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Research Article

The mediating role of metacognitive awareness in the relationship between mathematics teaching self-efficacy and mathematics teaching anxiety of pre-service teachers

Gizem Yücel[1] and Derya Özlem Yazlık[2]

[1]*Erciyes University, Institute of Educational Sciences, Türkiye (ORCID: 0009-0002-2749-4576)*
[2]*Nevşehir Hacı Bektaş Veli University, Faculty of Education, Department of Mathematics Education, Türkiye (ORCID: 0000-0002-2830-5215)*

This study examines the affective–cognitive mechanisms underlying mathematics teaching anxiety among pre-service teachers by focusing on the mediating role of metacognitive awareness. Specifically, it aims to clarify how mathematics teaching self-efficacy is associated with lower levels of teaching anxiety through cognitive regulation processes. Using a quantitative research design, data were collected from 456 pre-service mathematics teachers enrolled in teacher education programs. Structural equation modeling was employed to test the hypothesized mediation model, and gender and grade level were included as covariates to control for demographic differences. The results indicated that mathematics teaching self-efficacy positively predicted metacognitive awareness, which in turn negatively predicted mathematics teaching anxiety. Metacognitive awareness partially mediated the relationship between self-efficacy and teaching anxiety, suggesting that a non-negligible portion of this association operates through cognitive regulation processes. Gender demonstrated a significant association with metacognitive awareness; however, its effects on mathematics teaching self-efficacy and teaching anxiety—as well as all effects of grade level—were non-significant. Overall, the findings contribute to the teacher education literature by integrating affective and cognitive perspectives and by highlighting metacognitive awareness as a central psychological mechanism linking self-efficacy beliefs to mathematics teaching anxiety.

Keywords: Mathematics teaching anxiety; Mathematics teaching; Metacognitive awareness; Self-efficacy; Structural equation modeling

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1. Introduction

Research on the organization and improvement of teaching and learning environments has long been a central focus of educational studies. When examining the factors that determine the quality of these environments, teacher competencies consistently emerge as a crucial variable. Accordingly, considerable attention has been given to identifying the core competencies that teachers are expected to possess. Although teaching competence has traditionally been discussed in relation to subject-matter and pedagogical knowledge (Shulman, 1986), research has also highlighted the importance of teachers' beliefs and self-efficacy in shaping instructional practices

Address of Corresponding Author

Derya Özlem Yazlık, PhD, Nevşehir Hacı Bektaş Veli University, Faculty of Education, Department of Mathematics Education, 50300 Nevşehir, Türkiye.

doyazlik@nevsehir.edu.tr

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(Çetin, 2006; Tschannen-Moran et al., 1998). Studies examining teacher effectiveness suggest that variations in instructional performance cannot be explained solely by differences in content knowledge, as motivational and affective factors have been shown to influence teaching behaviors and classroom outcomes (Darling-Hammond, 2000; Hattie, 2009). In this context, teachers' beliefs about their professional competencies, that is, their self-efficacy levels, are regarded as a crucial factor (Schunk & Pajares, 2009). Teacher self-efficacy is defined as the confidence teachers have in their ability to ensure students' learning (Karalı, 2022). Research has shown that teachers with high levels of self-efficacy can communicate more effectively with students and plan and implement classroom activities more efficiently (Riggs & Enochs, 1990). In contrast, teachers with low levels of self-efficacy may experience concerns such as being unable to teach, making mistakes, or being perceived as inadequate, which may in turn cause them to feel more tense in classroom management (Bates et al., 2013; Hoffman, 2010; Ural, 2015). Such concerns may eventually lead teachers to experience teaching anxiety. Teaching anxiety, in turn, has been reported to negatively affect students' attitudes toward the course and their academic achievement (Baloğlu, 2001). Therefore, teacher education institutions must prepare teachers who are professionally competent, confident in their abilities, and less prone to teaching anxiety.

Especially in the context of mathematics instruction, many students are observed to develop negative attitudes toward the subject, experience fear of failure, and consequently suffer from anxiety (Zakariya, 2018). In the literature, this anxiety is defined as mathematics anxiety, and it has been reported to negatively affect students' motivation toward the subject (Zakaria & Nordin, 2008), their academic achievement (Namkung et al., 2019), and their problem-solving skills (Asiedu Menlah & Boateng, 2025). On the other hand, research has shown that teachers may also experience mathematics anxiety, which can be reflected directly or indirectly onto their students (Baloğlu, 2001). The difficulties students encounter in learning mathematics and the abstract nature of the subject may cause teachers to feel under pressure during instruction, which in turn may lead them to concerns such as making mistakes, being unable to respond to students' questions, or being perceived as inadequate (Ashcraft, 2002; Özben, 2019). Such thoughts may also pave the way for another type of anxiety among teachers, namely mathematics teaching anxiety. Mathematics teaching anxiety is defined as the tension, worry, and sense of failure teachers experience while teaching mathematical concepts or solving problems in the classroom (Peker, 2006). This type of anxiety can directly influence teachers' instructional decisions, leading them to avoid diversity in teaching methods and instead rely on more traditional, lecture-based approaches that are perceived as safer (Gresham, 2008; Uusimaki & Nason, 2004; Üldaş, 2005). This situation, in turn, restricts students' mathematics learning processes and may indirectly affect their achievement negatively (Baloğlu, 2001).

