

Pre-service Teachers' Performance in their University Coursework and Mathematical Self-Efficacy Beliefs: What is the Role of Gender and Year in Program?

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This study investigates the effects of gender and year in program on the performance and mathematical self-efficacy beliefs of 145 pre-service mathematics teachers in Turkey. One of the main purposes of this study is to investigate how duration in a teacher education program influenced the performance and mathematical self-efficacy beliefs of pre-service teachers. In addition, gender differences between male and female pre-service mathematics teachers, depending upon year in program, are examined. Results revealed that there were significant statistical effects of gender and year in program on both pre-service teachers' performance and self-efficacy scores. Female pre-service teachers scored significantly higher than males on performance, but no significant difference was detected between female and male pre-service teachers with respect to mathematics self-efficacy scores. Senior pre-service teachers had the highest scores compared to other students in the program on both performance and mathematics self-efficacy scores. Although the present study is small, the results tentatively suggest a further investigation of the relationship between performance and self-efficacy beliefs might be fruitful. Studying how mathematical self-efficacy develops across school years and what factors facilitate its development could yield valuable implications for the field of mathematics education.

Self-efficacy has been defined as an individual's judgment of their capability to organize and execute the courses of action required to attain designated types of performances (Bandura, 1986, 1997). Social Cognitive theorists claimed that self-efficacy beliefs strongly influence the choices people make, the effort they expend, and the degree of anxiety they experience. Bandura (1977) pointed out that self-efficacy expectations are major determinants of whether a person will attempt a task, how much effort will be expended, and how much effort will be displayed in the face of obstacles. Similarly, Schunk (1989, 1991) reported that when students approach academic tasks, students with high self-efficacy work harder and for longer periods compared to students with a lower self-efficacy. The role of self-efficacy helps to explain why people's performance attainment might differ even when they have similar knowledge and skills (Pajares & Miller, 1995). Bandura (1986) has suggested that personal self-efficacy is derived from four sources: (a) performance accomplishment, (b) vicarious experience, (c) verbal persuasion, and (d) emotional arousal. According to Bandura, actual experience, especially past success and failure, is the most influential source of efficacy.

Although researchers have examined the role of self-efficacy in various academic areas, mathematics has been a main focus (Hackett, 1985; Hackett & Betz, 1989; Pajares & Miller, 1994, 1995). Hackett and Betz (1989) defined mathematics self-efficacy as a situational or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular mathematical task or problem. These researchers investigated the relationship among mathematical performance, mathematics self-efficacy, attitudes toward mathematics, and the choice of mathematics related majors by 153 college women and 109 college men enrolled in introductory psychology courses at a large Midwestern University. They reported that mathematics performance was correlated moderately with mathematics self-efficacy. Similarly, both mathematics performance and mathematics self-efficacy significantly and positively correlated with attitudes toward mathematics and mathematics related majors. Students with high scores on mathematics self-efficacy and mathematics performance tended to report lower levels of mathematics anxiety, higher levels of confidence, and a greater tendency to see mathematics as useful compared to those with low scores.

In another research study, Randhawa, Beamer and Lundberg (1993) who studied more than 225 high school students in Canada reported that mathematics self-efficacy was a mediator variable between mathematics attitudes and mathematics achievement.

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Similarly, Stevens, Olivarez, Lan and Runnels (2004) evaluated self-efficacy and motivational orientation of students to predict mathematics achievement, including mathematics performance and students' plans to take additional mathematics courses. They studied 358 students from the 9th and 10th grades and reported that there was a relationship between self-efficacy and prior mathematics knowledge. In addition, self-efficacy predicts motivational orientation and mathematics performance. Similarly, Pietsch, Walker, and Chapman (2003) investigated the relationships among self-concept, self-efficacy, and performance in mathematics among 416 high school students, and self-efficacy beliefs were identified as most highly correlated with performance.

Although there are studies related to the mathematics self-efficacy beliefs of high school students, there are few studies that focus on pre-service teachers. It is believed that there is a need to assess the self-efficacious characteristics of teachers and their mathematics competencies before they go into the real classrooms. Teachers' sense of self-efficacy affects the effort they put into teaching, the goals they set, and their level of inspiration (Ashton, 1985). Thus, the factors that affect the mathematics self-efficacy beliefs of pre-service teachers will be one of the important concerns of this study.

