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Connecting beliefs, identity, and attitudes to practice: a systematic review of pre-service mathematics teachers

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Abstract. *This systematic literature review aims to examine how beliefs, professional identity, and attitudes shape pre-service mathematics teachers' instructional practices and professional development. The study addresses a critical gap in the existing literature, which has largely focused on these affective components in isolation rather than exploring their interconnections. A systematic search was conducted in the SCOPUS database for the period 2015–2026 using the keywords "beliefs," "identity," and "attitudes." Following the PRISMA framework, 20 peer-reviewed articles met the inclusion criteria and were synthesized qualitatively. The findings reveal that constructivist and dynamic beliefs are stronger predictors of inquiry-oriented instructional practices than content knowledge, yet a persistent belief-practice gap remains. Professional identity is context-dependent, shaped by working communities, failure experiences, and sustained engagement, with resilient pre-service teachers redefining goals rather than allowing failure to define them. Mathematics anxiety emerges as the most dominant affective barrier, and reducing it can trigger a positive domino effect on enjoyment, self-concept, and teaching enjoyment. Importantly, beliefs, attitudes, and identity are deeply interconnected: beliefs mediate the relationship between knowledge and practice, and causal chains link positive attitudes toward mathematics to positive teaching identity. This review concludes that teacher education cannot address these constructs in isolation. Implications include prioritizing belief transformation alongside knowledge, providing transformative field experiences, explicitly addressing failure to build resilience, and adopting holistic approaches that integrate beliefs, attitudes, and identity simultaneously.*

Keywords: *Attitude, Beliefs, Identity, Pre-service Mathematics Teacher*

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Introduction

The affective aspect plays a crucial role in the transformation of pre-service mathematics teachers, from simply learning mathematics to teaching mathematics. Among the various affective components, beliefs, professional identity, and attitudes are recognized as key factors influencing teachers professional development and how they teach in the classroom (Beisly et al., 2025). Beliefs act as lenses through which pre-service teachers understand the nature of mathematics, the purpose of teaching, and the role of students in learning. These beliefs impact not only how they develop lesson plans but also how they respond to students' errors, manage

discussions, and accept or reject innovative teaching approaches (Wellberg, 2025). Similarly, professional identity shapes how pre-service teachers perceive themselves as future mathematics educators including their sense of belonging, confidence, and commitment to the profession (Ladachart, 2025; Mitiche, 2024). Meanwhile, attitudes such as emotions, math anxiety, and self-efficacy also influence the extent to which students are willing to engage with mathematics materials and persist when facing various challenges in teaching (Cil & Akcay, 2025). These three factors are not mutually exclusive; they are interrelated and continuously interact throughout the pre-service teachers education (Lloyd, 2024; Radišić et al., 2024; Zonnefeld, 2024).

Research on the beliefs, identity formation, and attitudes of pre-service mathematics teachers has been extensively conducted across various educational and cultural contexts. Several studies have highlighted how constructivist and traditional beliefs influence teaching decisions (Wellberg, 2025), how professional identity develops through field experiences and critical moments (Ladachart, 2025; Mitiche, 2024), and how mathematics anxiety or positive attitudes toward mathematics emerge from school experiences or specific intervention programs (Beisly et al., 2025; Cil & Akcay, 2025). Zonnefeld (2024 found that gradual positive changes in beliefs and identity can occur over training. However, Lloyd (2024) pointed out that change is difficult because long-held beliefs often conflict with the new approaches being taught. Furthermore, a classic problem that remains frequently encountered is the mismatch between what prospective teachers believe, feel, and actually do in the classroom. Radišić et al., (2024) revealed that someone might claim to have strong constructivis beliefs, considering themselves a modern teacher, but in practice still use traditional lecture methods due to various limitations or unresolved emotional pressures. This shows that beliefs, identities, and attitude do not operate in isolation, but rather influence each other in complex and sometimes contradictory ways.

