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Pre-service teacher's beliefs in mathematics: A systematic literature review 2020-2024

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Article info

systematic literature review; pre-service teachers; beliefs; mathematics.

Abstract

A systematic literature review explores research areas related to pre-service teachers' beliefs about Mathematics to consider them in the development of teacher professional education. The articles from Scopus, DOAJ, and ERIC using the PRISMA diagram were extracted, and they included four stages: identification, screening, eligibility, and quality assessment. In total, 26 articles were analyzed. From the analysis, it was found that the country that has conducted the most research on beliefs is Turkey; the method most often used in various studies is quantitative; the characteristics of the sample are mostly prospective mathematics teachers; women dominate the gender of the sample; the construct that appears most often in research is beliefs about teaching mathematics; the instrument most often used is a questionnaire; there are research results from various literatures presented to add insight to readers; and another domain that often appears in research related to pre-service teachers' beliefs about mathematics is self-efficacy. The various research results reveal that women dominate gender issues. It is interesting to explore this topic more deeply, given that men have the same role as women in improving and fostering professionalism.

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1. Introduction

Research shows that students' success and attitudes towards mathematics influence instructors' views and practices, making mathematics education a long-standing issue in many countries. The impact of teachers on students goes beyond academic Performance on standardized tests; it encompasses a range of attitudes and behaviors that are important for long-term success. For example, upper primary school teachers significantly influence students' self-efficacy in

mathematics, happiness, and classroom behavior through their emotional support and classroom organization (Blazar & Kraft, 2017). In addition, teachers' attitudes, qualifications, and teaching practices affect student achievement in various subjects, including mathematics.

Research has shown that teacher background influences math achievement most, especially in the early grades (Boonen et al., 2014). A strong correlation exists between how teachers teach mathematics and their attitude toward the subject matter, significantly affecting student learning outcomes. Teachers who regard mathematics as a problem-solving process tend to teach mathematics mechanically. Teachers who perceive math as a problem-solving process tend to use approaches that encourage discussion and exploration. Improved learning outcomes will likely result from teachers matching their practice with student-centered ideas and creating an atmosphere where students actively develop mathematical knowledge (Minarni et al., 2018).

These beliefs are not formed instantly but result from past experiences as students and exposure to different teaching models. Teachers' views on mathematics and teaching are strongly influenced by their experiences as Mathematics students before becoming teachers. These beliefs are interdependent and shape their pedagogical approach. However, research shows that pre-service teachers have stronger and more consistent beliefs in teaching mathematics compared to pre-service teachers, whose beliefs are more tentative and less in line with their lesson plans (Vesga-Bravo et al., 2022). Pre-service teachers, in particular, play an important role in shaping the mathematical understanding and attitudes of the next generation of students.

Courses in teacher education programs, especially those that connect theory with practical examples, play a crucial role in shaping these beliefs (Jao, 2017). Mathematics courses that provide real mathematical experiences and foster autonomous behavior can positively change pre-service teachers' beliefs about mathematics. It can significantly influence pre-service teachers' beliefs, making them more supportive of reform approaches in their teaching (Segarra & Julià, 2022). For example, pre-service teachers who attended project and reflection-based courses tended to be more open to using concrete manipulatives and classroom discussions to teach mathematical concepts. Courses that connect theory with practical examples and provide opportunities for reflection and application are particularly effective in changing pre-service teachers' beliefs.

Teacher education programs influence pre-service teachers' beliefs about teaching mathematics, with personal beliefs showing more change than formal beliefs (Haser & Doğan, 2012). Teacher education programs that include experiential courses and practical teaching methods can shift pre-service teachers' beliefs towards a more reform-based and student-centered approach (Segarra et al., 2021). Regardless of pre-service teachers' previous experiences, teacher training programs can create learning opportunities that shape their ideas. This change in beliefs often occurs in response to curriculum reforms that emphasize meaningful learning and constructivist approaches, where teachers are required to not only master content but also understand how students construct mathematical understanding. Students must understand pre-service teachers' perspectives on Mathematics to create successful teacher education programs and promote effective teaching methods.

Professional development programs greatly enhance instructors' topic understanding and instructional strategies, thereby improving mathematics achievement among students (Polly et al., 2015). Researchers found that professional development programs that improved teachers' mathematical knowledge and student-centered teaching practices impacted student achievement (Ekmekci et al., 2019). Governments must try to understand and improve teachers' beliefs, knowledge, and literacy and address any education policies they set (Purnomo, 2017).