A second important concern of the study will be gender differences in mathematics, which has been one of the most important issues studied in mathematics education for many years. A number of empirical studies have shown that males tend to outperform females in measurement, proportionality, geometry, spatial geometry, analytic geometry, trigonometry, and application of mathematics (Battista, 1990; Fennema & Carpenter, 1981) while females have performed better than males in computation, set operation, and symbolic relation (Fennema, 1974). Furthermore, female students outperform male students on assessment of mathematical ability at the elementary and middle school levels, whereas male students outperform female students at the high school and college levels (Aiken, 1986-1987; Hyde, Fennema & Lamon, 1990; Maccoby & Jacklin, 1974). On the other hand, in recent years and in most of the countries, including the United States, studies suggest that female and male students perform at similar levels in mathematics. The closure of this gap between male and female performance has been experienced in many countries. Ma (2004) investigated gender differences in all 43 countries involved in Programme for International Student Assessment 2000 by using data from the

Organization for Economic Cooperation and Development (OECD). The results revealed consistent gender differences in favor of males in mathematics performance in most countries; however, he stated that these gender gaps in mathematics performance could be characterized as being universally small. In this sense, this study also aims to investigate whether these gender inequalities are still an issue in undergraduate programs in Turkey.

There is agreement that the relationship between gender and mathematics self-efficacy has not been explored as thoroughly as that between gender and math performance (Pajares & Miller, 1997). In their study with 327 eighth-grade students in a southern state of the USA, Pajares and Miller reported that females with low self-efficacy performed better than males with low self-efficacy, whereas males with higher self-efficacy performed better than females with high self-efficacy. Hackett and Betz (1981) mentioned that mathematics self-efficacy expectations of college males are stronger than those of college females, and, in a research study carried out with 262 undergraduate students enrolled in an introductory psychology course, males obtained significantly higher scores on mathematics self-efficacy scales. In comparison to females, males had a greater positive attitude toward mathematics, more confidence in their mathematics ability, and a greater tendency to view mathematics as more useful. Likewise, in a study with 350 undergraduates from a large public university, Pajares and Miller (1994) found that males reported higher mathematics self-efficacy than females, and females expressed higher levels of mathematics anxiety. Additionally, males had higher scores on the performance measure.

Contradictory to these findings, Cooper and Robinson (1991) reported no gender differences on mathematics self-efficacy, mathematics anxiety, and mathematics performance among undergraduates at a public mid-western university who selected mathematics oriented college majors. In another study, carried out by Schunk and Lilly (1984), the influence of performance on self-efficacy and attribution was investigated. Male and female students from grades 6 to 8 were asked to judge their self-efficacy for learning a novel mathematical task. Students were then provided with instruction and practice and received feedback. Although the females initially judged their self-efficacy as lower than the males, no gender difference was obtained at the end of the training.

As stated earlier, although there are studies that investigate the gender differences on mathematics

performance and mathematics self-efficacy at various grade levels, few studies focus on pre-service teachers. Having pre-service teachers with lower mathematics self-efficacy could affect their motivation, attitude, achievement, and even their future performance within the teaching profession. Thus, there is a need to assess pre-service male and female mathematics teachers' beliefs about their ability to perform specific mathematical competencies before they go into the classroom. In this respect, questions are raised whether gender and grade level are important factors that affect mathematics efficacy beliefs and performance of pre-service teachers during their university life. Thus, this study aims to examine how pre-service teachers' self-efficacy beliefs differ based on their year in the teacher education program and how gender differences affect these changes. Stated differently, this study aims to investigate the effect of gender and year in program on pre-service mathematics teachers' performance and mathematical self-efficacy in Turkey.

Method

Participants

Data was collected from 145 freshmen, sophomore, junior, and senior pre-service middle school mathematics teachers enrolled in an undergraduate program at a public university in Ankara, Turkey. Participants' age ranged from 18 to 24 and they were students within the Elementary Mathematics Teacher Education (ELE) Program in the department of education. Data were collected at the end of the spring semester of the 2003–2004 academic year. Participants of the study were asked whether they would voluntarily fill out a questionnaire. In total, 95 female and 50 male students participated in the study. The distribution of participants according to their year in the program is given in Table 1.

Table 1

Number of male and female students based on their year in university

Grade Level	F	M	Total
Freshmen	24	12	36
Sophomore	24	13	37
Junior	22	13	35
Senior	25	12	37
Total	95	50	145

Elementary Mathematics Teacher Education Program in Turkey

To be a university student in Turkey, senior high school students must pass the University Entrance Examination (UEE) administered by the Students Selection and Placement Center (ÖSYM) once a year. Based on their scores on the UEE, students are eligible to be students in the departments of universities in Turkey.

