

Full Length Research Paper

Mathematics teaching anxiety and self-efficacy beliefs toward mathematics teaching: A path analysis

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The purpose of this study was to investigate the relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs toward mathematics teaching through path analysis. There were a total of 250 pre-service primary school teachers involved in this study. Of the total, 202 were female and 48 were male pre-service primary school teachers. To collect the data, the researcher employed two types of instruments: the mathematics teaching anxiety scale and self-efficacy beliefs toward mathematics teaching scale. For data analysis, Linear Structural Relationship (LISREL) program was used. In the analysis of the data, the researcher used path analyze technique in order to explain the relations. The study revealed that the content knowledge dimension of mathematics teaching anxiety had a negative effect on the efficacy in teaching, motivation and taking on responsibility and effective teaching dimensions of self-efficacy beliefs toward mathematic teaching. Similarly, self-confidence dimension of mathematics teaching anxiety affected the efficacy in teaching and effective teaching dimensions of self-efficacy beliefs toward mathematic teaching negatively. And also, the teaching knowledge dimension of mathematics teaching anxiety had a negative effect on the effective teaching dimension of self-efficacy beliefs toward mathematics teaching.

Key words: Mathematics, teaching anxiety, self-efficacy belief, mathematics teaching.

INTRODUCTION

Self-efficacy can be defined as the beliefs of individuals on their capabilities to perform certain specific aims (Bandura, 1997). The theoreticians of social cognitive approach define self-efficacy as the belief of individuals on their capacities in order to carry out and organize the activities which are necessary to fulfill a task (Bandura, 1997; Pajares and Kranzler, 1995). Therefore, the evaluation of self-efficacy refers to the difficulty levels which individuals believe to overcome (Bandura, 2006).

The self-confidence of students on their capabilities helps them shape what they can do with their knowledge and skills. In other words, self-efficacy belief is the belief of individuals on the dichotomy of "I can do" or "I cannot do".

Another significant belief in the cognitive psychology is anxiety. The mathematics anxiety was defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic

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situations” (Richardson and Suinn, 1972). Due to the significance of self-efficacy beliefs and mathematics anxiety, the researchers scrutinized these two concepts in many studies (Cooper and Robinson, 1991; Kathleen, 2008; Pajares and Kranzler, 1995).

However, since limited research exists regarding the relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs toward mathematics teaching, the present study attempted to bridge the gap. By examining the issue, the relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs is expected to contribute to the teacher training programs at universities.

REVIEW OF LITERATURE

According to Bandura (1986), the origins of self-efficacy are the past performances, vicarious experiences, verbal persuasion and physiological states. In a similar way, Wood and Bandura (1989) reviewed the origins of individuals' self-efficacy beliefs under four main themes:

1. Mastery experiences: The most effective way for individuals to develop a powerful efficacy feeling is through mastery experiences. While performance achievement strengthens self-beliefs, failure creates the lack of self-confidence. However, if individuals gain success just in an easy way, they want to have its consequences immediately and become discouraged in the case of any failure. For the attainment of a burgeoning efficacy belief, individuals should have experiences which they overcome with perseverance. The difficulties and obstacles in people's lives serve for a beneficial aim in the instruction process which requires perpetual effort. After individuals gain the confidence on their capacities through their recursive achievements, they are able to overcome the difficulties and failures which affect them negatively.

2. Modelling: The second way to gain robust self beliefs is modeling process. To manage a variety of challenges, proficient models help individuals believe the efficacy of their capacities through the exercise of effective strategies. Modelling has also an effect on self-efficacy beliefs through social comparison. Individuals usually come to conclusion on their own capacities by comparing their capacities with the others'. Usher and Pajares (2009) call this source as vicarious experiences. According to them, individuals form their self-efficacy beliefs by comparing others through vicarious experiences. Since there are no absolute measures of proficiency, individuals can measure comparing their capabilities with the performances of others. Thus, students can both evaluate their own academic capabilities and compare themselves

with classmates, peers and adolescents.

3. Social persuasion: Social persuasion is the third way to increase the self-efficacy beliefs related to the capabilities individuals have to overcome their aims. Providing that individuals receive real support, they show much more effort to alleviate their anxiety which stems from their lack of self-confidence, and they become more successful. However, they can be captivated by the sense of failure which has a negative effect on personal competency perceptions if their beliefs on personal competencies increase in a nonrealistic way. The factors which motivate success and develop efficacy feeling build up much more positive effect than predicted. To ensure progress in personal development, success should be measured in terms of self-development rather than other aspects.