Despite the importance of these elements, several literatures provide a comprehensive picture of how pre-service teachers' beliefs are formed, developed, and incorporated into their teaching practices. This systematic literature review aims to gather knowledge about pre-service teachers'

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attitudes toward mathematics, including how these attitudes emerge, develop, and impact instructional strategies and student learning. The review seeks to inform teacher programs, policies, practices, and professional development and ultimately contribute to improving Mathematics education. To achieve this, the eight research questions to be addressed include:

1. Which countries do investigate pre-service teachers' beliefs about Mathematics in the literature?
2. What methods have the researchers used in the literature?
3. What are the sample characteristics across the literature?
4. Does the literature include the gender of the sample?
5. Does the literature consistently employ Mathematical belief structures?
6. Are research instruments used across the literature?
7. Do research results come from various literatures?
8. Does the literature integrate beliefs in Mathematics with other domains?

2. Method

This study employed the systematic literature review (SLR) research method. SLR research summarised several initial studies, presenting comprehensive and balanced facts (Mengist et al., 2020). A systematic literature review is a type of scientific research that solely addresses specific research questions by applying specific scientific methods, including the identification, selection, summarization, and in-depth evaluation of similar studies. Additionally, this strategy provides a deeper understanding of the study subject by evaluating a large research database. The primary motivation behind selecting SLR was to incorporate and gather scholarly works concerning pre-service teachers' attitudes toward mathematics.

We have conducted a literature search in August 2024. The literature search yielded 56 articles: 29 from international journals with Scopus index, six from DOAJ journals, and 21 from ERIC journals. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) research patterns to establish criteria and gather data. The steps are as follows: (a) identification, (b) screening, (c) eligibility, and (d) quality assessment. **Figure 1** illustrates the search and selection stages.

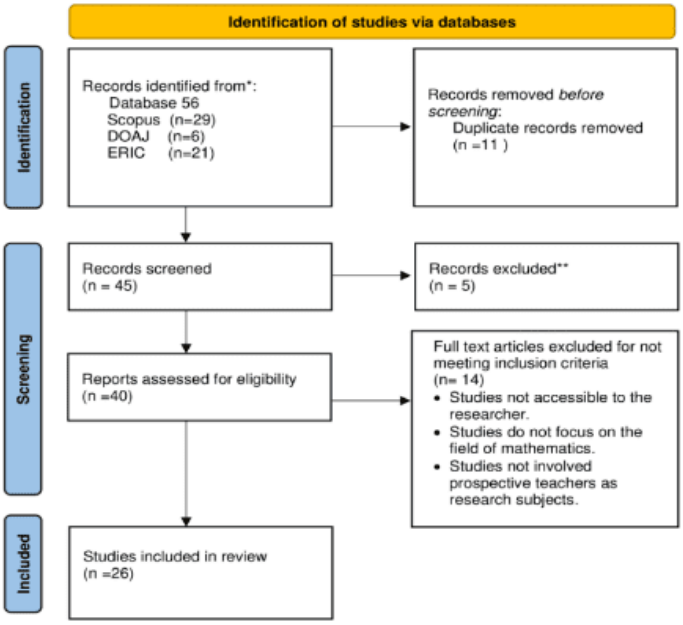

Figure 1. Illustrates the process of searching and selecting papers using the PRISMA flow chart diagram.

Identification

There are three ways to search for literature in the database. The first way is to search for articles published in English in Scopus-indexed journals. The direct access to the DOAJ portal database page (https://doaj.org/) is the second method, and the direct access to the ERIC portal page (https://eric.ed.gov/) is the third. The author utilizes the DOAJ and ERIC portals due to their worldwide recognition, credibility, and provision of open access across various subjects.

The next step involved searching for articles in the databases using the keywords' pre-service teachers', 'trust,' and 'maths''. Table 1 displays the article selection strategy.

Table 1. The selection strategy for the database

Database	Method	Search String	Result
Scopus	Software Publish or Perish	Search for "pre-service teacher's," "beliefs," and "mathematics" by title from 2020-2024	29
DOAJ	Login website	Search for pre-service teachers' beliefs in mathematics by title from 2020-2024	6
ERIC	Login website	Search for pre-service teachers' beliefs in mathematics by title from 2020-2024	21

In addition, The search for articles was restricted to articles in the four databases for publications from 2020 to 2024. The restriction was made to ensure the novelty of the research in the last 5 years.