Participants of this study were pre-service elementary mathematics teachers in a four-year teacher education program in the department of education. Pre-service elementary mathematics teachers in a teacher education program plan to teach mathematics in middle schools (6th, 7th and 8th grades) and also in elementary schools (4th and 5th grades). In order to graduate from the Elementary Mathematics Education Program, pre-service teachers take mathematics and mathematics education courses, as well as Physics, Chemistry, English, Turkish, History, Statistics and courses from Educational Sciences. The mathematics and mathematics education courses taken by pre-service mathematics teachers include the courses offered by the Turkish Council of Higher

Table 2

Mathematics and mathematics education courses taken by pre-service mathematics teachers

Grade/ Courses	Mathematics Lessons	Mathematics Education Lessons
Freshman	Analysis (I, II), Abstract Mathematics, Geometry	School Experience I
Sophomore	Analysis (III, IV), Linear Algebra (I, II)	Curriculum Planning and Evaluation
Junior	Introduction to Algebra, Analytic Geometry, Statistics and Probability (I, II), Elementary Number Theory	Instructional Technology and Material Development, Special Teaching Methods I
Senior		Computer Assisted Instruction in Mathematics Education, School Experience II, Special Teaching Methods II, Evaluation of Subject Matter Course Books, Practice Teaching

Education (YÖK) as given in Table 2 (YÖK, 1998a, 1998b).

Instrument

In order to determine the self-efficacy scores of pre-service teachers with respect to mathematics, the Mathematics Self-Efficacy Scale (MSES) developed by Umay (2001) was used. MSES is a Likert scale, using a five-point scale ranging from “Always =5” to “Never =1.” The score on MSES ranged from 14 to 70. The scale consists of 14 items, and these items were grouped under three dimensions based on a factor analysis. Umay (2001) stated that the items loaded in first factor are related to the mathematics self-perception. Items like “I can easily help people around, related to their mathematical problems” and “I realized that I’m losing my self-confidence while studying mathematics” were included in the first category. The second category, behavioral realization in mathematical topics, includes items such as “I feel competent enough in mathematical problem solving” and “I feel that I’m doing something wrong while solving mathematical problems.” The last factor related to transferring mathematics into daily life skills consists of items similar to “I think that I can use mathematics effectively in my daily life” and “I think mathematically while planning my time/day.”

In order to measure the internal consistency (reliability) of the MSES, Cronbach’s alpha was calculated. The Cronbach’s alpha for MSES was calculated as .83 with 145 pre-service teachers that is considered to be high in most social science applications.

MSES was applied to the freshman, sophomore, junior and senior pre-service elementary mathematics teachers. The instructions specified that students’ answers were anonymous, no answer was right or wrong, and students were supposed to choose the one answer per item that best described his or her opinion about the item. Completing the questionnaire required 10–15 minutes and the questionnaire was administered to students during their class hour. A total of 145 students answered the questionnaire.

Student performance was measured by their Cumulative Grade Point Average (CGPA) on a 4.00 scale. Students’ total CGPA at the end of the second semester of 2003–2004 academic year was used as a variable of their performance in this study. In other words, in this study mathematics performance refers to the cumulative grade point average of pre-service teachers on both mathematics and mathematics education courses.

Results

The descriptive statistics related to year in program of male and female students with respect to performances and mathematics self-efficacy scores are summarized in Table 3. Means, standard deviations, and sample size (N) are displayed for each dependent variable.

Multivariate Analysis of Variance (MANOVA) was conducted to determine the effect of gender and year in program on pre-service teachers’ performance and mathematics self-efficacy. In order to detect the

Table 3.

Descriptive Statistics for male and female students with respect to self-efficacy scores and performance

	Year	N	Mean			Std. Dev.		
			Male	Female	Total	Male	Female	Total
Performance	1	36	39.5	45.0	43.2	9.4	9.8	9.9
	2	37	47.8	52.0	50.2	8.1	11.6	10.6
	3	35	46.3	51.1	49.3	7.2	7.2	7.5
	4	37	56.1	57.6	57.1	5.9	6.8	6.5
MSES	1	36	47.7	50.0	49.1	8.8	11.5	10.6
	2	37	52.4	47.0	48.6	11.5	9.1	10.2
	3	35	45.4	49.5	48.0	9.5	8.6	9.0
	4	37	52.0	55.1	54.1	11.5	7.9	9.2

significance in MANOVA, we were interested in Wilks' Lambda and the associated probability value.