4. Physiological states: While evaluating the capabilities of individuals, it is of importance to consider the judgments of individuals related to their psychological states. Individuals attribute their poor performances to emotional excitement and tension. Individuals also attribute their poor performances in the activities that requires strength and endurance to their pain, ache and exhaustion.

Similarly, the sources of Middle School Mathematics Self-Efficacy are categorized under four factors; mastery experience, vicarious experience, social persuasions and physiological state (Usher and Pajares, 2009). Self-efficacy belief is considered to be one of the most important factors in the affective domain of mathematics teaching (Dede, 2008). According to Pajares and Kranzler (1995), self-efficacy beliefs are the self-judgments of individuals related to the beliefs on their capacities to carry out and organize necessary activities which are essential to get accomplishment.

Pajares and Kranzler (1995) describe mathematics self-efficacy as the belief of an individual on his/her own capabilities to perform mathematics tasks successfully. Different studies on mathematics self-efficacy can be found in the literature. For instance, these studies were on the effect of general mental ability, gender and high school math level on mathematics self-efficacy (Pajares and Kranzler, 1995), the effect of mathematics self-efficacy on mathematics anxiety and mathematics performance (Cooper and Robinson, 1991; Hoffman, 2010; Jain and Dowson, 2009; Pajares and Kranzler, 1995), the role of self-efficacy beliefs in the mathematical problem-solving of gifted students (Pajares, 1996), the effect of gender on self-efficacy (Avcı, 2012), the effect of gender on mathematics self-efficacy (Hall and Ponton, 2005), the effect of mathematics self-efficacy on mathematics teaching anxiety (Ural, 2015), and so on. However, there could not be found any study which

examines the relationship between self-efficacy belief toward mathematics teaching and anxiety toward mathematics teaching in the literature.

Mathematics teaching anxiety can be defined as the tension or anxiety feeling which teachers or pre-service teachers experience in the instruction of mathematical concepts, theorems, formulas or problem-solving approach, briefly in the teaching of mathematics (Peker, 2006). Recently, many studies have been carried out on the anxiety toward mathematics teaching (Alkhateeb, 2014; Ertekin, 2010; Ertekin et al., 2010; Peker, 2006, 2009a, 2009b, 2009c, 2015; Peker and Ertekin, 2011; Sağlam, 2014; Yazıcı et al., 2011; Ural, 2015). For instance, Peker (2008) found that the teaching anxiety of pre-service teachers increases as long as the need of student group for concretization rises. Similarly, Sağlam (2014) and Alkhateeb (2014) stated that the anxiety levels of pre-service teachers lessen as their grades further. Peker (2009a) that expanded microteaching practices have an effect on the reduction of the mathematics teaching anxiety of pre-service teachers. Peker (2009b) pointed out that teaching problem-solving strategies have an effect to decrease the teaching anxiety of pre-service teachers. Peker (2009c) argued that teaching anxiety differ by the learning styles of pre-service teachers.

Peker and Ertekin (2011) asserted a moderate positive relationship between mathematics anxiety and mathematics teaching anxiety of pre-service teachers. Ünlü and Ertekin (2013) pointed out there is a moderate positive relationship between self-efficacy beliefs of pre-service teachers toward mathematics teaching and their mathematics self-efficacy beliefs.

In another study, Ertekin (2010) found a very low relationship between the mathematical beliefs of pre-service teachers and their mathematics teaching anxiety. Ural (2015) found a moderate negative relationship between self-efficacy perceptions of pre-service teachers and their anxiety levels toward mathematics teaching. Lastly, Peker (2015) made out that there is a moderate negative relationship between self-efficacy beliefs of pre-service teachers toward mathematics teaching and their anxiety levels toward mathematics teaching. In the study of Peker (2015), the correlation analyses were conducted through statistical package for the social sciences (SPSS) package software.

As can be understood from the review of literature, the previous studies examined the relationship between self-efficacy and math anxiety simply. Also, it is clear that there is a dearth of studies studying on the relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs toward mathematics teaching. Therefore, in the current study, a path analysis was carried out to examine this relationship following the results of the correlation analyses. Thus, more concrete results were expected to

be produced on the relationship among the variables.