Screening

The screening results revealed 26 articles, including five that could not be fully accessed, 11 duplicates across three search databases, and 14 that were not included in this study due to irrelevance in the research field. **Table 2** below presents the results of the descriptive analysis.

Table 2. The results of the descriptive analysis

Criteria	Description	Result
Main Information	Year	2020-2024
	Total Documents	26
	Database Scopus	19
	Database DOAJ	1
	Database ERIC	6
Type of Document	Article	26
Category	Scopus (Q1)	9
	Scopus (Q2)	6
	Scopus (Q3)	7
	Scopus (Q4)	0
	Scopus (Non-Q)	4

The authors conducted a descriptive analysis, reviewing key information, document types, and article categories to present insights into article development. Exclusion criteria included inaccessible articles and articles that did not explicitly address pre-service teachers' beliefs in the context of mathematics teaching.

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Eligibility

At this step, we manually checked each article to ensure it complied with the standards, read the entire paper, and evaluated the abstract and title. Once we verified the eligibility, we received 26 articles.

Quality Assessment

This step involved validating the articles obtained. We selected papers from journals in the Scopus, DOAJ, and ERIC indices. We selected articles published in the specified timeframe from 2020 to 2024. The purpose of selecting works from this literary epoch was to investigate uniqueness. We also ensured that each article met certain quality thresholds, such as journal indexation and clarity of research methodology. For this study, we reviewed 26 articles, 25 in English and 1 in Spanish.

We analyze the countries, methods, sample characteristics, gender, constructs, and instruments used through diagrams. Next, using tables, we examined and discussed the research findings. Furthermore, we employed network and content analysis to classify the study's measurable domains and bibliometric analysis to determine the pre-service teachers' views in mathematics. A bibliometric study was carried out utilizing Vosviewers with Mendeley keyword data. Next, we looked at each article's pattern of similarity.

3. Results

RQ 1: Countries

Figure 2 shows the countries that have conducted the most research on pre-service teachers' beliefs about mathematics.

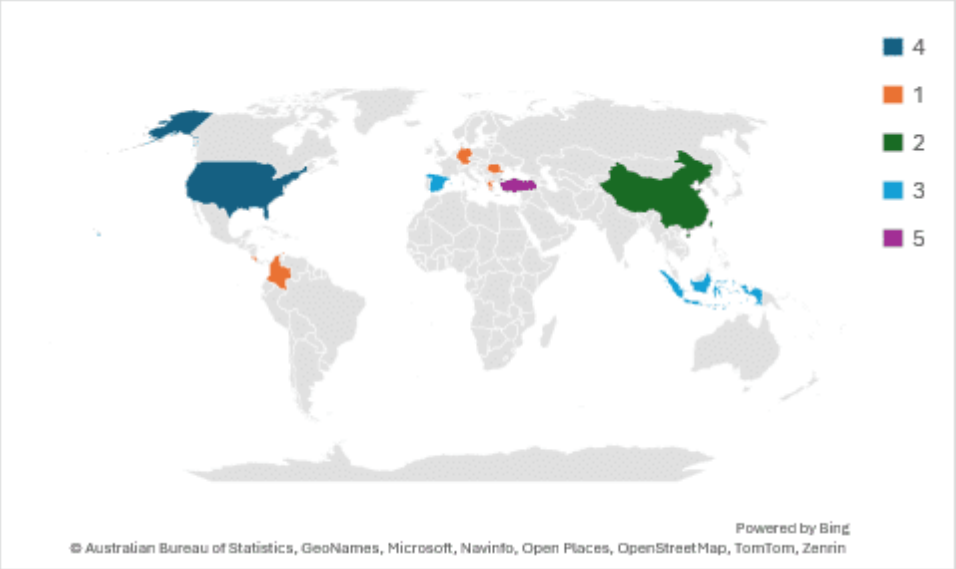

Figure 2. Which countries investigate pre-service teachers' beliefs about mathematics in the literature

The findings based on **Figure 2** show that many studies have been conducted in America, Europe, and Asia. Developed countries dominate over developing countries, suggesting a possible relationship between a country's level of educational development and attention to the study of teacher beliefs. With five papers, Turkey has the most research on pre-service teachers' mathematical beliefs, followed by the United States with four. China, Taiwan, Indonesia, and Spain

have three publications each. Meanwhile, the countries with the least literature are Colombia, Belgium, Canada, Lebanon, Costa Rica, Greece, and Romania, each with only one publication.