As can be seen, it is important for teachers, and even earlier for prospective teachers, to recognize the teaching anxiety they experience and to develop strategies to manage it in terms of their professional competencies (Yetgin, 2023). In this context, coping with teaching anxiety requires prospective mathematics teachers to recognize the presence of anxiety and to reflect on the cognitive and affective processes underlying it. This process of awareness is closely related to metacognitive awareness, which refers to an individual's awareness and regulation of their own cognitive and affective functioning (Efklides, 2014; Flavell, 1979). Teacher candidates with higher levels of metacognitive awareness are better positioned to approach instructional challenges more adaptively and to regulate the instructional process more effectively (Yavuz, 2009). This approach is thought to contribute to the regulation of anxiety during instruction and to help teachers use their professional competencies more effectively. Therefore, metacognitive awareness is considered an important variable as it supports teacher competencies and contributes to reducing mathematics teaching anxiety. Accordingly, this study investigated whether the metacognitive awareness levels of prospective mathematics teachers play a mediating role in the relationship between mathematics teaching self-efficacy and mathematics teaching anxiety through structural equation modeling. The findings of the study are expected to reveal the relationships among these variables from a holistic perspective, contribute to the literature, and guide teachers, educators, and researchers in the field of mathematics education.

2. Literature Review

In this section, the concepts of mathematics teaching self-efficacy, mathematics teaching anxiety, and metacognitive awareness will be discussed, and a general overview of the related literature will be provided.

2.1. Mathematics Teaching Self-Efficacy

The concept of self-efficacy holds a central place in Bandura's (1997) social cognitive theory and is defined as an individual's personal judgment regarding their capacity to successfully perform a specific task. Teacher self-efficacy, in this context, refers to teachers' beliefs in their ability to facilitate student learning, manage classroom processes effectively, and cope with challenges encountered in instructional settings (Tschannen-Moran & Woolfolk-Hoy, 2001). Unlike professional knowledge and skills, teacher self-efficacy encompasses teachers' internal confidence and the attitudes they reflect in their professional practices. Teachers with high levels of self-efficacy tend to put forth greater effort during instruction, are more willing to adopt innovative teaching strategies, and directly contribute to student achievement (Henson, 2001; Riggs & Enochs, 1990).

For pre-service teachers, self-efficacy is considered one of the key determinants of the teacher preparation process. Studies in the literature have shown that pre-service teachers with high levels of self-efficacy plan student learning processes more effectively, employ a greater variety of instructional methods, and demonstrate greater persistence when faced with challenges (Akbaş & Çelikkaleli, 2006; Poulou, 2007). In contrast, pre-service teachers with low levels of self-efficacy are reported to experience concerns about making mistakes or being perceived as inadequate, which leads them to rely more heavily on teacher-centered and traditional approaches (Kaçar & Beycioğlu, 2017). Moreover, it has been reported that pre-service teachers' self-efficacy beliefs affect not only their teaching skills but also their professional motivation and communication patterns in the classroom (Shah, 2023).

In the context of mathematics teaching, self-efficacy belief refers to teachers' confidence in their ability to effectively teach mathematical concepts and processes, enhance students' mathematics achievement, and cope with instructional difficulties that may arise during the learning process (Akosah et al., 2024; Enochs et al., 2000). Teachers with high mathematics teaching self-efficacy are able to implement more effective instructional practices in developing students' fundamental mathematical competencies such as reasoning, problem-solving, making connections, and communication (Ministry of National Education [MoNE], 2008). Furthermore, the literature emphasizes that such teachers are more successful in providing positive feedback to students, fostering supportive classroom climate, and enhancing motivation toward learning (Swars et al., 2007). Therefore, mathematics teaching self-efficacy is considered a critical variable both for the professional development of pre-service teachers and for the academic success of students.

2.2. Mathematics Teaching Anxiety

Mathematics teaching anxiety is defined as the tension, fear of failure, and concern about being perceived as inadequate that teachers or pre-service teachers experience during the process of teaching mathematics (Peker, 2006). This form of anxiety is specific to the instructional context and stems from the pedagogical challenges teachers encounter in the classroom (Baloglu, 2001). Therefore, it differs from the mathematics anxiety experienced by students in mathematics courses. Furthermore, the abstract nature of mathematical concepts and the requirement for higher-order cognitive processes give mathematics teaching anxiety a domain-specific character beyond general teaching anxiety (Bursal & Paznokas, 2006).