One interesting finding from recent research is that professional identity is not formed in a linier or straightforward manner. Prospective teachers often experience so called turning points moments when their expectations collide with the realities of the field, or when they fail at a teaching assignment. These moments can be opportunities for identity reshaping, although the process is often uncomfortable and challenging (Mitiche, 2024). More practically, educational programs that incorporate mediated field experiences have been shown to be effective in shifting prospective teachers beliefs form teacher-centered to student-centered (Zonnefeld, 2024). In fact, this shift in beliefs occurs not only among prospective teachers at the beginning level, but also among those who have entered the final stages of their education.

Although the number of studies in this area continues to grow, Lloyd (2024) argues that the existing literature remains fragmented. Most studies focus on only one affective component either belief, identity, or attitude without fully examining how the three interact. Furthermore, Radišić et al., (2024) add the differences in theoretical approaches, methods, and research context make it difficult to gain a coherent and integrated understanding. Much of the literature is also dominated by research from western countries, making the results not necessarily directly applicable tp regions with different cultural background. Beisly et al. (2025) exemplify that in Southeast Asia, shred values, religious views, and more hierarchical educational traditions may shape the interaction between belief, identity, and attitude differently. However, Cil & Akcay (2025) acknowledge that studies from such context are still very limited and have not been systematically synthesized. Therefore, Mitiche (2024) emphasizes the need for a comprehensive and context sensitive review not only mapping each affective component, but also how they influence each other throughout the education of prospective mathematics teachers.

Thus, this study aims to systematically review existing research on the affective domain of pre-service mathematics teachers, particularly the role of beliefs, professional identity, and

attitudes, and how these interact. This study seeks to answer the following questions:

RQ1: How do pre-service mathematics teachers' beliefs influence their instructional practices?

RQ2: How is pre-service mathematics teachers' professional identity formed?

RQ3: What affective factors shape pre-service mathematics teachers' attitudes?

RQ4: How do beliefs, attitudes, and identity interact in pre-service mathematics teacher education?

By offering as a structured and critical synthesis of the literature, this study contributes to advancing a more integrated understanding of the dynamics between beliefs, attitudes and identity in mathematics education, as well as its implications for developing more effective teacher education programs that are sensitive to local context, particularly in Southeast Asia.

Method

This research utilises a systematic literature review as the methodology to analyse prior research on pre-service mathematics teachers' identities (Gough et al., 2012). Such a review is critical for producing a methodical, conceptual, and analytical overview of past studies (Perdana & Muslih, 2021) and for generating insights for future research (Borrego et al., 2014). Only peer-reviewed studies from databases that include a wide range of educational research journals are considered to ensure quality. A PRISMA flowchart (Page et al., 2021) was used to visually present the search process and information flow, from identification and screening to final inclusion, along with the total number of included studies, ensuring reproducibility and transparency.