RQ 2: Methods

Figure 3 presents data on the methods used across the literature to investigate pre-service teachers' exposure to mathematics.

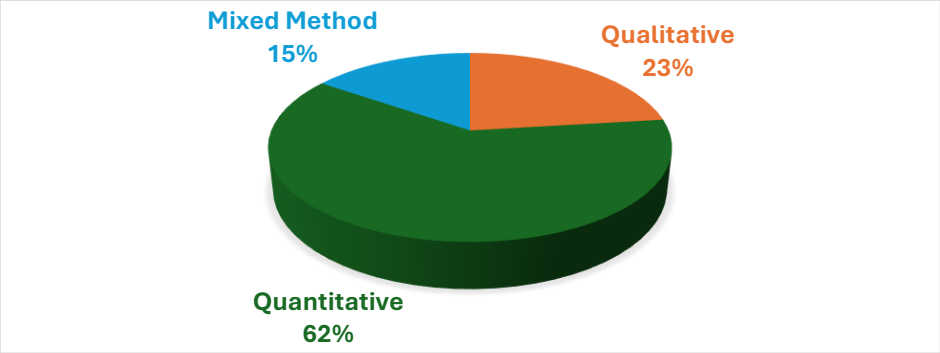

Figure 3. Methods used in the literature

Figure 3 shows that quantitative methods dominate this study, used by 62% or 16 of 26 kinds of literature. Qualitative methods were used in six pieces of literature (23%), while mixed methods were only found in four (15%). The dominance of quantitative approaches shows a tendency to measure beliefs in a structured and scaled manner, but qualitative approaches explore the in-depth meaning of pre-service teachers' beliefs contextually.

RQ 3: Characteristics of the sample

Figure 4 displays the characteristics of the sample, which are based on data from various literature investigating pre-service teachers' beliefs in mathematics.

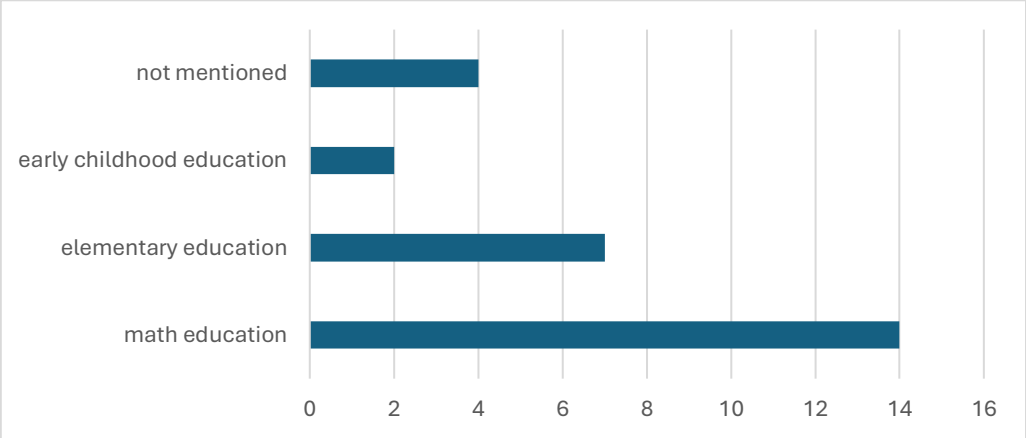

Figure 4. Sample characteristics across the literature

Figure 4 shows the characteristics of the sample. We found the characteristics of the pre-service teacher sample in the literature by categorizing the academic fields into mathematics education, primary education, and early childhood education. Maths education is the most dominant field, mentioned in 14 of 26 publications. Primary education is mentioned in seven pieces of literature, and early childhood education is mentioned in only two. Four pieces of literature do not specifically mention the academic field of pre-service teachers. It suggests that most research focuses on pre-service teachers directly studying or involved in formal mathematics education.

RQ 4: Gender

Figure 5 displays the gender data for the sample in the literature, which investigates pre-service teachers' beliefs in mathematics.