The purpose and importance of the study

This study aims to examine the relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs toward mathematics teaching, and instead of giving the relationship in terms of a basic correlation analysis, the study aims to delineate the direction and effect size of the relationship with a Path analysis. In line with the aim of the study, the following research question was posed:

1. What is the direction and effect size of the relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs toward mathematics teaching?

METHODOLOGY

Research design

This study is an associational research which is a descriptive research methodology and attempts to describe the relations among variables. Associational research studies help researchers understand phenomenon thoroughly, and the primary examples of the associational research are correlational and causal comparative methodologies (Fraenkel and Wallen, 2009). Following the principles of the associational research, the relationship between the anxiety toward mathematics teaching and self-efficacy belief toward mathematics teaching was examined. Then, the effect of the anxiety toward mathematics teaching on the self-efficacy beliefs toward mathematics teaching was illustrated through Path diagrams to understand the direction and effect size of the variables.

Participants

The study group was comprised of 250 primary school pre-service teachers who studied in a city of Aegean Region of Turkey. The participants passed the courses such as basic mathematics, mathematics teaching, and teaching practice, and became ready to teach at schools. Of the participants, 19.2% was male and 80.8% was female. The participation to the study was on a voluntary basis.

Instruments

In this research, Mathematics Teaching Anxiety Scale (MATAS), which was developed by Peker (2006), was used. The second scales used in the study was Self-Efficacy Beliefs toward Mathematics Teaching Scale (SEBMTS), which was originally developed by Riggs and Enochs in 1990 with the name of STEBI (Science Teaching Efficacy Belief Instrument) and adapted by Dede (2008).

Mathematics teaching anxiety scale

The mathematics teaching anxiety scale is a five-point Liker-type

Table 1. Descriptive statistics for mathematics teaching anxiety scale and self-efficacy beliefs toward mathematics teaching scale (N = 250).

Scales	Sub-dimensions	Mean	SD
Mathematics teaching anxiety scale	Content knowledge	2.078	0.714
	Self-confidence	2.347	0.666
	Attitude toward mathematics teaching	2.025	0.670
	Teaching knowledge	1.969	0.682
Self-efficacy beliefs toward mathematics teaching scale	Efficacy in teaching	3.593	0.651
	Motivation and taking on responsibility	3.741	0.714
	Effective teaching	3.949	0.537

scale with 23 positive and negative items. Peker (2006) made a factor analysis that revealed four factors, *content knowledge* – 10 items (factor loading ranging from 0.53 to 0.86), *self-confidence* – 6 items (factor loading ranging from 0.57 to 0.76), *attitude toward mathematics teaching* – 4 items (factor loading ranging from 0.61 to 0.70), and *teaching knowledge* – 3 items (factor loading ranging from 0.68 to 0.78). The reliability estimates of the MATAS obtained by using Cronbach's alpha measure for the total scale were 0.91, and for the each subscales were; 0.90 (*content knowledge*), 0.83 (*self-confidence*), 0.71 (*attitude toward mathematics teaching*), and 0.61 (*teaching knowledge*), respectively. In this study, the researcher made confirmatory factor analysis that revealed four factors, *content knowledge* – 10 items (factor loading ranging from 0.55 to 0.78), *self-confidence* – 6 items (factor loading ranging from 0.59 to 0.69), *attitude toward mathematics teaching* – 4 items (factor loading ranging from 0.58 to 0.69), and *teaching knowledge* – 3 items (factor loading ranging from 0.59 to 0.71). The reliability estimates of the MATAS were obtained by using Cronbach's alpha measure for the total scale was 0.93, and for the each subscales were; 0.92 (*content knowledge*), 0.86 (*self-confidence*), 0.88 (*attitude toward mathematics teaching*), and 0.87 (*teaching knowledge*), respectively.

