $p = .001$), connecting mathematics within itself ($\chi 2 = 10.00$, $p = .02$), connecting with the real-life ($\chi 2 = 26.37$, $p = .001$), and connecting with different disciplines ($\chi 2 = 10.63$, $p = .01$). Similar to the results obtained from the total scale, the fourth graders generally had the highest mean ranks in these sub-dimensions, whereas the lowest scores belonged to the first-year participants.

The scores of the pre-service teachers were also analyzed in detail based on each undergraduate program regarding their grade levels. Accordingly, the results of Kruskal Wallis H test indicated a significant difference in the total scores of pre-service primary mathematics teachers according to their grade levels ($\chi 2 = 14.13$, $p = .003$). Considering the mean ranks, the fourth graders had the highest scores (133.2) while the third graders had the lowest scores (89.5). Also, the first graders had a mean rank of 103.2 and the second graders had a mean rank of 99.8.

When the mathematical connection self-efficacy beliefs of pre-service secondary mathematics teachers were examined according to their grade level, the results of ANOVA indicated no significant difference in their total scores regarding their grade levels ($F(3, 74) = 0.61$, $p = .61$).

The results obtained from ANOVA for the comparison of mathematical connection self-efficacy beliefs of pre-service science teachers showed a significant difference according to their grade levels ($F(3, 141) = 2.99$, $p = .033$). That is, pre-service science teachers' total scores varied significantly according to their grade levels. The homogeneity of the variances was examined to find out which grade levels differed significantly. Due to the homogeneous distribution of the variances ($F(3, 141) = 1.33$, $p = .268$), the results of the Scheffe test were considered and a significant difference was determined between the first and the fourth grade ($p = .037$).

Discussion and Conclusions

In this study, the mathematical connection self-efficacy beliefs of pre-service teachers were investigated regarding different variables. Within this scope, responses obtained from 434 pre-service teachers to the mathematical connection self-efficacy scale were examined according to their gender, undergraduate program, and grade level, considering their total scores as well as the scores obtained from each sub-dimension of the scale. First, the study revealed no significant difference in the mathematical connection self-efficacy beliefs obtained from the whole scale in addition to the scores obtained from the sub-dimensions according to the gender variable. This result implies that male and female participants have similar beliefs. This is supported by the previous studies' findings regarding mathematical connection self-efficacy beliefs (Kaya, 2020; Yılmaz, 2022) and mathematical self-efficacy beliefs (İpek, 2019; Uzar, 2010). In addition, Siagian et al. (2022) revealed that gender variable was not effective in mathematical connection ability, but high learning motivation caused differentiation. However, the findings of several studies were in favor of male participants in this respect (Adal & Yavuz, 2017; Huang, 2013; Karaman & Çil, 2021). When the mean ranks are considered, the current study also showed that males had higher scores than females in the total scale and four sub-dimensions. Besides, females had higher scores in the sub-dimension of difficulty. Thus, female pre-service teachers' mathematical connection self-efficacy might be improved through their pre-service education.

Second, the study considered participants' mathematical connection self-efficacy beliefs regarding their undergraduate programs. The participants' total scores and three sub-dimensional scores (difficulty, using mathematics, connecting with the real world) did not differ significantly according to their undergraduate program. However, when the mean ranks are taken into consideration, the mean of pre-service science teachers in