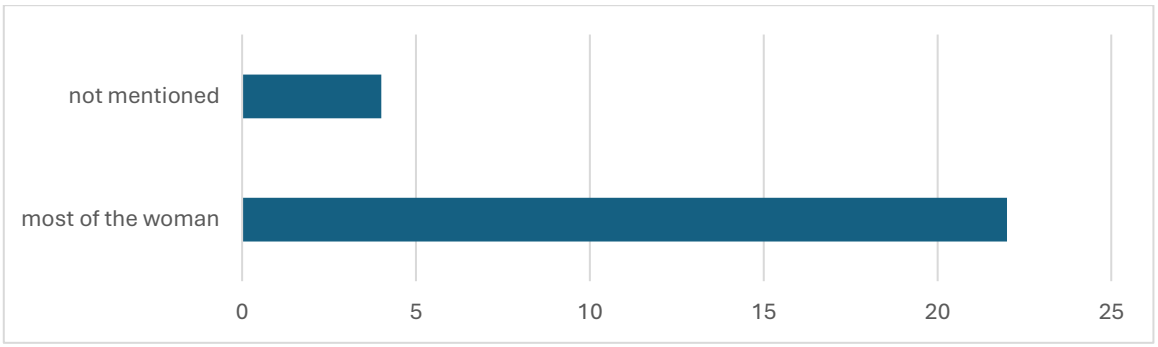

Figure 5. Gender of the sample in the literature

Figure 5 displays the most frequently sampled gender, examining pre-service teachers' beliefs about mathematics across the literature. Most of the 22 pieces of literature include more females than males in the sample. None of the studies included males as the majority of the sample. Four texts do not mention gender explicitly.

RQ 5: Constructs

Figure 6 displays data on the constructs of beliefs in mathematics used across the literature to investigate pre-service teachers in mathematics.

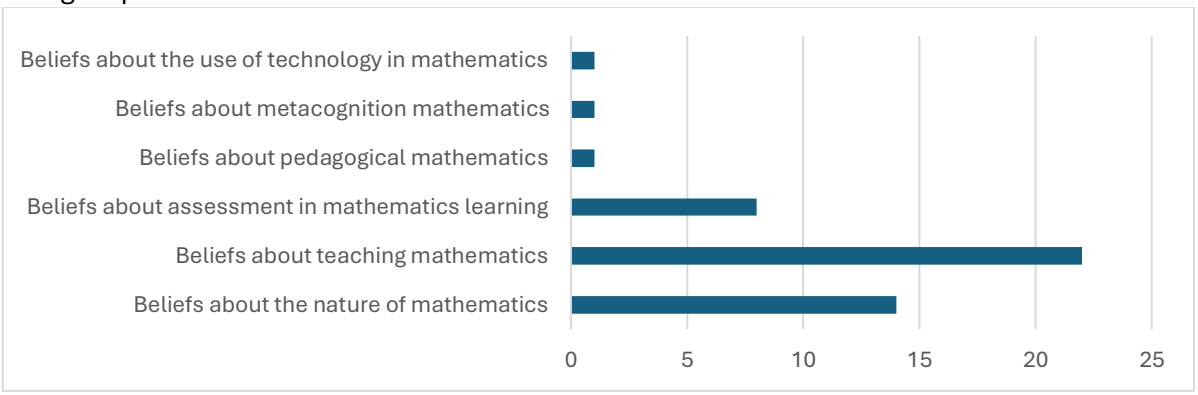

Figure 6: Constructs of beliefs in mathematics used across the literature

The most popular constructs for studying pre-service teachers' attitudes towards mathematics are shown in **Figure 6**. Beliefs about teaching mathematics are the most frequently investigated construct, with 22 out of 26 literatures mentioning it. It is followed by beliefs about the nature of mathematics (14 literatures) and assessment in learning (8 literatures). The least frequent constructs are beliefs about metacognition, pedagogy, and technology, each in only one study. This variation in constructs indicates the complexity of understanding pre-service teachers' beliefs and opens up opportunities for further exploration of this under-researched area.

RQ 6: Instruments

Figure 7 displays data on the instruments used in the literature to investigate pre-service teachers' attitudes toward mathematics.