The results revealed that there was a statistically significant effect for both gender and year in program on pre-service teachers' performance and self-efficacy scores (Wilks' Lambda (λ) = 0.729, $F(6, 272) = 7.75$, $p < .05$). Multivariate test results showed that there was a significant mean difference on teachers' performance and their self-efficacy scores with respect to both gender $F(2, 136) = 3.3$, $p < .05$ and year in program $F(6, 272) = 7.8$, $p < .05$. Univariate Analysis of Variances (ANOVA) on each dependent variable was conducted as a follow-up test to the MANOVA to reveal the effect of each independent variable on each dependent variable separately. The results showed that there was a significant effect of both gender ($p < .05$) and year in program ($p < .05$) on performance. In order to assess the importance of the findings, effect size, which indicates the relative magnitude of the differences between means, was calculated. Effect size is the "amount of the total variance in the dependent variable that is predictable from knowledge of the levels of the independent variable" (Tabachnick & Fidell, 1996, p.53). Eta Square (η^2), the commonly used effect size statistic, revealed that 25% of variance in performance was explained by year in program, and 5% by gender.

Since the overall F test was significant, follow-up tests were conducted to evaluate mean differences among grade levels in program. After carrying out the univariate analysis that showed there was a significant effect of both gender and year in program on performance, Bonferroni post hoc analysis was carried out to reveal the significant mean differences between grade levels on pre-service teachers' performances. The results are given in Table 4.

Table 4

Mean difference of GPAs with respect to year in program

DV	Grade (I)	Grade (J)	Mean Difference (I-J)
GPA	4	1	14.0*
		2	6.9*
		3	7.8*
		3	6.1*
GPA	2	1	-0.9
		1	7.1*

* indicates the mean difference is significant at the .05 level

Bonferroni post hoc tests revealed there was a significant mean difference between senior and junior

pre-service teachers ($p < .05$), between senior and sophomore pre-service teachers ($p < .05$), and between senior and freshman pre-service teachers ($p < .05$) respectively, where senior students had the highest performance scores and freshman had the lowest. Although sophomores scored higher, no significant mean difference between sophomore and junior students ($p > .05$) with respect to performance was found. On the other hand, there was a significant mean difference between juniors and freshmen ($p < .05$) and between sophomores and freshman pre-service teachers ($p < .05$) with respect to performance.

In Figure 1, the relationship between gender, year in program, and the gender and year in program interaction on performance is given. From the graph, it can be seen that female pre-service teachers had higher scores compared to males at each year in program. With respect to performance, senior pre-service teachers had the highest scores, and the mean difference between male and female seniors was smaller than in other grades. Gender differences were greater in freshmen and junior students compared to sophomore and senior students. Additionally from Figure 1, we can discuss the relationship between gender and year in program on performance.

From figure 1, we can conclude that there was no significant gender and year in program interaction on performance. In other words, the effect of gender did not depend on the year in program and females scored higher than males at each year in program.

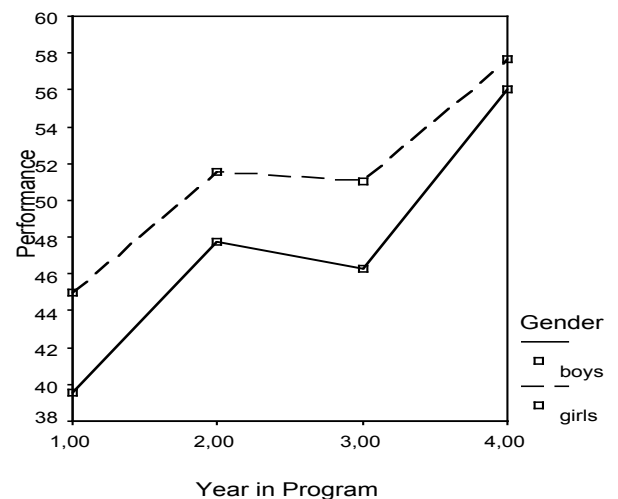


Figure 1. The relationship between gender, year in program and performance

Contradictory to these results, findings in terms of self-efficacy scores revealed that there was no significant effect of gender ($p > .05$) and year in program ($p > .05$) on mathematics self-efficacy scores. Eta Square (η^2)

revealed that gender explained 0.2%, and year in program explained 5% of the self-efficacy scores. In Figure 2, the relationship between gender, year in program, and self-efficacy is given.