The literature highlights that mathematics teaching anxiety is particularly prevalent among pre-service teachers and negatively affects their preparation for the profession (Baloglu, 2001; Peker, 2009). Pre-service teachers who experience this type of anxiety are reported to fear making mistakes, being unable to answer students' questions, or being judged as incompetent, which in turn causes them to feel greater tension during classroom practices (Baloglu, 2001; Peker, 2009; Ural, 2015). This situation restricts pre-service teachers' professional self-confidence, adversely impacts their instructional performance, and leads them to avoid student-centered approaches, instead resorting to traditional methods they perceive as safer (Uusimaki & Nason, 2004). Such methodological preferences by teachers may constrain students' learning processes and foster negative attitudes toward mathematics. Consequently, mathematics teaching anxiety is not only an individual emotional state but also a pedagogical factor that influences instructional methods, classroom interaction, and student achievement.

2.3. Metacognitive Awareness

Metacognitive awareness is defined as the capacity of individuals to recognize, monitor, and regulate their own cognitive processes (Flavell, 1979). In other words, it refers to the ability to be aware of the strategies employed during learning, to monitor these strategies, and to adapt them when necessary (Schraw & Dennison, 1994). In the literature, this concept has also been described as "learning to learn" or "thinking about thinking" (Brown, 1980; Papleontiou-Louca, 2003). More recent studies emphasize that metacognitive awareness is not only related to cognitive processes but also closely associated with motivational processes, playing a notable role in predicting academic performance (Efklides, 2014; Veenman, 2016).

Metacognitive awareness contributes to learning processes in multiple ways. Individuals with this skill can identify which strategies are effective, make more conscious decisions in problem-solving processes, and develop alternative approaches when faced with difficulties (Garner & Alexander, 1989; Schraw & Dennison, 1994). Moreover, metacognitive awareness provides flexibility in the learning process, enabling individuals to choose strategies appropriate to different situations and to modify existing strategies when necessary. Recent research has also shown that metacognitive awareness supports individuals' creativity, enhances their motivation toward learning, and strengthens their cognitive performance (Wilson & Bai, 2010; Zohar & Barzilai, 2013).

In the context of teacher education, metacognitive awareness is important for enabling pre-service teachers to consciously manage the instructional process. It has been reported that pre-service teachers with higher levels of metacognitive awareness conduct their lessons in a more organized manner, select appropriate strategies during instruction while monitoring their implementation, and engage in more effective reflective evaluations at the end of the teaching process (Çakıroğlu, 2007; Gunstone & Northfield, 1994). In this regard, metacognitive awareness contributes not only to the development of pre-service teachers' awareness of their own learning but also to their ability to manage instructional processes (Zohar & Barzilai, 2013). Therefore, metacognitive awareness is regarded as a fundamental variable at the core of contemporary teacher education that supports the professional competencies of pre-service teachers.

2.4. Relationships among Variables

Mathematics teaching self-efficacy refers to pre-service teachers' beliefs in their capacity to plan mathematics lessons, implement effective instruction, and manage classroom processes successfully. The literature consistently indicates that such beliefs are closely linked to teachers' emotional experiences during instruction. Pre-service teachers with high levels of self-efficacy are more likely to approach teaching situations with confidence and to interpret instructional challenges as manageable, whereas those with lower self-efficacy tend to perceive teaching as threatening and report higher levels of anxiety. Empirical studies conducted with pre-service teachers have repeatedly demonstrated a significant negative association between mathematics teaching self-efficacy and mathematics teaching anxiety (Aksu & Kul, 2019; Deringöl, 2018; Özben, 2019; Peker, 2016; Temiz, 2012; Ural, 2015; Ünlü et al., 2017). These findings suggest that strengthening self-efficacy perceptions may play a protective role against anxiety experienced during mathematics instruction. Based on this body of evidence, the following hypothesis was formulated: H1. *Mathematics teaching self-efficacy negatively predicts mathematics teaching anxiety.*

Beyond its direct emotional implications, mathematics teaching self-efficacy is also theorized to support teachers' cognitive and self-regulatory capacities. Individuals who believe in their instructional competence are more likely to monitor their performance, evaluate alternative strategies, and actively regulate their thinking during teaching. Consistent with this view, empirical research has reported positive associations between self-efficacy beliefs and metacognitive awareness among pre-service teachers (Alkan & Erdem, 2014; Bars, 2016). These studies indicate that self-efficacy may foster teachers' ability to reflect on and regulate their own cognitive processes. Accordingly, the following hypothesis was proposed: H2. *Mathematics teaching self-efficacy positively predicts metacognitive awareness.*

Metacognitive awareness, in turn, is theoretically and empirically associated with emotional regulation in instructional contexts. Pre-service teachers who are more capable of monitoring and evaluating their cognitive and emotional processes are better equipped to cope with uncertainty, instructional difficulties, and perceived failures. Prior research has identified significant negative relationships between metacognitive awareness and mathematics teaching anxiety among both elementary and mathematics teacher candidates (Efe-Ayaz, 2019; Öztürk & Serin, 2020; Yetgin, 2023). These findings suggest that metacognitive awareness may function as a psychological buffer, enabling teachers to reinterpret stressful teaching situations as controllable and improvable rather than threatening. Thus, the following hypothesis was advanced: H3. *Metacognitive awareness negatively predicts mathematics teaching anxiety.*