Self-Efficacy beliefs toward mathematics teaching scale

The self-efficacy beliefs toward mathematics teaching scale is a five-point Likert-type scale with 14 positive and negative items. Self-Efficacy Beliefs toward Mathematics Teaching Scale was originally developed by Riggs and Enochs in 1990 with the name of STEBI (Science Teaching Efficacy Belief Instrument) and adapted by Dede (2008). Dede (2008) made a factor analysis that revealed three factors, *efficacy in teaching* – 4 items (factor loading ranging from 0.58 to 0.78), *motivation and taking on responsibility* – 6 items (factor loading ranging from 0.46 to 0.76) and *effective teaching* – 4 items (factor loading ranging from 0.45 to 0.76). The reliability estimate of the SEBMTS obtained by using Cronbach's alpha measure for the total scale was 0.80 by Dede (2008). In this study, the researcher made confirmatory factor analysis that revealed three factors, *efficacy in teaching* – 4 items (factor loading ranging from 0.30 to 0.64), *motivation and taking on responsibility* – 4 items (factor loading ranging from 0.27 to 0.77) and *effective teaching* – 4 items (factor loading ranging from 0.24 to 0.46). As the factor loadings of the two items in *motivation and taking on responsibility* subfactor were lower than 0.20, they were ignored in the current study. The reliability estimates of the SEBMTS obtained by using Cronbach's alpha measure for the total scale was 0.76, and for the each subscales were; 0.52 (*efficacy in teaching*), 0.60 (*motivation and taking on responsibility*), and 0.47 (*effective teaching*)

respectively.

Process

To analyze the data, SPSS and LISREL package softwares were used. The descriptive statistics of the variables and correlation analysis were conducted through SPSS. The model which examines the effect of mathematics teaching anxiety on self-efficacy belief toward mathematics teaching was tested through LISREL (Linear Structural Relationship). Firstly, correlation analysis was used in order to determine the relationship between mathematics teaching anxiety and self-efficacy beliefs toward mathematics teaching. After that, for data analysis, LISREL (Linear Structural Relationship) program was used. The structural equation models help researchers to assess and modify their models and to make use of the model to develop their theories (Anderson and Gerbing, 1988). One of the types of the structural equation model is path analysis known as causal modeling, and the path analysis aims to analyze the relationships between observed variables (Bayram, 2010). Therefore, in the analysis of the data, the researcher used Path analysis technique in order to explain the relations.

RESULTS

The results of this study were given in this section. The arithmetic mean and standard deviation values for the subfactors of Mathematics Teaching Anxiety Scale and Self-Efficacy Beliefs toward Mathematics Scale were presented in Table 1.

According to Table 1, the anxiety which stems from teaching knowledge was the lowest one (M = 1.969, SD = 0.682), and the anxiety related to self-confidence was the highest one (M = 2.347, SD = 0.666) in terms of mathematics teaching anxiety of primary school pre-service teachers. Considering the self-efficacy beliefs of primary school pre-service teachers toward mathematics teaching, efficacy in teaching had the lowest mean (M = 3.593, SD = 0.651), and effective teaching had the highest mean (M = 3.949, SD = 0.537).

The path diagram was given in Figure 1 to show the effect of the subfactors of the anxiety toward mathematics teaching on the subfactors of mathematics teaching self-efficacy beliefs. The path analysis was conducted to