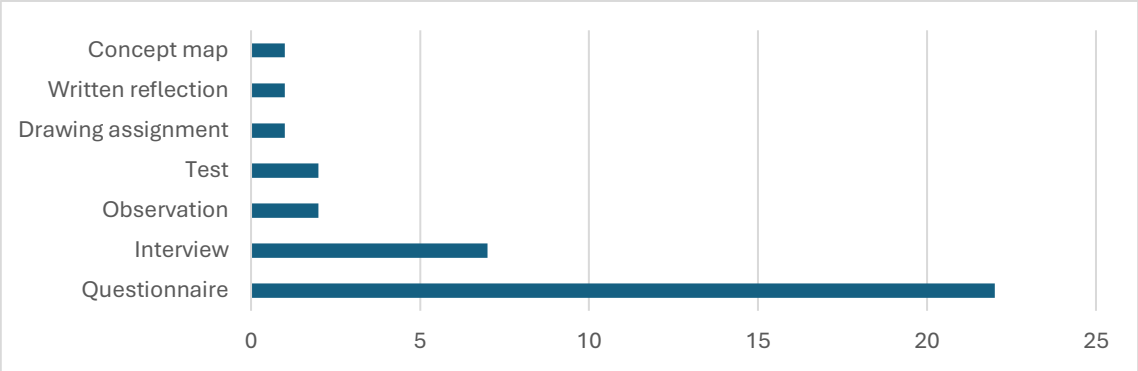

Figure 7. Instruments used across the literature

Figure 7 shows the instruments most commonly used to examine pre-service teachers' beliefs about mathematics. The most frequently used instrument is questionnaires (used in 22 out of 26 studies), followed by interviews (7 studies) and observations and tests (2 each). Written reflections, drawing tasks, and concept maps are used in only one study each. The dominance of questionnaires signals researchers' preference for tools that allow for large-scale data collection.

RQ 7: Research results

Table 3 Reveals the research data utilized in the literature to examine pre-service teachers' attitudes toward mathematics.

Table 3. Research results from various literature

No	The Author	Results
1.	Sarah Wellberg	Pre-service teachers' perspectives on the nature of mathematics closely influence their course choices. Pre-service teachers who have completed more mathematics courses tend to regard mathematics as a collection of rules (Wellberg, 2024).
.2.	Grace-Judith Vesga-Bravo Zaida-Mabel Angel-Cuervo Gerardo-Antonio Chacón-Guerrero	While teacher applicants have more preliminary opinions that are typically not consistent with what is expressed in their lesson plans, teachers have stronger convictions demonstrated in their suggestions for the classroom (Vesga-Bravo et al., 2022).
3.	Grace Judith Vesga-Bravo Zaida Mabel Angel-Cuervo	Interpreting expressed beliefs does not always align with practice (Vesga-Bravo & Angel-Cuervo, 2021).
4.	Petra Scherer Jennifer Bertram	Pre-service teachers' perceptions of student accomplishment and their level of self-efficacy for teaching inclusive mathematics shift throughout the teacher education program (Scherer & Bertram, 2024).
5.	Y. W. Purnomo	Created a scale that is both valid and dependable and addresses the three fundamental assumptions about the nature of mathematics (Purnomo, 2023).
6.	M. José Justicia-Galiano and Santiago Pelegrina	The study's findings imply several different origins for math myths rather than just one fundamental cause. Advocating specific ideas about who can do arithmetic might exacerbate unfavorable feelings about the subject (Justicia-Galiano & Pelegrina, 2024).
7.	Vanessa Hanin and Jennifer Holm	Three distinct belief profiles among pre-service teachers: anti-social constructivist, socio-constructivist, and flexible. These profiles indicate higher complexity than the commonly accepted binary model and support the need for a more balanced approach to teaching (Hanin & Holm, 2023).