Although previous studies have established pairwise relationships among mathematics teaching self-efficacy, metacognitive awareness, and mathematics teaching anxiety, most of this research has relied on bivariate analyses. As a result, the psychological mechanism through which self-efficacy beliefs translate into reduced teaching anxiety remains under-modeled. Drawing on Bandura's social cognitive theory, it can be argued that self-efficacy influences affective outcomes not only directly but also indirectly via cognitive regulation processes. From this perspective, metacognitive awareness can be conceptualized as a plausible mediating mechanism that links self-efficacy beliefs to mathematics teaching anxiety by shaping how teachers monitor, interpret, and manage instructional challenges. To address this gap, the present study proposes the following hypothesis: H4. Metacognitive awareness mediates the relationship between mathematics teaching self-efficacy and mathematics teaching anxiety.

3. Method

3.1. Research Model

This study aimed to examine the relationships among pre-service mathematics teachers' levels of mathematics teaching self-efficacy, metacognitive awareness, and mathematics teaching anxiety. Specifically, it was hypothesized that metacognitive awareness mediates the relationship between mathematics teaching self-efficacy and mathematics teaching anxiety. To test these theoretically grounded direct and indirect effects, structural equation modeling [SEM] was employed.

SEM is a comprehensive statistical technique that enables researchers to test theoretical models involving both latent and observed variables and to examine direct, indirect, and mediating effects simultaneously (Byrne, 2013; Kline, 2011). Given the theoretical nature of the proposed model and the presence of latent constructs, SEM was considered an appropriate analytical framework.

3.2. Participants

Structural Equation Modeling generally requires sample sizes larger than 200 to meaningfully test hypothesized relationships and to minimize measurement error (Kline, 2011). Accordingly, a total of 478 pre-service mathematics teachers enrolled in the mathematics education programs of three universities located in Central Anatolia were reached for this study. Since the participants were accessible to the researchers, a convenience sampling method was employed. Participation was voluntary, and the pre-service teachers completed the measurement instruments via Google

Forms. Before the analyses, Mahalanobis distances were examined, and 22 multivariate outliers were identified. Given the sufficiently large sample size, these outliers were excluded, resulting in a final sample of 456 pre-service mathematics teachers. Table 1 presents the distribution of participants by gender and grade level.

Table 1
Distribution of Participants by Grade Level and Gender

Gender	*1st Year*	*2nd Year*	*3rd Year*	*4th Year*	*Total*
Female	101 (27.5%)	104 (28.4%)	73 (19.8%)	89 (24.3%)	367 (100%)
Male	31 (34.8%)	21 (23.6%)	16 (18.0%)	21 (23.6%)	89 (100%)
Total	132 (28.9%)	125 (27.4%)	89 (19.5%)	110 (24.2%)	456 (100%)

Note. According to Table 1, 28.9% of the pre-service teachers were first-year students (n = 132), 27.4% were second-year students (n = 125), 19.5% were third-year students (n = 89), and 24.2% were fourth-year students (n = 110). In addition, 80.5% of the participants were female (n = 367), while 19.5% were male (n = 89).

3.3. Instruments

3.3.1. Mathematics Teaching Anxiety Scale

The "Mathematics Teaching Anxiety Scale," developed by Peker (2006), was used to measure the anxiety levels of pre-service mathematics teachers regarding teaching mathematics. The scale consists of 23 items and four sub-dimensions rated on a five-point Likert scale. The total score ranges from 23 to 115, with higher scores indicating higher levels of teaching anxiety. The Cronbach's alpha reliability coefficient was reported as .91 by Peker (2006) and calculated as .93 in the present study. Exploratory factor analysis revealed that factor loadings ranging from .392 to .809, explaining 63.2% of the total variance.

3.3.2. Mathematics Teaching Competence Scale

The "Mathematics Teaching Competence Scale," developed by Esendemir et al. (2015), was used to assess pre-service mathematics teachers' perceived competence in teaching mathematics. The 20-item, five-point Likert-type scale that comprises four dimensions: problem solving, communication, connections, and reasoning. The total score ranges from 20 to 100, with higher scores indicating higher levels of perceived competence. The Cronbach's alpha reliability coefficient was reported as .96 by the developers and calculated as .94 in the present study. Exploratory factor analysis revealed factor loadings ranging from .692 to .847, accounting for 66.8% of the total variance.

Although the developers named the scale the "Mathematics Teaching Competence Scale," the items conceptually reflect pre-service teachers' perceived teaching competence, which aligns with the theoretical definition of teaching self-efficacy. Therefore, in the structural model, this construct was labeled as Mathematics Teaching Self-Efficacy [MTSE] while the original scale name was retained in the instruments section to ensure correct attribution.