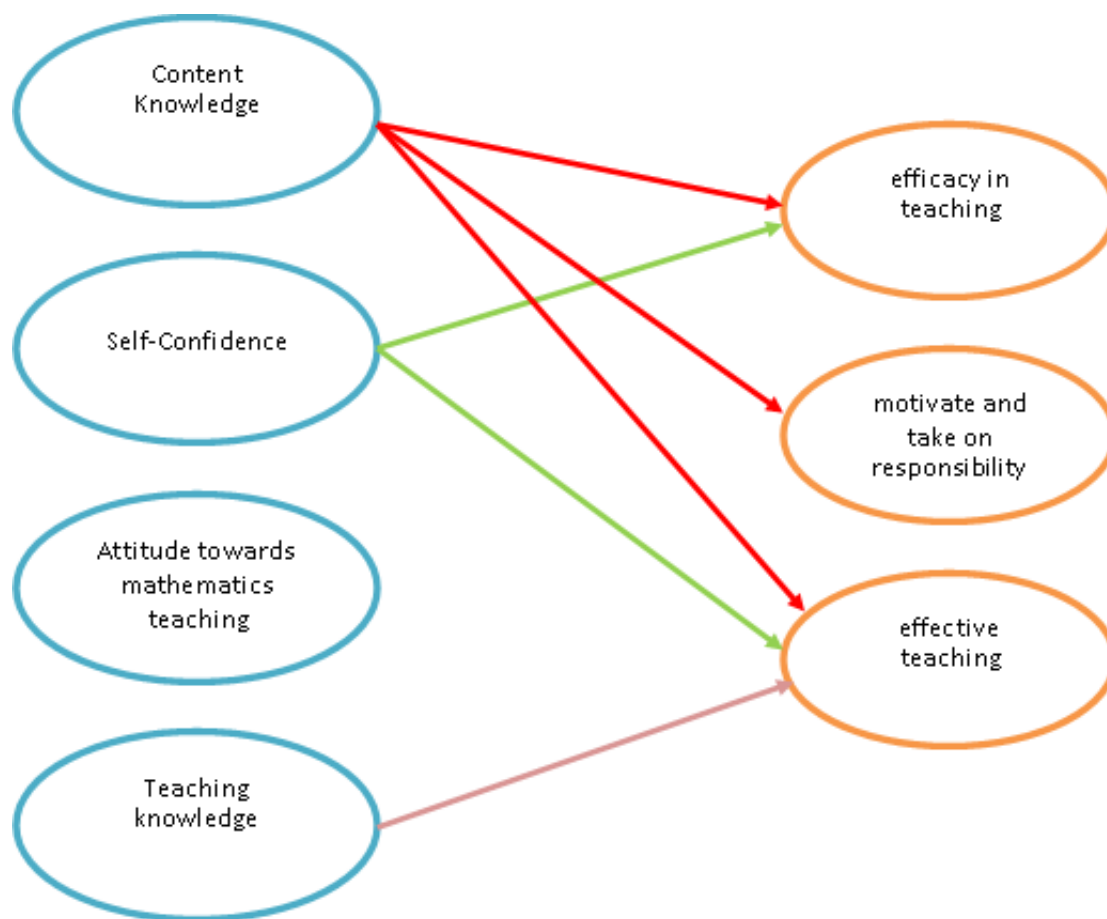


Figure 1. Path diagram related to mathematics teaching anxiety and self-efficacy beliefs toward mathematics teaching.

determine how and at which level the anxiety levels of pre-service primary school teachers towards mathematics teaching affect self-efficacy beliefs.

In Figure 2, you can see the results of Path Analysis related to mathematics teaching anxiety and mathematics teaching self-efficacy belief. The goodness of fit for the results of path analysis in Figure 2 was examined, and the chi-square values were found to be significant ($X^2 = 1264.15$, $df = 548$, $p < 0.01$). The ratio between the chi-square value and the degree of freedom was found to be $X^2 / df = 2.31$, and Çokluk, Şekercioğlu, and Büyüköztürk (2010) consider the model congruent with real values. Among the good of fitness indices, Root Mean Square Error of Approximation (RMSEA) was 0.075, and Standardized Root Mean square Residual (SRMR) was 0.074. As the values were less than 0.08, they indicated a good fit. The values for other goodness of fit indices such as Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) were found to be 0.77 and 0.73 respectively. Also, Comparative Fit Index (CFI) was 0.96, and it indicated a perfect fit with a larger value than

0.95. These values indicated that the goodness of fit indices for the model were at an acceptable level (Çokluk, Şekercioğlu, and Büyüköztürk, 2010).

The results of this study revealed that the *content knowledge* dimension of mathematics teaching anxiety affected the *efficacy in teaching* dimension of self-efficacy beliefs toward mathematics teaching negatively at the level of -0.36, the *motivation and taking on responsibility* dimension of self-efficacy beliefs toward mathematics teaching negatively at the level of -0.62, and the *effective teaching* dimension of self-efficacy beliefs toward mathematics teaching negatively at the level of -0.33.

Similarly, *self-confidence* dimension of mathematics teaching anxiety affected the *efficacy in teaching* dimension of self-efficacy beliefs toward mathematics teaching negatively at the level of -0.45, and the *effective teaching* dimension of self-efficacy beliefs toward mathematics teaching negatively at the level of -0.30. And also, the *teaching knowledge* dimension of mathematics teaching anxiety affected the *effective teaching* dimension of self-efficacy beliefs toward