No	The Author	Results
8.	Tuğba Öçal	Participants' negative and positive experiences were closely linked to their beliefs about unforgettable mathematics teaching, focusing on the influence of teachers, students, methods, and materials (Öçal, 2021).
9.	Bhesh Mainali	Findings revealed that both participants had negative beliefs toward mathematics before the course. However, one participant experienced positive changes after the course, while the participant with a mathematics learning disability (MLD) continued to hold negative beliefs (Mainali, 2022).
10.	Maria Yamak & Youmen Chaaban	Following the course, there were significant differences in personal and general efficacy beliefs and understanding of how to learn math (Yamak & Chaaban, 2022).
11.	Jin Su Jeong & David González-Gómez	The flipped classroom methodology (F-ABN) showed a significant impact on PSTs' self-belief, making the class more interactive and increasing their confidence in learning mathematics (Jeong & González-Gómez, 2022).
12.	Jaime Segarra, Carme Julià	Accomplishments and their opinions and attitudes toward mathematics. The primary factor was the Personal Mathematics Teaching Efficacy (PMTE) subscale (Segarra & Julià, 2022).
13.	Wing Yee Lo	Most prior learning experiences, both favorable and unfavorable, influenced Wing Yee Lo's perspectives on teaching mathematics. Pre-service educators understand the significance of improving their students' learning environments going forward (Lo, 2020).
14.	Xinrong Yang, Gabriele Kaiser, Johannes König, Sigrid Blömeke	Beliefs about mathematics had stronger associations with inquiry-oriented teaching practices than mathematical content knowledge (Yang et al., 2020).
15.	Dilara Yılmaz, Hakan Turan	Pre-service teachers' self-efficacy belief levels were high for both subjects. There were no significant differences by gender. Level 4 pre-service teachers had higher self-efficacy beliefs when teaching mathematics. There was a moderately positive relationship between self-efficacy beliefs in both subjects (Yılmaz & Turan, 2020).
16.	Melih Derya Gurer, Recai Akkaya	Pre-service math teachers favored constructivist teaching, and this worldview greatly influenced the components of the Technology Acceptance Model (TAM). Conventional wisdom has a beneficial impact on perceived ease of use but does not affect attitudes toward or perceptions of the utility of technology (Gurer & Akkaya, 2022).
17.	Wanda Nugroho Yanuarto, Siti Mistima Maat, Eka Setyanigsih, Muhammad Galang Isnawan, Mohamad Ikram Zakaria	Teaching anxiety is a mediator in the association between pre-service teachers' opinions about the relationship between TPACK and ICT literacy and their degree of ICT literacy. (Yanuarto et al., 2023).
18.	Ifada Novikasari, Yüksel Dede	Pre-service math instructors had favorable beliefs for the C1, C3, and C4 components, while the C2 component was neutral. This study significantly added to the knowledge body in mathematical literature (Novikasari, 2021).
19.	Yung-Chi Lin	The bulk of participants expressed a preference for building pedagogical content knowledge (PCK) over content knowledge (CK) and held views that were both teacher- and student-centered (Lin, 2022).

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No	The Author	Results
20.	Hendra Kartika, Lessa Roesdiana	There is a negative correlation between metacognitive beliefs and math anxiety, with females experiencing more anxiety in math than males (Kartika & Roesdiana, 2020).
21.	Helen Alfaro Víquez dan Jorma Joutsenlahti	Both demonstrated a belief in a constructivist, learner-centered orientation and agreed that mathematical skills are not fixed and not related to gender or culture (Alfaro Víquez & Joutsenlahti, 2021).
22.	Konstantinos Lavidas, Irini Skopeliti, Konstantinos Zacharos	The level of mathematics anxiety and experience significantly influences pre-service teachers' attitudes and views about teaching arithmetic (Lavidas et al., 2023).
23.	Peter C. Cormas	The training shifted the views of teacher applicants toward constructivism. Teachers-to-be had comparable ideas about science and math when they started and finished the course (Cormas, 2022).
24.	Ayse Ozben Elif Kilicoglu	The pre-service teachers' anxiety about teaching mathematics was below average, whereas the other components were at normal levels. The degree of concern and perceived self-efficacy were negatively correlated, while the degree of professional confidence and perceived self-efficacy were positively correlated. (Ozben & Kilicoglu, 2021).
25.	Berna Cantürk Günhan	Assessments of pedagogical topic comprehension positively impacted the attitudes of pre-service math instructors toward teaching mathematics. Their views about mathematics are a complete mediating factor in the link between their attitudes toward teaching mathematics and their judgments of pedagogical topic knowledge (Cantürk Günhan, 2020).
26.	Christine M. Phelps-Gregory Martha Frank Sandy M. Spitzer	Even though some pre-service teachers' ideas have changed, many of their persistent falsehoods have remained constant and resistant to modification (Phelps-Gregory et al., 2020).

Table 3 shows the results of various studies examining pre-service teachers' beliefs about mathematics. Researchers describe the literature in the hope that it can be a reference for readers regarding various research results. However, the above literature reveals some similarities, such as the positive influence of the pre-service teachers' belief domain on several other domains studied alongside it, which we aim to explore further through research question 8.

RQ 8: Other domains

Figure 8 illustrates the use of other domain data and beliefs in mathematics in the literature examining pre-service teachers' attitudes toward mathematics.

Figure 8. The literature utilizes other domains in conjunction with mathematical beliefs

Figure 8 shows that pre-service teachers' beliefs in Mathematics are self-efficacy. Anxiety, professionalism, equity, and inclusion are related to pre-service teachers' math beliefs; self-efficacy is the most common study. Self-efficacy is the most frequently researched domain, along with mathematics beliefs. Other domains that also emerged were anxiety, professionalism, equity, and inclusion. Future research can explore causal relationships and possible interventions to strengthen positive beliefs.