3.3.3. Metacognitive Awareness Inventory

To measure pre-service mathematics teachers' metacognitive awareness, the "Metacognitive Awareness Inventory" developed by Schraw and Dennison (1994) and adapted into Turkish by Akın et al. (2007) was employed. The inventory consists of 52 items on a five-point Likert scale and is structured under two main dimensions: knowledge of cognition (declarative knowledge, procedural knowledge, and conditional knowledge) and regulation of cognition (planning, monitoring, evaluating, debugging, and information management strategies). The total score ranges from 52 to 260, with higher scores reflecting greater metacognitive awareness. The Cronbach's alpha reliability coefficient was reported as .95 by Akın et al. (2007) and calculated as .96 in the present study. Exploratory factor analysis showed that factor loadings ranging from .347 to .689, explaining 59.8% of the variance.

3.4. Data Collection Process

In the data collection process, the purpose of the study was first explained to the participants. Subsequently, a total of 478 pre-service teachers from three different cities voluntarily participated, and the measurement instruments were administered online via Google Forms. The participants were given approximately five days to complete the scales sincerely and carefully. An examination of the completion times indicated that the participants filled out the scales within an appropriate and consistent timeframe. Following statistical analyses, 22 cases identified as multivariate outliers were excluded from the study, and the analyses were conducted with 456 participants.

3.5. Data Analysis

In the data analysis process, descriptive statistics (means, standard deviations, and correlations) were first examined for the main variables. Univariate normality was assessed by inspecting skewness and kurtosis values; skewness values ranged from −0.628 to 0.444, and kurtosis values ranged from −0.328 to 0.485, both falling within acceptable thresholds. Multivariate normality was evaluated using Mahalanobis distances, which resulted in the identification of 22 outliers. Since the sample size was sufficient, these cases were removed from the dataset prior to analysis. In addition, tolerance (.809) and VIF (1.235) values indicated no evidence of multicollinearity among the variables (Kline, 2011; Tabachnick & Fidell, 2013).

To assess potential common method bias, Harman's single-factor test was conducted. The first factor accounted for 27% of the total variance, which is well below the commonly accepted 50% threshold, suggesting that common method variance did not pose a significant threat to the findings. As an additional check, a single-factor confirmatory model was tested in AMOS by loading all items onto a single latent factor. The model demonstrated poor fit (χ^2 = 18187.639, df = 4371, χ^2/df = 4.161, RMSEA = .083, CFI = .461, TLI = .450, IFI = .463, NFI = .396), further confirming that the data were not explained by a single-factor structure.

The measurement model was tested using Confirmatory Factor Analysis (CFA) conducted in AMOS 24. Model fit was evaluated using χ^2/df, RMSEA, SRMR, NFI, TLI, and CFI indices (Byrne, 2013; Kline, 2011; MacCallum & Austin, 2000). After establishing an acceptable measurement model, the structural model was tested.

In the structural model, gender and grade level were included as covariates predicting mathematics teaching self-efficacy, metacognitive awareness, and mathematics teaching anxiety. This approach was preferred over multi-group SEM as subgroup sample sizes particularly for male participants and third-year students were insufficient for reliable multi-group comparisons.

The mediating role of metacognitive awareness was examined using the bias-corrected bootstrapping method with 5,000 samples and a 95% confidence interval (Preacher & Hayes, 2008). The indirect effect was considered statistically significant when the confidence interval did not include zero. Based on Baron and Kenny's (1986) logic, a reduction in the direct effect after including the mediator was interpreted as partial mediation, whereas a nonsignificant direct effect indicated full mediation. Additionally, the magnitude of the standardized indirect effect was examined to assess the practical significance of the mediation effect.

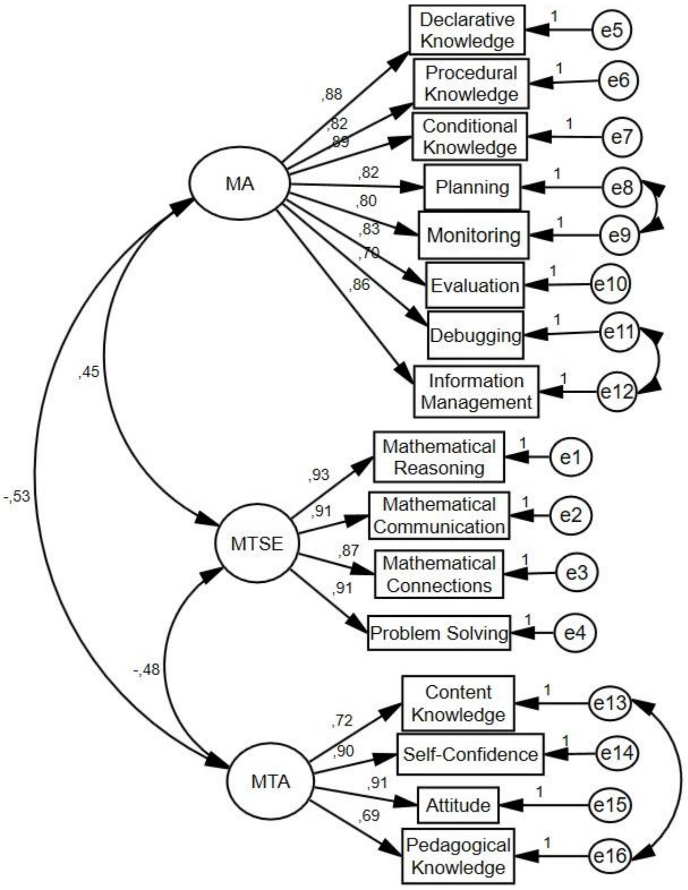
4. Findings

This section first presents the results of the measurement model, followed by the findings related to the structural model.