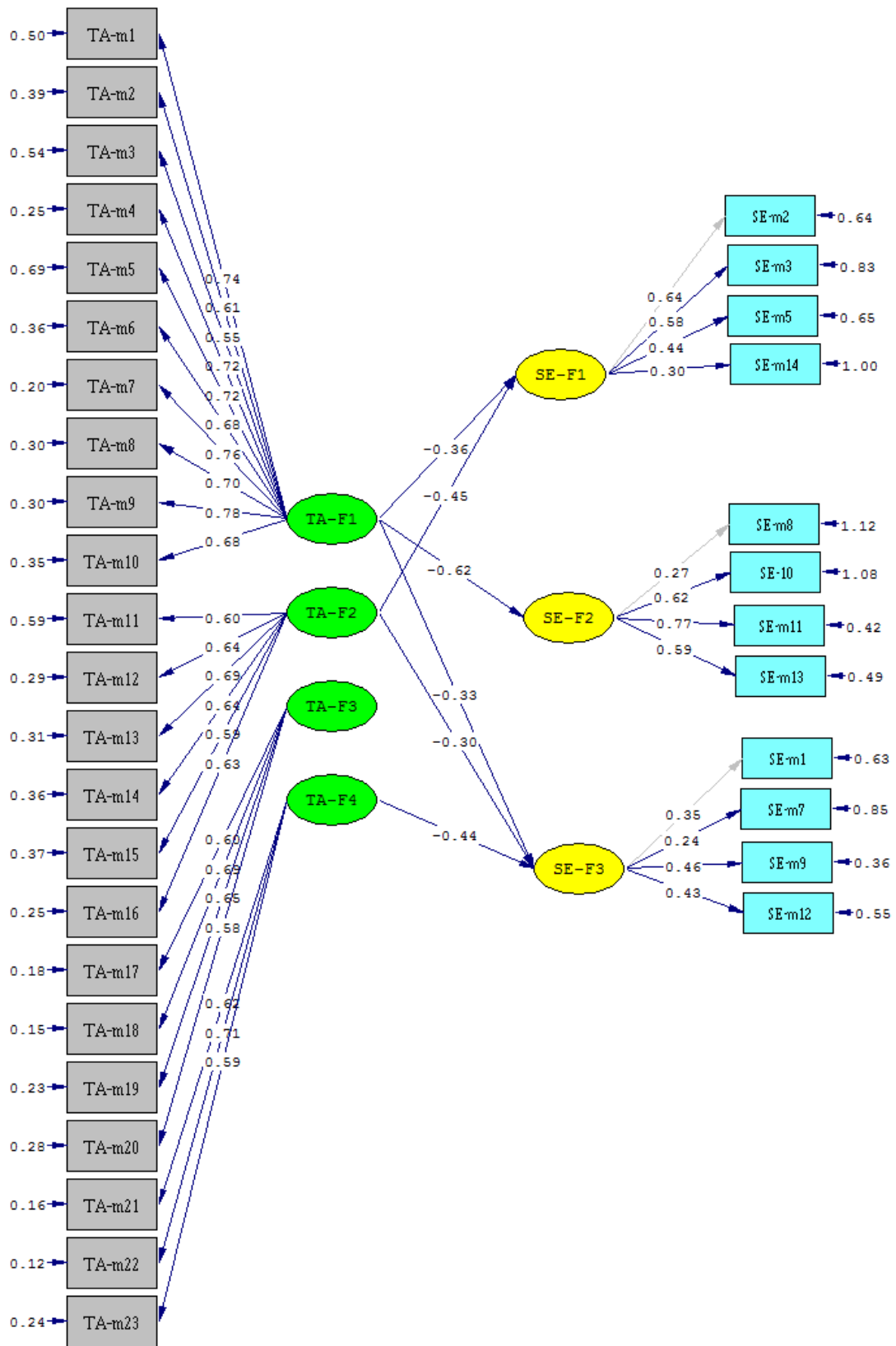


Figure 2. Results of path analysis related mathematics teaching anxiety and self-efficacy beliefs toward mathematics teaching.

mathematics teaching negatively at the level of -0.44.

DISCUSSION

In the present study, the relationship between the mathematics teaching anxiety of pre-service primary school teachers and their self-efficacy beliefs toward mathematics teaching were investigated through path analysis. As stated in the review of literature, many studies scrutinized the relationship between mathematics anxiety and mathematics self-efficacy beliefs (Cooper and Robinson, 1991; Hoffman, 2010; Jain and Dowson, 2009; Pajares and Kranzler, 1995).