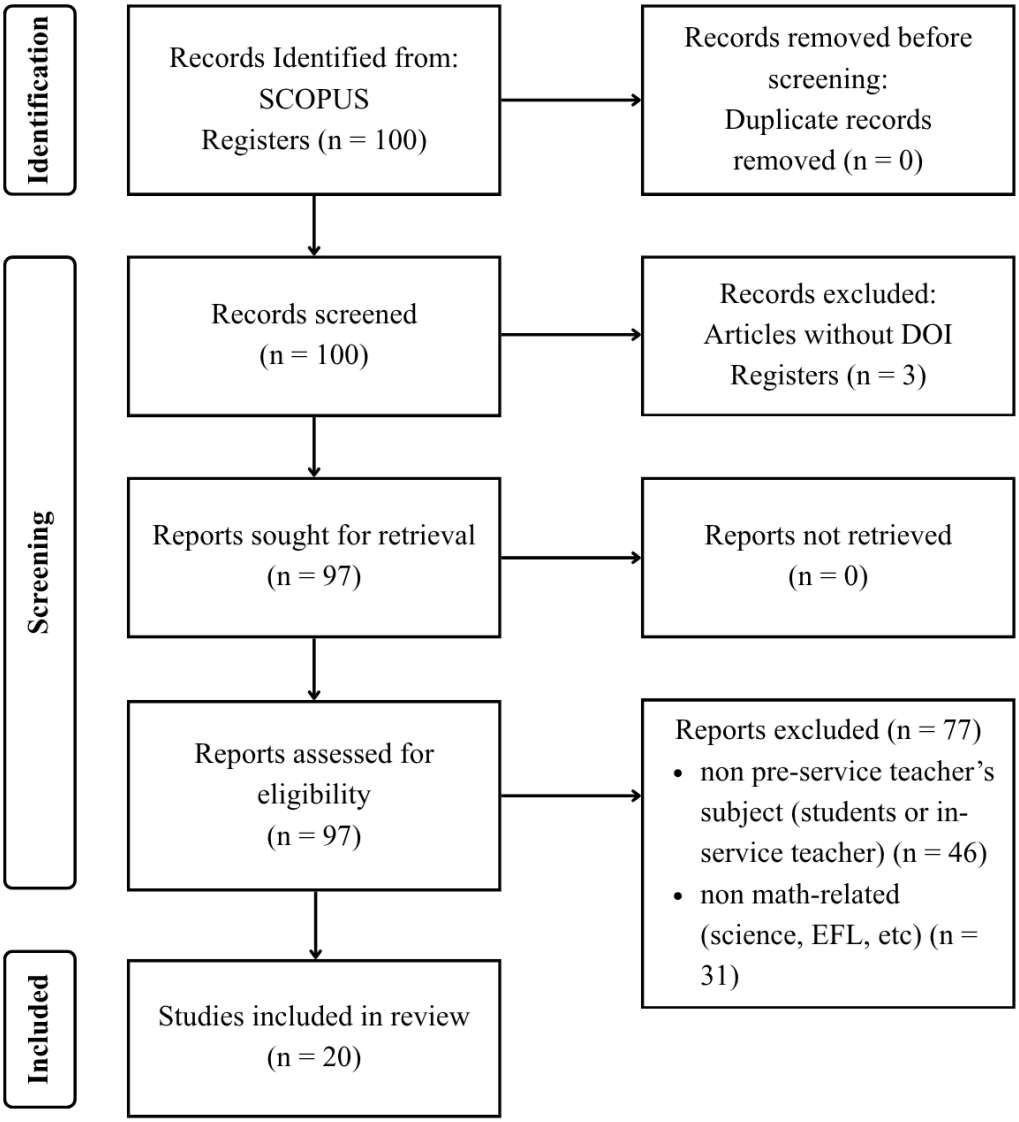

Figure 1. PRISMA Flow diagram Tailored to The SLR

A selection process was conducted to establish inclusion and exclusion criteria for the identified articles. Inclusion criteria included articles sourced from the SCOPUS database with "beliefs," "identity," and "attitudes" as primary keywords, published within a specified timeframe, with full-text access, and related to pre-service teachers and mathematics. The search for this SLR was conducted through the SCOPUS database for the period 2015-2026. The keywords "beliefs," "identity," and "attitudes" were used as a search string for journals in the SCOPUS database. Terms such as"pre-service teachers," "mathematics," or "math," were not included in the search string. This aimed to avoid overly restricting the search result and to reach a broader scope of relevant studies. These aspects were then addressed during the screening process based on the established inclusion and exclusion criteria. The search process resulted in 100 articles from the SCOPUS database. This research only focuses on articles that have been peer-reviewed, so theses, proceedings, and the like are not included.

The study selection process followed the PRISMA framework, which consists of identification, screening, and included. Of the 100 articles listed in the SCOPUS database, no duplicate records were found. All 100 articles proceeded to the screening stage. Three articles were excluded due to the lack of a DOI (Digital Object Identifier). The decision to only include articles with a DOI was a strategic step to ensure bibliometric traceability, long-term accessibility, and

academic accountability of the sources. The remaining 97 articles then proceeded to the retrieval stage. Based on a review of the titles and abstracts, no articles were excluded at this stage. The 97 articles were then assessed for eligibility through full-text analysis. As a result, 76 articles were excluded: 46 articles because the subjects were not pre-service teachers and 31 articles because they were not related to mathematics. Ultimately, 20 articles met all inclusion criteria and were included in the qualitative synthesis.