4.1. Findings on the Measurement Model

The analysis of the measurement model indicated an acceptable level of model fit indices (χ^2 [98, N = 456] = 247.955, p < .001, χ^2/df = 2.530, CMIN = 247.955, NFI = .961, TLI = .971, CFI = .976, RMSEA = .058, SRMR = .048). In addition, the standardized factor loadings of the measurement model ranged from .69 to .93, and all loadings were statistically significant. These results confirm the validity of the measurement model. Figure 1 presents the diagram of the measurement model.

Figure 1
Measurement Model



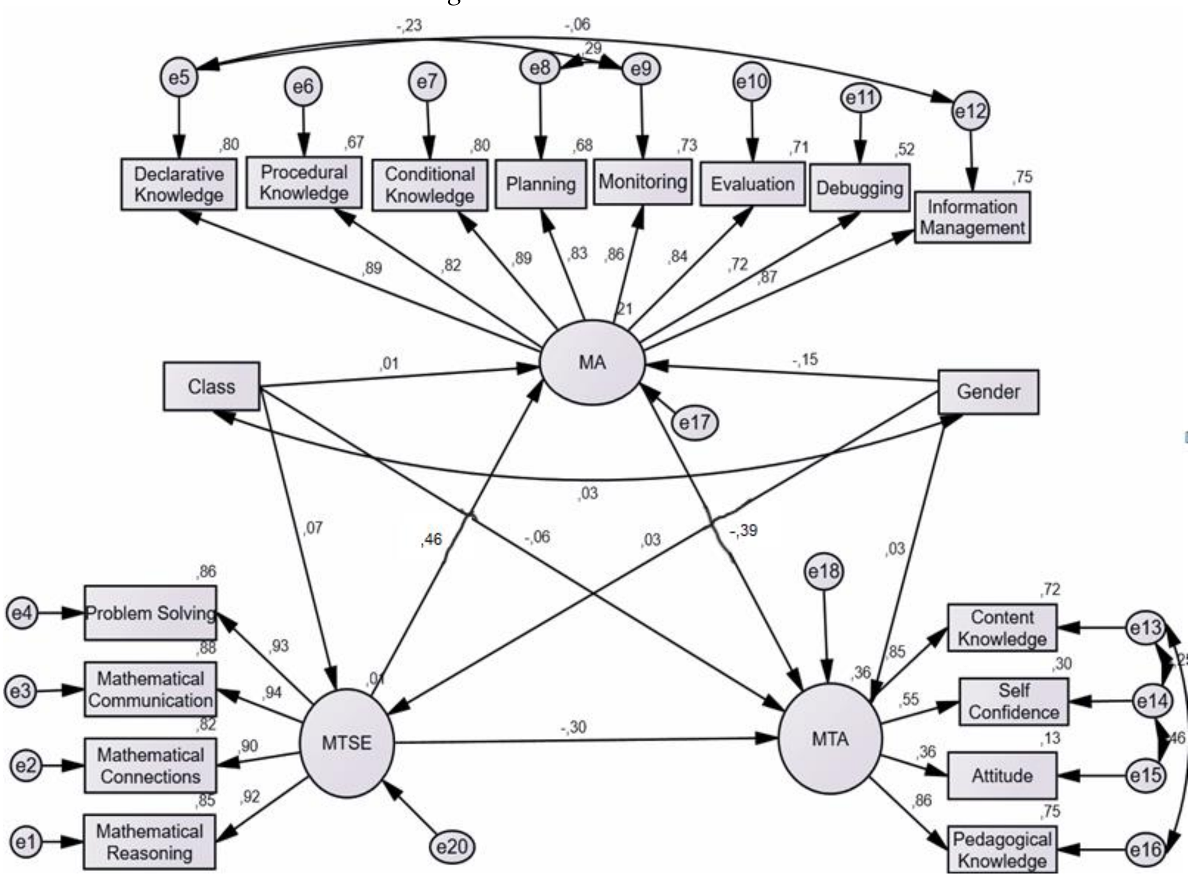
4.2. Findings Related to the Structural Model

Following the validation of the measurement model, the hypothesized structural model including metacognitive awareness as a mediator and gender and grade level as covariates was tested. The model demonstrated good overall model fit (χ^2[121, N = 456] = 260.544, p < .001, χ^2/ df = 2.15, NFI = .958, TLI = .971, CFI = .977, RMSEA = .050, SRMR = .047). Figure 2 presents the final structural mediation model with standardized path coefficients, illustrating the direct and indirect structural relationships among mathematics teaching self-efficacy, metacognitive awareness, and mathematics teaching anxiety, while statistically controlling for gender and grade level.