Among these, Jain and Dowson (2009) found that self-efficacy beliefs affect mathematics anxiety, and Hoffman (2010) indicated a negative moderate relationship between self-efficacy and mathematics anxiety. However, limited studies have examined the relationship between mathematics teaching anxiety and self-efficacy belief toward mathematics teaching (Ural, 2015; Peker, 2015). In his study with pre-service mathematics teachers, Ural (2015) made out a negative moderate relationship between mathematics teaching anxiety and mathematics self-efficacy perception. Peker (2015) found significant negative relationship between pre-service primary school teachers' mathematics teaching anxiety and their self-efficacy beliefs toward mathematics teaching. On the other hand, the previous studies could not implicitly explicate which variable, among the variables of mathematics teaching anxiety and self-efficacy belief toward mathematics teaching, had an effect on the other. Therefore, through the path analysis, the current study suggested that mathematics teaching anxiety has an effect on the self-efficacy beliefs toward mathematic teaching.

All subfactors of mathematics teaching anxiety except for the subfactor of the attitude toward mathematics teaching emerged to have an effect on the subfactors of self-efficacy beliefs toward mathematics teaching. That is, *Content Knowledge* subfactor of mathematics teaching anxiety have an effect upon *efficacy in teaching*, *motivation and taking on responsibility* and *effective teaching*. Peker (2015) revealed negative moderate relations between the subfactor of *content knowledge*, and the each subfactor of *efficacy in teaching*, *motivation and taking on responsibility* and *effective teaching*.

The results of this study indicated the effect of the mathematics teaching anxiety's *self-confidence* subfactor on *efficacy in teaching* and *effective teaching*. Also, Peker (2015) determined a negative moderate relation between *self-confidence*, and *efficacy in teaching* and *effective teaching*, and a low negative relation between *self-confidence* and the subfactor of *motivating and taking on responsibility*. The Path analyses in the current study also point out that the effect of the relations between

these two subfactors were not at a significant level.

As one of the results of the current study, *teaching knowledge* subfactor of mathematics teaching anxiety have an effect on *effective teaching*. Peker (2015) pinpointed to a negative moderate relationship between the subfactors of *teaching knowledge* and *effective teaching*, and a low negative relationship between *teaching knowledge*, and the subfactors of *efficacy in teaching* and *motivation and taking on responsibility*. According to the path analysis, the subfactors which have low negative relations seem not to have a significant effect.

On the one hand, any significant effect could not be found between *attitude toward mathematics teaching* subfactor of mathematics teaching anxiety and the subfactors of self-efficacy beliefs; on the other hand, Peker (2015) found negative moderate relations between *attitude toward mathematics teaching*, and each of *efficacy in teaching* and *effective teaching* subfactors. Furthermore, the relation between the subfactors of *attitude toward mathematics teaching* and *motivating and taking on responsibility* was found to be at a low level. However, according to the path analysis, the subfactors which have low negative relations seem not to have a significant effect again.

To sum up, there has been a dearth of studies that examine the relationship between mathematics teaching anxiety of pre-service teachers and their self-efficacy beliefs toward mathematics teaching so far, and this increases the significance of the results presented in the current study.

Certainly, the results of the current study mean much and have implications for the teacher education programs. To increase the self-efficacy beliefs of pre-service teachers towards mathematics teaching, the mathematics teaching anxiety levels of the students should be lowered. To be able to achieve this, the aim should be to plan and apply some activities in mathematics and mathematics teaching courses. Also, the curriculum, more specifically course syllabi, should be designed to give part to this kind of activities.

LIMITATION AND FURTHER STUDY

First, the results regarding the subscales of "Self-Efficacy Beliefs toward Mathematics Teaching" scale should be interpreted with caution as the reliability values of the subscales were lower than 0.70. However, the reliability value of the whole scale was higher than 0.70, and it means that the scale was reliable.

The results of this study are limited to the data collected from the pre-service teachers in the sampling group. However, pre-service secondary school mathematics teachers and pre-service high school mathematics teachers are among the groups which will

have concerns on mathematics teaching. Therefore, some similar studies can be carried out through collecting data from a larger group of pre-service secondary school mathematics teachers and pre-service high school mathematics teachers. The results of these studies can be compared to the results of the current study.

Also, self-report instruments have limitations in revealing the perception of the participants. Therefore, in the following studies, the interview technique can be benefited from regarding the responses of pre-service teachers to the scale, and the results can be delineated deeply.

Lastly, some similar studies can be conducted with the pre-service teachers from different geographies considering the limitations in the current study, and the results of these studies can be compared to the ones in the current study.

Conflict of interests

The author has not declared any conflict of interests.

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