Result

A structured data extraction process was employed to systematically address the research questions, aiming to organize and synthesize relevant information from the selected studies. The extraction framework was specifically tailored to capture key aspects concerning pre-service mathematics teachers' beliefs, attitudes, and identities. The analysis of each study included an examination of its contextual background, methodological characteristics, and primary focus, followed by a detailed identification of the types of beliefs, attitudes, and identity were subsequently categorized to determine whether they were aligned, misaligned, or partially aligned, and how they interacted to shape pre-service teachers' professional competence. This structured method enables consistent and transparent comparison across studies, facilitating the identification of patterns, themes, and research gaps in the existing literature.

Beliefs Drive Practice (RQ1)

A consistent finding across multiple studies is that constructivist and dynamic beliefs about mathematics are stronger predictors of pre-service teachers' instructional practices than content knowledge. Mathematics methods courses and transformative field experiences can shift beliefs toward reform-based approaches. However, a persistent gap exists between professed beliefs and enacted practices.

Table 1. Data Extraction Aligned with Research Questions 1

No	Author	Year	Country	Focus	Method	Participants	Key Findings
1	Lau, W. W. F.	2021	Hong Kong	Teacher's beliefs, self-efficacy, conceptions	Quantitative	80 pre-service teachers	Math beliefs & personal teaching efficacy predicted traditional conceptions. Math self-efficacy & outcome expectancy predicted constructivist conceptions
2	Yang, et.al.	2020	China	Teacher's knowledge, beliefs, practices	Quantitative	495 pre-service teachers	Beliefs are stronger predictors of self-reported practices than knowledge; core beliefs act as filters
3	Jao, L.	2016	Canada	Teacher's belief change	Mixed Method	28 pre-service teachers	Experience with reform-based approaches as learners & reflection are critical for belief change

4	Lloyd, M. E. R.	2017	USA	Teacher's belief transformation	Mixed Method	40 pre-service teachers	One positive field experience confirming innovation can sustain belief change. T5 PSTs need explicit disconnect awareness
5	Hidayat, R., et.al.	2024	Malaysia	Teacher's beliefs and TPACK	Quantitative	159 pre-service teachers	TPACK is crucial for shaping positive beliefs about technology integration in math teaching
6	Yang, X. & Leung, F. K. S.	2015	China	Teacher's beliefs and ICT use	Quantitative	787 pre-service teachers	Beliefs about math nature & teaching align with beliefs about technology use
7	Gurer, M.D. and Akkaya, R.	2021	Turkey	Teacher's beliefs and attitude	Quantitative	714 pre-service teachers	Constructivist beliefs are important for positive attitudes toward technology.
8	Mainali, B.	2022	USA	Teacher's beliefs	Qualitative	2 pre-service teachers	Highlights challenges in changing deeply rooted negative beliefs, especially for pre-service teachers with MLD. Underscores importance of methods courses and individualized instruction

Identity is Context-Dependent (RQ2)

Professional identity is a dynamic, socially constructed process shaped by working communities, failure experiences, sustained engagement, and quality practicum experiences. Pre-service teachers with strong mathematics identities demonstrate resilience by redefining goals rather than allowing failure to define them.

Table 2. Data Extraction Aligned with Research Questions 2

No	Author	Year	Country	Focus	Method	Participants	Key Findings
1	Livy, S., et.al.	2018	Australia	Mathematical Content Knowledge, Teacher Identity	Qualitative	2 pre-service teachers (Lisa dan Rose)	Program structure & sustained engagement are critical; lesson planning & reflection support

							MCK development
2	Lutovac & Flores	2021	Portugal	Failure, teacher Identity	Qualitative	45 pre-service teachers	Failure reflection should be included in teacher education; identity work around failure supports resilience
3	Lutovac	2019	Finland	Failure, Resilience, Identity	Narrative	2 pre-service teachers (math specialist)	Subjective understanding of failure is crucial. Teacher education should address failure experiences to build resilience
4	Lutovac	2020	Finland	Teacher's identity	Qualitative	43 elementary & 18 secondary pre-service math teachers	Past math failure shapes pre-service teachers' possible selves with elementary and secondary PSTs showing more similarities than differences.
5	Goos, M., et.al	2017	Australia	Collaboration, Boundary, Crossing	Qualitative	6 universities	Cross-disciplinary collaboration between mathematicians & math educators created new boundary practices. Enablers: trust, shared problems. Barriers: physical separation, workload models
6	Machalow, R., et al	2020	USA	Narrative Arcs, Identity	Narrative	163 Pre-service teachers (5 cohorts)	Relationally-oriented teaching transforms narratives; reform movement has not significantly changed pre-service teachers experiences over time

Attitudes are Multidimensional (RQ3)

Attitudes toward mathematics encompass enjoyment, anxiety, perceived usefulness, perceived difficulty, and self-concept. Mathematics anxiety is the most dominant affective factor, with perceived relevance triggering positive attitude change, particularly for pre-service teachers with negative initial identities.