As displayed in Figure 2, mathematics teaching self-efficacy had a significant positive effect on metacognitive awareness (β = .46, p < .001), and metacognitive awareness in turn had a significant negative effect on mathematics teaching anxiety (β = –.39, p < .001). Accordingly, H2 (Mathematics Teaching Self-Efficacy→Metacognitive Awareness) and H3 (Metacognitive Awareness→ Mathematics Teaching Anxiety) were supported. In addition, mathematics teaching self-efficacy retained a significant direct negative effect on mathematics teaching anxiety after metacognitive awareness was included (β = –.30, p < .001). In terms of effect magnitude, the standardized path from mathematics teaching self-efficacy to metacognitive awareness (β = .46) indicates a moderate positive association, while the path from metacognitive awareness to mathematics teaching anxiety (β = –.39) reflects a moderate negative association.

Gender and grade level were modelled as observed covariates predicting the three latent constructs. Among these paths, only the effect of gender on metacognitive awareness was statistically significant (β = –.15, p < .001), indicating that male pre-service teachers reported lower levels of metacognitive awareness compared to their female counterparts. In contrast, the effects of gender and grade level on mathematics teaching self-efficacy and mathematics teaching anxiety

Figure 2
Structural Mediation Model Including Gender and Grade Level as Covariates



were not statistically significant (p > .05). Since these covariate effects did not alter the substantive relations among mathematics teaching self-efficacy, metacognitive awareness, mathematics teaching anxiety, they were retained in the model solely for statistical control, as their inclusion did not alter the substantive relations among the variables.

The mediating role of metacognitive awareness in the association between mathematics teaching self-efficacy and mathematics teaching anxiety was examined using a bias-corrected bootstrapping procedure with 5,000 resamples. Consistent with the structural paths, the standardized indirect effect of mathematics teaching self-efficacy on mathematics teaching anxiety through metacognitive awareness was negative and statistically significant (β = –.17), and the corresponding 95% bootstrap confidence interval did not include zero, supporting the presence of mediation. Accordingly, H4, which proposed that metacognitive awareness mediates the relationship between mathematics teaching self-efficacy and mathematics teaching anxiety, was supported. In terms of effect magnitude, this standardized indirect effect represents a meaningful and practically relevant mediation effect, indicating that a non-trivial portion of the total relationship between self-efficacy and teaching anxiety operates through metacognitive awareness. The total effect of mathematics teaching self-efficacy on mathematics teaching anxiety was β = –.47, thus supporting H1, whereas the direct effect in the presence of the mediator was β = –.30, indicating that a substantial portion of the overall relationship between self-efficacy and teaching anxiety was transmitted through metacognitive awareness. Examination of squared multiple correlations showed that the model accounted for approximately 1% of the variance in mathematics teaching self-efficacy, 21% of the variance in metacognitive awareness, and 36% of the variance in mathematics teaching anxiety (see Figure 2). This low proportion of explained variance in mathematics teaching self-efficacy is theoretically expected, as this construct functioned primarily as an exogenous variable in the model and was predicted only by demographic covariates. The standardized direct, indirect, and total effects of the structural mediation model are presented in Table 2.

Table 2
Direct, Indirect, and Total Effects of the Structural Mediation Model

Path	*β*	*SE*	*95% CI (LLCI)*	*95% CI (ULCI)*	*p*
Direct Effects					
MTSE → MA	0.46	0.06	0.37	0.54	***
MTSE → MTA	−0.30	0.09	−0.40	−0.21	***
MA → MTA	−0.39	0.07	−0.49	−0.29	***
Total Effect					
MTSE → MTA	−0.47	0.04	−0.566	−0.392	***
Indirect Effect					
MTSE → MA → MTA	−0.17	0.03	−0.240	−0.127	***

Note. MTSE: Mathematics Teaching Self-Efficacy; MA: Metacognitive Awareness; MTA: Mathematics Teaching Anxiety. ***$p < .001$.

5. Discussion and Conclusion

This study examined the mediating role of metacognitive awareness in the relationship between preservice mathematics teachers' mathematics teaching self-efficacy and mathematics teaching anxiety. The findings showed that mathematics teaching self-efficacy significantly and negatively predicted mathematics teaching anxiety. This finding indicates that stronger beliefs in one's instructional competence are associated with lower levels of anxiety related to teaching mathematics. From a theoretical perspective, self-efficacy contributes to individuals' perceived control over task demands, which may reduce the extent to which teaching situations are appraised as threatening. In the context of mathematics teaching, feeling competent in planning, implementation, and classroom management may therefore alleviate anxiety by strengthening confidence in instructional performance. These findings are consistent with previous research reporting negative associations between mathematics teaching self-efficacy and mathematics teaching anxiety among preservice mathematics teachers (Aksu & Kul, 2019; Peker, 2016; Ural, 2015; Ünlü et al., 2017), preservice elementary teachers (Deringöl, 2018; Temiz, 2012), and preservice special education teachers (Özben, 2019). The convergence of findings across different teaching fields suggests that the anxiety-reducing role of teaching self-efficacy may represent a common mechanism in teacher education contexts.