the sub-dimension of using mathematics is higher than that of pre-service mathematics teachers. The fact that mathematical knowledge is not based on experimentation but can be verified by experimentation and is produced with the help of concepts within itself separates it from other sciences as a method. It does not benefit from other sciences in its own development but contributes to the development of all other sciences such as science (Altun, 2016). This difference reveals the importance of using mathematics and making mathematical connections in science teaching. While this situation was expected to be in favour of pre-service science teachers in the sub-dimension of connecting mathematics with different disciplines, the results of the current study show that there is a significant difference in favour of pre-service primary mathematics teachers. On the other hand, Karaman and Çil (2021) determined that primary mathematics teachers had higher mathematical connection self-efficacy than classroom teachers and experienced teachers had higher mathematical connection self-efficacy. In addition, the current study revealed significant differences among the undergraduate programs in terms of the sub-dimension of connecting mathematics within itself. When the mean ranks are considered, it is seen that pre-service primary mathematics teachers had the highest mathematical connection self-efficacy beliefs, whereas pre-service science teachers had the lowest beliefs. In the literature, Coşkun's (2013) study indicated that mathematics teachers can make more connections than classroom teachers. However, this emphasizes the need for improving pre-service science teachers' beliefs since they will utilize mathematics in their courses at the elementary level. Similarly, pre-service physics teachers were determined to experience difficulties in connecting their physics knowledge with mathematics (Başkan Takaoğlu, 2015). This result is important when the literature indicating low levels of mathematical connections among elementary students (Kenedi et al., 2019) and high school students (Rahmi et al., 2019; Trihatun & Jailani, 2019) are considered. The results are disappointing in terms of realising integrated learning. Whereas reforms have been noticed in the past in school mathematics and science teaching to encourage a more coherent organization of teaching, the current era brings to the fore the need for teacher educators to help both teachers and students not only to see the important connections between disciplines, but also to understand how one discipline can support the learning of another. In particular, it is important that teachers understand contexts that contain potentially important links between mathematics and science (Frykholm & Glasson, 2005). The results of Frykholm and Glasson's (2005) study showed that pre-service teachers' collaborative work together in the construction of interdisciplinary units that connect mathematics and science subjects increased their knowledge of the associations between mathematics and science. Hence, the results of the current study may be due to the lack of appropriate environments for pre-service mathematics and science teachers to work together.

Third, the study showed that there was a significant difference among the participants' beliefs regarding their grade levels. The highest beliefs belonged to the senior

students, whereas the lowest beliefs belonged to the junior students. This result can be evaluated as a positive reflection of the training that pre-service teachers receive in the faculty. Similar to the impact on the total scores, the scores obtained from four sub-dimensions (using mathematics, connecting mathematics within itself, connecting mathematics with the real world, and connecting mathematics with different disciplines) differed significantly regarding pre-service teachers' grade levels. Also, the highest scores belonged to the senior pre-service teachers, whereas the lowest scores belonged to the junior pre-service teachers. On the other hand, İpek (2019) determined that mathematical self-efficacy decreased as the grade level increased. Also, Yavuz Mumcu (2018) found that senior pre-service mathematics teachers had problems connecting the concept of derivative within mathematics. In addition, Jameson and Fusco (2014) showed that adult learners had lower mathematical self-efficacy. These results contradict the current study. However, the scores obtained from the sub-dimension of difficulty were similar among the grade levels. This result shows that beliefs regarding the difficulty of mathematics do not change significantly during university. The study of Uzar (2010) also revealed that there was no significant difference in mathematical self-efficacy according to grade level. On the other hand, although not obtaining a significant difference in the difficulty sub-dimension in the current study, the mean rank has the highest score in the first grade, then it decreases in the second grade and increases again in the third and fourth grades. This may be due to the lack of skills of pre-service teachers on how to include mathematical connections in their teaching with the increase in their field education courses as the level of education increases.

The detailed analyses indicated that pre-service secondary mathematics teachers had similar beliefs among grade levels. However, teacher candidates are expected to improve their mathematical connection skills during their pre-service education. So, as their mathematical connection skills increase, their mathematical self-efficacy also increases (Trihatun & Jailani 2019). For this reason, Demirci (2023) highlights the significance of using activities and mind mapping to increase individuals' mathematical connection self-efficacy. On the other hand, senior pre-service primary mathematics teachers had significantly higher beliefs than third-year students. Surprisingly, third-year students had the lowest beliefs. The reason for this is that the third graders receive several mathematics teaching courses such as algebra, statistics, teaching numbers, and geometry during their training (IoHE, 2018a). In their study, Zehir and Zehir (2016) concluded that mathematics literacy self-efficacy beliefs of pre-service primary mathematics teachers were higher in the senior level compared to the second grade. Eli et al. (2013) explain this situation as pre-service mathematics teachers view such courses as distinct fields, which causes difficulties in making mathematical connections. In addition, senior pre-service science teachers had significantly higher beliefs than junior pre-service teachers. This result reflects the positive effect of interdisciplinary science teaching courses given in the final year of the science teaching program (IoHE,

2018b). Thus, senior pre-service science teachers might have realized the importance of mathematics during their training.

