Metaphors and mathematical beliefs among Finnish pre-service teachers

A comparison of two teacher education pathways

EUNJI KIM, DARANEE LEHTONEN, PÄIVI PERKKILÄ AND JORMA JOUTSENLAHTI

This study examines the mathematical beliefs of 97 Finnish pre-service primary school teachers in two teacher education pathways—a conventional program and a career-changer program. Using an essay-format survey and metaphor analysis, participants articulated beliefs about mathematics, previous teachers' teaching methods, and beliefs about oneself as a mathematics learner. Journey metaphors were most common, while career-changers more strongly emphasized the perceived necessity of mathematics. Cross-tabulation revealed nuanced belief structures shaped by diverse experiential histories. The findings show how integrating metaphors with belief profiles offers deeper insight into emerging professional beliefs and supports more targeted, reflective practices in teacher education.

Teachers' beliefs are deeply intertwined with affective and experiential dimensions (Hannula, 2020; Lutovac, 2020; Machalow et al., 2022; Xenofontos & Andrews, 2023). Pre-service teachers enter teacher education with beliefs shaped by accumulated personal experiences as mathematics learners, including critical memories, social interactions, and dispositions that frame their understanding of mathematics (Machalow et al., 2022; Rösken et al., 2007; Salonen, 2024). Pre-service teachers (pre-service primary school class teachers in Grades 1–6) often begin teacher education with varied interests and uneven prior content knowledge compared with mathematics-specialized teachers, contributing to lower confidence in teaching mathematics (Asikainen et al., 2017; Ingram et al., 2018; Panero et al., 2023).

Beliefs function as systems that regulate learning and shape instructional decisions (Erens & Eichler, 2019; Malmivuori, 2006), influencing

Eunji Kim, *Tampere University*
Daranee Lehtonen, *University of Turku*
Päivi Perkkilä, *University of Turku*
Jorma Joutsenlahti, *Tampere University*

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how teachers interpret mathematics, learning and teaching, and themselves as learners and future professionals (Beswick, 2012; Hannula, 2020; Pajares, 1992). When externalized, beliefs should be interpreted alongside other affective orientations—such as attitudes and emotions—to better understand evolving belief systems (Joutsenlahti, 2005; Mahlios et al., 2010; McGlone, 2007).

In Finland, both the National Core Curriculum (NCC) for basic education and the Multidimensional Adapted Process (MAP) model in teacher education highlight non-cognitive orientations—including beliefs, attitudes, and values—as essential components of teacher competences (Finnish National Agency for Education [EDUFI], 2016; Metsäpelto et al., 2024). Yet systematic tools for identifying and supporting these orientations remain limited, as teacher education curricula continue to prioritize cognitive and technical competencies over affective or experiential dimensions (Metsäpelto et al., 2022). This gap calls for tools that help pre-service teachers articulate, examine, and reconstruct tacit beliefs that shape future classroom practices.

Accordingly, metaphor tasks provide such a tool. Metaphors allow teachers to express implicit beliefs through figurative representation, revealing assumptions and emotions that are difficult to articulate directly (Arslan & Haser, 2025; Falani et al., 2023; Gomez, 2021; Markovits & Forgasz, 2017). They function both pedagogically—supporting reflection—and analytically—making belief-related orientations visible (Mahlios et al., 2010; Portaankorva-Koivisto, 2013; Reeder et al., 2009), and are particularly useful for accessing tacit or affect-laden interpretations that are not easily expressed in propositional form.

Finnish teacher education has expanded to include career-change pathways (EDUFI, 2021). International research suggests that career-changers bring broader belief systems shaped by prior occupations, often more pragmatic or socially grounded (Baeten & Meeus, 2016; Hodgen & Askew, 2007; Richardson & Watt, 2005). These diverse experiences may influence beliefs about mathematics, instructional responsibility, and teaching (Kim et al., 2025). However, most research on mathematical beliefs in mathematics education has focused on mathematics specialists or traditional pre-service cohorts (Machalow et al., 2022), and comparatively little is known about how mathematical beliefs vary across qualification pathways in Finland. This study addresses this gap by analyzing Finnish pre-service teachers' mathematical beliefs across two teacher education programs and examining how these beliefs are reflected through metaphors.

Literature background and conceptual framework

Conceptualization of teachers' mathematical beliefs

In mathematics education, teachers' beliefs are understood as multidimensional constructs that shape how they interpret mathematical content and how they support students' learning processes. For example, teachers who view mathematics as patterns and numbers often aim to inspire students to appreciate its beauty, whereas those who perceive it as a structured discipline emphasize sequential skills development (Portaankorva-Koivisto, 2013). Early belief research further distinguishes beliefs from knowledge: beliefs are subjective, evaluative, and often resistant to change, functioning as filters through which teachers interpret instructional situations (Fives & Buehl, 2012; Pajares, 1992). Beliefs operate not in isolation but as interconnected components of broader belief systems—dynamic networks integrating affective (Hannula, 2020), development (Niemi et al., 2025), and narrative (Lutovac et al., 2024) perspectives. These systems evolve over time, shaped by emotional experiences, school trajectories, and professional identity formation, supporting Hannula et al.'s (2005) dynamic interpretation. Belief systems are integrated structures comprising cognitive interpretations, emotional responses, goal orientations, and socially situated experiences that jointly guide teachers' instructional judgments, acting as self-regulation mechanisms shaping mathematics-related behaviors (Hannula, 2007; Malmivuori, 2006).