Another important finding of the study was that mathematics teaching self-efficacy significantly predicted metacognitive awareness. This result suggests that preservice teachers who perceive themselves as competent in teaching mathematics are more likely to engage in greater levels of awareness and regulation of their cognitive functioning. Individuals with strong self-efficacy beliefs are known to approach tasks more strategically, persist in challenging situations, and engage more actively in self-regulated learning processes (Bandura, 1997; Zimmerman, 2000). Accordingly, preservice teachers with higher teaching self-efficacy may be more inclined to plan instructional steps deliberately, monitor their teaching performance, and evaluate the effectiveness of their instructional decisions. This interpretation is supported by studies indicating that individuals with high self-efficacy use cognitive and metacognitive strategies more effectively (Chemers et al., 2001; Pintrich & De Groot, 1990; Soyer & İnaler, 2024). Moreover, research focusing on teaching-related self-efficacy has similarly reported positive associations between self-efficacy beliefs and metacognitive awareness (Alkan & Erdem, 2014; Bars, 2017). Together, these findings suggest that self-efficacy may contribute to metacognitive development by encouraging more intentional and reflective engagement with teaching processes.

The study also found that metacognitive awareness significantly and negatively predicted mathematics teaching anxiety. Metacognitive awareness, defined as awareness and regulation of one's cognitive processes (Flavell, 1979; Schraw & Moshman, 1995), may reduce teaching anxiety by enabling individuals to recognize instructional difficulties in a timely manner and to employ appropriate regulation strategies. Preservice teachers with higher metacognitive awareness may be better able to monitor their emotional responses during instructional activities, evaluate the sources of anxiety, and maintain a sense of control over instructional demands. In this way, metacognitive awareness may help prevent anxiety from reaching levels that interfere with teaching performance. This interpretation aligns with previous studies demonstrating negative relationships between metacognitive awareness and mathematics teaching anxiety among preservice teachers (Efe-Ayaz, 2019; Öztürk & Serin, 2020; Yetgin, 2023). In addition, theoretical work emphasizes that metacognitive regulation is not limited to cognitive functioning but is also closely related to motivational and affective regulation processes (Efklides, 2014; Veenman, 2016), supporting its relevance in understanding anxiety-related outcomes.

Finally, the findings revealed that metacognitive awareness partially mediated the relationship between mathematics teaching self-efficacy and mathematics teaching anxiety. This result indicates that self-efficacy influences teaching anxiety not only directly but also indirectly through metacognitive awareness. In other words, preservice teachers with high teaching self-efficacy tend to report lower anxiety partly because they display higher levels of awareness and regulation of their cognitive processes. Metacognitive awareness thus appears to function as a key psychological mechanism that links beliefs about instructional competence to emotional experiences related to teaching. The partial nature of the mediation suggests that while metacognitive awareness plays a meaningful role, other cognitive or affective factors may also account for additional variance in teaching anxiety.

6. Recommendations and Future Research

The findings of this study suggest that mathematics teaching self-efficacy may reduce teaching anxiety both directly and indirectly through metacognitive awareness. Based on these results, teacher education programs may benefit from incorporating structured instructional practices that systematically support the development of preservice teachers' metacognitive regulation skills. For example, reflective teaching journals may prompt preservice teachers to plan, monitor, and evaluate their instructional decisions more deliberately. Similarly, structured metacognitive training modules focusing on lesson planning, instructional reflection, and self-evaluation may enhance awareness of cognitive and emotional processes involved in teaching.

In addition, structured peer feedback activities, in which preservice teachers critically analyze and discuss each other's instructional practices, may promote metacognitive engagement and support the regulation of teaching-related anxiety. Such practices may help preservice teachers develop greater awareness of their instructional strengths and areas for improvement, thereby reinforcing both metacognitive awareness and teaching self-efficacy.

The cross-cultural generalizability of the findings should also be considered. This study was conducted within a specific teacher education context, and cultural factors related to evaluation practices, performance expectations, and perceptions of anxiety may influence the observed relationships. Future research conducted in different cultural and educational contexts may help determine whether the mediating role of metacognitive awareness operates similarly across teacher education systems.

Finally, as the data in this study were collected using self-report measures, the findings may be susceptible to common method variance. Future research may employ longitudinal, experimental, or mixed-methods designs and incorporate qualitative data sources to provide a more comprehensive understanding of the relationships among self-efficacy, metacognitive awareness, and teaching anxiety.

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Data availability: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable requests.

Declaration of interest: The authors declare no conflict of interest.

Ethical approval: The study was approved by the Social and Humanities Sciences Scientific Research and Publication Ethics Committee of Nevşehir Hacı Bektaş Veli University on 30 April 2024 with the approval number: 2024.05.80. Written informed consent was obtained from all participants and their legal guardians. Data collection adhered to ethical guidelines, ensuring anonymity, confidentiality, and participants' rights.

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