Table 3. Data Extraction Aligned with Research Questions 3

No	Author	Year	Country	Focus	Method	Participants	Key Findings
1	Marban, J. M., et.al.	2021	Spain	Teacher's affective domain (Anxiety, Attitudes, Beliefs)	Quantitative	1473 pre-service teachers	Anxiety is a key factor influencing other affective components and indirectly affects enjoyment of teaching through the mediation of enjoyment of mathematics.
2	Leavy, A., et.al.	2015	Ireland	Teacher's attitude, reform curriculum	Quantitative	360 & 419 pre-service teachers (two cohorts)	The 2003 cohort had higher enjoyment, while the 2013 cohort had higher value beliefs. Attitudes remained relatively stable despite curriculum reform
3	Heffernan & Newton	2019	USA	Teacher's identity	Mixed-method	16 early childhood pre-service teachers	An identity exploration intervention using the PRESS model in a college algebra course helped early childhood pre-service teachers change their mathematics identity, with those holding negative initial identities showing the most significant changes.
4	Segarra, J. et al.	2021	Spain	Teacher's beliefs	Quantitative	419 pre-service teachers	Student teaching practice is key to improving personal teaching efficacy.
5	Jacobs, G. J., &Durandt, R.	2017	South Africa	Teacher's attitudes	Quantitative	50 pre-service teachers	Attitudes are domain-specific and influenced by gender and prior achievement. The study highlights the importance of exposing pre-service teachers to modelling during

							formal education and using an appropriate modelling pedagogy to build confidence and positive attitudes.
6	Tak, C. C. et al.	2025	Malaysia	Teacher's attitude	Quantitative	378 pre-service teachers	Attitude had a significant relationship with mathematics reasoning. Metacognitive awareness mediated the relationship between attitude and mathematics reasoning.

Beliefs, Attitudes, and Identity Interconnect (RQ4)

Based on the synthesis of Tables 1, 2, and 3, it was found that beliefs, attitudes, and identity are deeply interconnected. Beliefs mediate the relationship between knowledge and practice. Causal chains connect positive attitudes toward mathematics to positive teaching identity. Elizabeth & Lloyd (2017) identified five typologies of belief transformation that also reflect the integration of attitudes and identity. Yang et al. (2020) showed that beliefs mediate the relationship between knowledge and practice. Marbán (2020) demonstrated a causal chain from positive attitudes toward mathematics to a positive teaching identity.

Discussion

This study synthesizes findings across multiple international contexts to understand how pre-service mathematics teachers' professional dispositions develop. The results consistently reveal that beliefs, attitudes, and identity are not isolated psychological constructs but are deeply interconnected and context-dependent. The discussion is organized around four major themes that emerged from the integrated analysis.

Beliefs Drive Practice (RQ1)

A consistent finding across the reviewed studies is that pre-service teachers' (PSTs') beliefs about the nature of mathematics and mathematics teaching are powerful predictors of their instructional practices, often more so than their content knowledge alone. Yang et al. (2020) found that Chinese PSTs' dynamic beliefs about mathematics as a process of inquiry and their constructivist beliefs about teaching were significantly associated with self-reported inquiry-oriented practices, while mathematical content knowledge showed no direct correlation.

Similarly, Gurer & Akkaya (2021) demonstrated that constructivist pedagogical beliefs positively influenced perceived usefulness, ease of use, and attitudes toward technology, which in turn predicted intentions to integrate technology. Conversely, traditional beliefs did not significantly predict technology acceptance. Hidayat et al. (2024) extended this by showing that Technological Pedagogical Content Knowledge (TPACK) components significantly predicted beliefs about discovery learning and multiple representations. Yang & Leung (2015) also confirmed that pre-service teachers' dynamic beliefs about mathematics and constructivist beliefs

about learning were correlated with constructivist beliefs about ICT use, whereas traditional beliefs were associated with traditional ICT use.