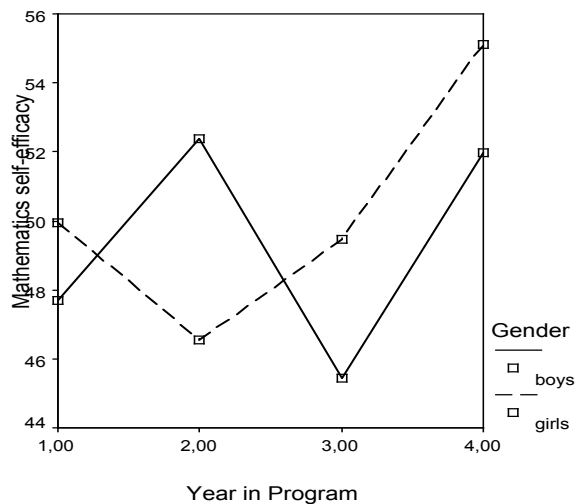


Figure 2. The relationship between gender, year in program and mathematics self-efficacy

From Figure 2, similar to performance, senior pre-service teachers' self-efficacy scores were the highest and junior pre-service teachers' were the lowest compared to other grades. Freshman, junior, and senior females had higher scores compared to their male counterparts with respect to self-efficacy scores. However, sophomore males outperformed females with respect to self-efficacy scores. Results revealed that although there are gender differences between male and female pre-service teachers on their self-efficacy scores, these differences were not significant among grade levels. Furthermore, gender and year in program interaction was not significant with respect to self-efficacy scores, which implies the effect of gender did not depend on the grade level of students with respect to their mathematics self-efficacy scores.

To sum up the findings, we can say that senior pre-service teachers have the highest scores compared to other grades on both performance and mathematics self-efficacy. The difference between seniors and other grades is significant in terms of their performance. On the other hand, this difference is not significant with respect to self-efficacy scores. Results obtained in terms of gender differences were also similar, females outperformed males on both performance and self-efficacy scores except for the sophomores where males achieved higher scores than females on mathematics self-efficacy. Again, gender difference is significant in

terms of performance, but is not significant in terms of mathematics self-efficacy scores.

Discussion

In this study, the overall test scores revealed that there was a significant effect of both gender and year in program on pre-service elementary mathematics teachers' performance and mathematics self-efficacy scores.

The fact that female pre-service teachers outperformed males on performance scores contradicts earlier studies that found male students outperformed female students at the high school and college levels (Aiken, 1986–1987; Hyde, Fennema & Lamon, 1990; Maccoby & Jacklin, 1974). Similarly, females' higher self-efficacy scores were not consistent with the results that revealed a significant difference between male and female students on mathematics self-efficacy scores in favor of males (Betz & Hackett, 1983; Pajares & Miller, 1994).

In meta-analysis carried out by Hyde, Fennema, Ryan, et al., (1990) it was mentioned that gender differences in most aspects of mathematics attitude and affect were small. Although male students outperformed females on mathematics self-confidence, the difference was not significant. Similarly, Hyde, Fennema, and Lamon (1990) explained that gender differences in mathematics performance for all ages indicates only a slightly better performance by males. Ma (2004) found that these gender gaps in mathematics performance could be characterized as being universally small. In the present study, the higher performance and self efficacy scores of females may be attributed to the strong correlation between the two constructs (Hacket & Betz, 1989; Randhawa et al., 1993; Stevents et al., 2004). Females' higher competence in math related tasks could lead them to achieve higher scores on their performances or vice versa.

Similarly, the fact that female students significantly outperformed males on their performance measured by overall GPAs may be due to the cultural factors affecting attitudes of students toward mathematics and the teaching profession. In Turkey, similar to most countries, teaching is stereotypically seen as a female profession, especially at elementary and middle grade levels. The majority of mathematics and science teachers working in elementary and middle schools are female. Males, who more often have science or math majors, mostly prefer to work in secondary schools. After graduation from the program, pre-service teachers work in middle schools which

could be an important factor on increasing motivation and efficacy-beliefs of female pre-service teachers' to spend more time on their courses and achieve higher scores. In this study, results also revealed that there was no significant gender and year in program interaction on performance, which means that the effect of gender did not depend on the year in program. Regardless of the year in program, females scored higher than males with respect to performance. Similarly, in order to see whether the differences on self-efficacy scores among the year in program vary as a function of gender, we can discuss the gender and year in program interaction with respect to self-efficacy scores. Results also showed that this interaction was not significant. As in performance, the effect of gender did not depend on year in program. Thus, it can be concluded that cultural factors such as accepting teaching as a female profession and other constructs have positive effects for females. Female pre-service teachers outperformed their male partners throughout their university education with respect to performance and mathematics self-efficacy.