4. Discussion

The research findings show that Turkey has the highest level of research confidence. This aligns with the belief that the USA, the UK, and Turkey are the most productive countries in mathematics education research (Ali, 2018). The study also showed that since 2002, mathematics education studies in Turkey have significantly increased using quantitative methods to measure pre-service teachers' beliefs (Ciltas et al., 2012).

The results showed that females dominated the most frequently used sample characteristics, specifically the gender of pre-service mathematics instructors, in research samples collected from various literature. This aligns with the belief that women predominantly occupy teaching, accounting for 68% of all teaching and administrative positions at primary and secondary levels (DeCourse & Votgle, 1997). These findings highlight the broader gender dynamics within the teaching profession and raise questions about potential biases in the recruitment and representation of participants in the study. Further research could examine why male representation is lower and how this affects the generalizability of study results.

Another study finding showed that questionnaires were the most commonly used instrument. This aligned with the direct statement that questionnaires typically assess attitudes, beliefs, and behaviors (Yongqi Gu, 2016). However, the dominance of questionnaires also suggested potential limitations in capturing pre-service teachers' beliefs in depth. If more qualitative research were explored, such as in-depth interviews or classroom observations, it would allow for a more holistic exploration of the nuances of these beliefs.

This study finds that beliefs about teaching math are the most commonly studied. Research showed that teachers' perceptions about learning to teach mathematics significantly influence the pace of curricular transformation (Handal & Herrington, 2003). Meanwhile, research on mathematics confidence has yielded mixed results. Researchers have often looked at the domain

of confidence. Research revealed a positive relationship between pre-service teachers' perceptions of self-confidence and their level of self-confidence (Ozben & Kilicoglu, 2021).

5. Conclusion and Implications

We found the issue of gender in the literature exciting in light of the findings described earlier. The results show that women outnumber men in several studies. There are more female candidates for teaching positions than males. These findings highlight the inequality of gender representation and open up opportunities to further explore how gender identity influences the formation of prospective teachers' teaching beliefs and practices. Consequently, investigating the roles of male and female pre-service teachers is of great interest. The present study aims to establish and build pre-service teachers' beliefs in mathematics.

Previous literature highlights the importance of improving pre-service teachers' beliefs, directly impacting the effectiveness of learning mathematics in the classroom. Governments must endeavor to understand and improve teachers' beliefs, knowledge, and literacy and adjust their education policies. Building mathematical knowledge and attitudes to teaching is also an important component of Indonesian teacher development and education programs, particularly at the pre-service teacher education stage.

Therefore, future research should be directed toward designing and developing interventions to strengthen the mathematical beliefs of pre-service teachers, especially males, who have been underrepresented. Future research should consider methodological approaches such as longitudinal studies to track changes in beliefs over time or mixed methods to simultaneously explore a more comprehensive understanding of quantitative and qualitative data.

Furthermore, the role of self-efficacy in shaping pre-service teachers' teaching beliefs and practices can be the focus of an in-depth exploration. It provides insights into how teachers' confidence in mathematics correlates with their chosen instructional strategies.

The research argument is that, although pre-service teachers already know each instructional practice implemented during their education program, it is important to build beneficial mathematical beliefs in themselves and an important aspect of employability that pre-service teachers are expected to possess.

From a policy perspective, the research results can be used to design belief-based training, integrate critical reflection in the teacher education curriculum, and develop cultural and gender context-based learning modules.

While the systematic review method ensures comprehensiveness and transparency, the dominance of quantitative studies (62%) may limit the exploration of deeper qualitative perspectives. Future studies can adopt a mixed approach more explicitly to integrate numerical and narrative data in understanding teachers' beliefs thoroughly, especially in complex and multicultural educational contexts.

Credit authorship contribution statement

Yesi Martha Afrillia: Methodology, Resources, Formal analysis, Data curation, Conceptualization. **Yoppy Wahyu Purnomo**: Review, Methodology.

Declaration of competing interest

The authors affirm that they have no known competing personal or financial interests that may have impacted the work presented in this paper.

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Ethical Declaration

Before beginning the trial, each participant gave their informed consent. They were aware of the goals, methods, and consequences-free withdrawal policy.

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