However, the relationship between beliefs and practice is not always straightforward. Elizabeth & Lloyd (2017) identified five typologies of belief transformation, including a "deceivingly traditional" group (Typology 5) who reported innovative beliefs on surveys but described extremely traditional classroom practices, indicating that beliefs do not always translate directly into action without supportive field experiences and reflective scaffolding. Livy & Vale (2018) similarly found that pre-service teachers' mathematical content knowledge development was influenced by their learner identity, sustained engagement, and quality of teaching experiences, highlighting that beliefs alone are insufficient without structured opportunities for enactment.

Identity is Context-Dependent (RQ2)

Teacher identity is not a fixed trait but is dynamically shaped by the interaction between personal history, teacher education coursework, and the sociocultural contexts of schools. Lutovac (2020) found that PSTs' possible teacher selves, their hopes, expectations, and fears about future teaching, were profoundly shaped by their past experiences of math failure. Notably, pre-service elementary teachers often constructed "avoidant" possible selves, while pre-service mathematics teachers questioned whether they could understand struggling students due to their own history of success. Lutovac (2019) further explored how two pre-service mathematics teachers with strong mathematical backgrounds interpreted failure differently, demonstrating resilience through adaptive strategies such as lowering expectations or redefining success.

Goos & Bennison (2017) highlighted how interdisciplinary collaboration between mathematicians and mathematics educators created "boundary practices" that fostered new professional identities. In their Australian study, PSTs who experienced co-taught courses integrating content and pedagogy developed stronger mathematics teacher identities. However, physical separation of departments, workload models, and cultural differences between disciplines hindered identity development. Jao (2017) showed that a mathematics methods course could shift pre-service teachers' beliefs toward reform-based approaches, but the most significant changes occurred when pre-service teachers had opportunities to reflect on their experiences and apply new approaches in practicum settings. Kim & Bolger (2016) demonstrated that pre-service teachers who developed STEAM lesson plans showed improved awareness, perceived ability, value, and commitment toward integrated pedagogy, but their identity development was constrained by lack of experience and difficulty distinguishing technology from engineering.

Mainali (2022) provided a unique case of a pre-service teacher with a mathematics learning disability (MLD). Despite completing two methods courses, her negative beliefs about mathematics did not change because her primary beliefs were deeply rooted in early, repeated failure experiences. However, she developed positive attitudes toward teaching and expressed that her MLD would help her empathize with struggling students. This case reveals that identity can develop asynchronously, one dimension may change while others remain stable, depending on the depth and timing of experiences. Leavy & Hourigan (2015) compared two cohorts of pre-service teachers entering a teacher education program a decade apart and found that those who experienced reform mathematics curricula had higher value for mathematics but lower enjoyment, suggesting that identity is also shaped by broader curricular reforms.

Attitudes are Multidimensional (RQ3)

Attitudes toward mathematics and its teaching are not unidimensional but comprise cognitive, affective, and behavioral components. Marbán (2020) used structural equation modeling to show that mathematics anxiety had the strongest direct negative effect on enjoyment of mathematics, which in turn influenced enjoyment of teaching mathematics and attitudes toward mathematics didactics. Mathematics self-concept and perceived usefulness also played significant but smaller roles. This multidimensionality explains why some PSTs may find mathematics useful (cognitive) yet still dislike teaching it (affective). Segarra et al. (2021) found that personal mathematics teaching efficacy (PMTE) increased significantly across the bachelor's degree, particularly after a course connected to teaching practice, while mathematics teaching outcome expectancy (MTOE) did not show significant improvement, indicating that different attitudinal dimensions respond differently to interventions.