To summarize, this study outlines the differences and similarities in terms of mathematical connection self-efficacy beliefs among three undergraduate programs. Mathematical connection self-efficacy beliefs are necessary for mathematics teachers. Also, science teachers require sufficient mathematics skills to teach effectively. When the means of the junior and senior pre-service teachers are considered, the differences in the scores imply the importance of training they receive in the faculty. On the other hand, differences among the undergraduate programs indicate a lower level of mathematical connection self-efficacy belief among pre-service science teachers. However, science is indicated as the most connected discipline with mathematics (Özgen, 2013). Considering this, more attention should be given to the improvement of the mathematical connection skills of science teachers during their pre-service education. In addition, an important issue in contemporary educational approaches such as STEM education and among 21st century skills is the ability to work together. Hence, to improve the mathematical connection skills of pre-service science teachers, instructional programs in which teachers or pre-service teachers from different branches will work together can be conducted. Thus, the change in mathematical connection self-efficacy beliefs of teachers and pre-service teachers can be evaluated. Besides, the differences shown in this study can be examined with qualitative research methods to obtain more detailed data. Also, the study might be carried out with different undergraduate programs to make more detailed comparisons. For example, pre-service classroom, physics, chemistry, and biology teachers might be included in the study sample. In addition, mathematical connection self-efficacy belief studies can be examined by including different variables, such as the cumulative grade points average of the participants. Thus, pre-service teacher training programs might be improved regarding mathematics skills.

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Būsimųjų mokytojų matematinių ryšių saviveiksmingumo kiekybinis tyrimas: Turkijos duomenys

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Santrauka

Šiuo tyrimu siekiama išnagrinėti būsimųjų mokytojų įsitikinimus apie matematinių ryšių saviveiksmingumą atsižvelgiant į skirtingus kintamuosius. Tuo tikslu naudojant apklausos metodą buvo atliktas tyrimas, kuriame dalyvavo 434 būsimieji mokytojai, studijuojantys Turkijos valstybinio universiteto pradinių ir vidurinių mokyklų matematikos ir gamtos mokslų mokymo programose. Duomenys buvo renkami naudojant demografinės informacijos formą ir matematinio ryšio saviveiksmingumo Özgen ir Bindak (2018) skalę. Šią skalę sudarė penkios subdimensijos (sunkumas, matematikos naudojimas, matematikos dalių susiejimas,

matematikos susiejimas su realiu pasauliu ir matematikos susiejimas su skirtingomis disciplinomis). Gauti duomenys buvo analizuojami naudojant SPSS 20.0 statistinę programą pagal lyties, bakalauro studijų programos ir pažymių lygių kintamuosius.

Remiantis gautais rezultatais, statistiškai reikšmingų saviveiksmingumo balų skirtumų tarp būsimų mokytojų lyties ir bakalauro studijų programos nenustatyta. Kita vertus, nustatytas statistiškai reikšmingas skirtumas pagal pažymių lygį. Be to, reikšmingų skirtumų nustatyta ir keturiose iš penkių skalės subdimensijų, pagrįstų šiuo kintamuoju. Atsižvelgiant į gautus rezultatus ir reikšmingus skirtumus, ypač dėl pažymių lygio priežastis, rekomenduojama nuodugniai atlikti tolesnius tyrimus taikant kokybinius metodus.

Esminiai žodžiai: *matematinis ryšys, saviveiksmingumas, mokytojai, matematika ir gamtamokslinis ugdymas.*

Gauta 2024 04 19 / Received 19 04 2024
Priimta 2024 06 28 / Accepted 28 06 2024