Geary (1996) differentiated between two sets of mathematical abilities, that he called them biologically primary and biologically secondary. Geary mentioned that both females and males have an innate set of biologically primary mathematical abilities such as numerosity, ordinality, counting, and simple arithmetic, which are numerical abilities, which is why no difference exists between young males and females. Contrary to the biologically primary abilities, secondary mathematical abilities arise only through interaction with the specific sociocultural practices. Such mathematical abilities include more complex and abstract domains of mathematics like algebra, geometry, and calculus. Geary stated that if there is no gender difference between males and females, there might be certain socio-cultural practices that influence the development of cognitive and affective systems supporting the biologically secondary mathematical abilities in males and females alike. In this study, since female students significantly outperformed male students, one possible explanation might be that socio-cultural practices discussed above might enhance the development of secondary mathematical abilities in females more than in males, supporting Geary's view.

In addition to the gender differences, the results also revealed the significant effect of year in program on performance on pre-service mathematics teachers. Senior pre-service teachers scored significantly higher than junior, sophomore, and freshman students with respect to mathematics performance. Freshmen

students' lower grades may be attributed to their struggle to adapt to the program and university life after high school. Freshmen students in the program must take mathematics courses such as analysis, discrete mathematics, and other science classes with which they are not familiar. Similarly, senior students' higher scores on performance may be attributed to their adaptation to the university life and to the program.

A number of mathematics classes offered by the program can be another source for senior pre-service teachers higher scores on performance compared to the other grades. As given in Table 2, senior students have no math or science classes in their final years if they have successfully completed their courses in previous years. Thus, students might feel more competent in their education courses compared to their mathematics courses. Attitude towards education courses, peer learning, career choice, or the idea that they will graduate soon, could also affect the performance of senior students by increasing their motivation and confidence, resulting in higher performance.

In terms of the self-efficacy scores, senior students again achieved the highest scores, where scores of students in other years in the program were similar to each other. Umay (2001) believed that the four sources from which self-efficacy derives (Bandura, 1977, 1997) are related to the content and application of mathematics and mathematics education courses. In other words, the mathematics self-efficacy beliefs of pre-service mathematics teachers' stem from their competence in mathematics and also from their success in relation to the educational practices they are experiencing. Consequently, when we talk about the mathematics self-efficacy of pre-service teachers we should consider all the experiences throughout their program, including their work in mathematics and education courses. In this area, this study did make a connection between the performance and self-efficacy scores of pre-service elementary teachers. Senior students who had the highest performance also had the highest self-efficacy scores. Thus, a strong relationship between performance and self-efficacy scores can be deduced from these findings. Senior students' greater mathematics self-efficacy beliefs or other affect variables like motivation, competence, and attitude might directly affect their performances or vice versa. Furthermore, Umay (2001) stated that education faculties in Turkey have been reconstructed and the teacher-training system has been standardized to follow one model throughout Turkey. In her study, she examined the perceived mathematics self-efficacy of the freshman and senior students in the division of

mathematics teaching. She found that there was a significant difference in terms of senior students with respect to mathematics self-efficacy. My results also support these findings where, although results are not significant, mathematics self-efficacy scores of senior students were higher than those of freshman students, which indicate that pre-service education programs can have an effect on the efficacy beliefs of students during their university education pre-service.

This study reveals that there is a statistically significant effect of gender and year in program on both pre-service teachers' performance and self-efficacy scores. Senior pre-service teachers have the highest scores compared to the other lower graders and females outperformed the males at each year in program with respect to both performance and mathematics self-efficacy. In light of these findings, we can conclude that studies should be carried out with different grade levels to gain deeper insight into the cultural factors, attitudes, and affective variables that could create gender differences related to mathematics performance and mathematics self-efficacy. Further in-depth research studies should be carried out to explore how cultural factors, prerequisite knowledge and demographic characters can influence the development of self-efficacy beliefs of both pre-service and in-service teachers. In addition, how these variables relate and affect the instructional practices of teachers is warranted and essential. Investigating the reasons that can create differences among constructs including performance, self-efficacy beliefs, motivation, etc., studying how mathematics self-efficacy develops across the school years, and what factors facilitate its development could yield valuable implications for the educational field.

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