Jacobs & Durandt (2017) found that pre-service teachers' attitudes toward mathematical modelling were positive on enjoyment and value dimensions but weaker on self-confidence, with male and higher-achieving pre-service teachers displaying more positive attitudes. Heffernan & Newton (2019) illustrated that pre-service teachers who experienced identity exploration tasks showed three patterns of change: unchanged, nominal changes, and notable changes. Those with extremely negative initial attitudes experienced notable changes when they perceived mathematics as relevant, demonstrating that attitudes are malleable when interventions target perceived relevance and self-confidence. Tak et al. (2025) further decomposed attitudes into affective, behavioral, and cognitive dimensions, finding that metacognitive awareness mediated the relationship between attitude and mathematical reasoning, indicating that positive attitudes alone are insufficient without metacognitive regulation.

Beliefs, Attitudes, and Identity Interconnect (RQ4)

The most compelling finding across the synthesized studies is that beliefs, attitudes, and identity are not independent but form an interconnected system that shapes PSTs' professional development. Lau (2021) demonstrated that mathematical beliefs (formal vs. constructivist) and mathematics teaching efficacy (personal teaching efficacy and outcome expectancy) differentially predicted traditional and constructivist conceptions of teaching. Specifically, traditional conceptions were predicted by formal mathematical beliefs and low personal teaching efficacy, while constructivist conceptions were predicted by mathematics self-efficacy and teaching outcome expectancy. This suggests that beliefs about the nature of mathematics are entwined with beliefs about one's own capability and the impact of teaching.

Heffernan & Newton (2019) illustrated this interconnectivity through the PRESS model (Promoting Relevance, triggering Exploration, Safety, Scaffolding). PSTs who experienced identity exploration tasks in a college algebra course showed patterns of change: those with extremely negative initial attitudes experienced notable changes in self-perceptions, beliefs, and action possibilities when they perceived mathematics as relevant. Their identity as a "math person" shifted because their beliefs about mathematics changed, which in turn altered their attitudes and future-oriented goals. Machalow et al. (2020) added a longitudinal perspective, showing that narrative arcs (positive turning point and consistently frustrated) were associated with different mathematics orientations (relational vs. instrumental). PSTs who shifted from instrumental to relational understanding due to a supportive teacher or course experienced lasting positive identity change.

Finally, Mainali (2022) provided a unique case of a PST with a mathematics learning disability (MLD). Despite two methods courses, Nichole's negative beliefs about mathematics did not change because her primary beliefs were deeply rooted in early, repeated failure experiences.

However, she did develop positive attitudes toward teaching and expressed that her MLD would help her empathize with struggling students. This case reveals that beliefs, attitudes, and identity can develop asynchronously, one may change while others remain stable, depending on the depth and timing of experiences. Taken together, these findings argue for teacher education programs that explicitly address the interconnectedness of beliefs, attitudes, and identity through sustained, scaffolded, and context-sensitive interventions.

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Conclusion

This systematic review synthesized 20 peer-reviewed articles to examine beliefs, attitudes, and identities of pre-service mathematics teachers. Four main conclusions emerged.

First, beliefs are stronger predictors of instructional practices than content knowledge. However, a persistent belief-practice gap exists, with some pre-service teacher reporting innovative beliefs but enacting traditional practices without awareness. One transformative field experience can sustain belief change. Second, professional identity is a dynamic, context-dependent construct shaped by working communities, failure experiences, and sustained engagement. The concept of "future memory" explains how pre-service education guides professional growth. Failure experiences play a significant role, with resilient pre-service teacher redefining goals rather than allowing failure to define identity. Third, mathematics anxiety is the dominant affective barrier. Reducing anxiety should be the first priority in teacher education, as it triggers a positive domino effect on enjoyment, self-concept, and teaching enjoyment. Perceived relevance triggers attitude change, particularly for pre-service teacher with negative initial identities. Fourth, beliefs, attitudes, and identity are deeply interconnected. Beliefs mediate the knowledge-practice relationship; knowledge influences practice only when filtered through appropriate beliefs. Causal chains connect positive attitudes toward mathematics to positive teaching identity. Teacher education cannot address these constructs in isolation.

Implications for teacher education include prioritizing belief transformation alongside knowledge, providing transformative field experiences, explicitly addressing failure to build resilience, reducing mathematics anxiety as a first step, and adopting holistic approaches that address beliefs, attitudes, and identity simultaneously. Future research should employ longitudinal designs, cross-cultural comparisons, and mixed methods to further understand these complex relationships.

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