For future teachers with limited teaching experience, reflections on earlier schooling—such as perceived difficulty, enjoyment, effort, talent, and support from family or teachers—play a substantial role in shaping belief systems. These experiences often form belief profiles—positive, neutral (termed *mixed* in this study), or negative—as documented in earlier research (Hannula et al., 2005; Kim et al., 2023; Rösken et al., 2007).

In the present study, these belief profiles are examined through three analytic domains: (a) beliefs about mathematics (BM)—how individuals conceptualize the nature of mathematics; (b) beliefs about previous teachers' teaching methods (PT)—evaluations of instructional practices and pedagogical support in school mathematics; and (c) beliefs about oneself as a mathematics learner (SL)—including self-confidence, perceived ability, emotional responses, and prior success or struggle. Together, these domains are treated as interacting components within broader belief systems, providing a structured framework for analyzing pre-service teachers' beliefs in relation to their prior experiences.

Beliefs and prior learning histories

Earlier research shows that pre-service teachers' beliefs are strongly anchored in their prior mathematical experiences rather than emerging as abstract constructs. These beliefs develop through long-term classroom participation, interactions with teachers and peers, and culturally mediated narratives about mathematical ability (Rösken et al., 2007; Skott, 2018). Experiences of success or failure often crystallize into stable narrative scripts that shape future teachers' identities (Lutovac, 2020; Lutovac & Kaasila, 2022). Such scripts influence how individuals imagine themselves as teachers, often before entering teacher education. Relational or instrumental orientations toward mathematics frequently originate from "critical moments," such as encouragement from a teacher or a discouraging episode (Machalow et al., 2022; Xenofontos & Andrews, 2023). These patterns often solidify early and persist into adulthood, shaping responses to new pedagogical ideas.

Finnish research echoes these distinctions: Hannula et al. (2005) identified positive, neutral, and negative belief profiles among pre-service teachers, shaped by perceived mathematical talent, emotional responses, and memories of previous teachers' actions. Positive profiles reflected confidence, diligence, and easy of learning; negative profiles indicated low confidence, difficulty or dislike, and negative teacher memories; neutral profiles showed mixed feelings and moderate confidence.

Building on these insights, this study examines Finnish pre-service teachers' mathematical beliefs using an essay-format survey with guided prompts and metaphor tasks, as such formats enable participants to articulate experiential and affective dimensions that are often inaccessible through structured instruments.

Metaphors as pedagogical tools and research methods

Metaphors are widely used to examine teachers' beliefs, learning histories, and instructional orientations in mathematics education. They enable individuals to express abstract ideas through concrete comparisons, supporting cognitive engagement and personal meaning-making (Latterell & Wilson, 2016). Explicit prompts during metaphor elicitation improve interpretability by encouraging participants to articulate their reasoning (Arslan & Haser, 2025; Reeder et al., 2009). For example, "Mathematics is like a garden" may evoke ideas of ongoing care, growth, or structured beauty.

Research shows that metaphors reveal entrenched beliefs that often persist despite exposure to new pedagogical perspectives (Reeder et al., 2009), serving as narrative tools enabling emotionally rich reflections

about teaching mathematics (Gomez, 2021). Because metaphor creation requires cognitive processing, personal experience, and linguistic expression, metaphors function as devices for comparing conceptual domains (Rönkkö et al., 2014).

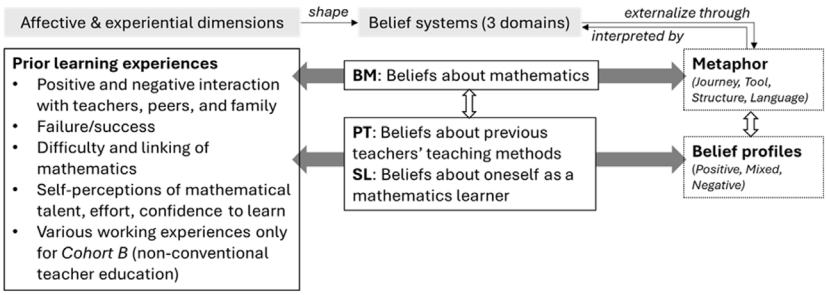
Several metaphor categorization frameworks exist in mathematics education. While earlier models include a wide range of categories (e.g., Latterell & Wilson, 2016; Reeder et al., 2009), this study employs the four-category framework proposed by Portaankorva-Koivisto (2013) due to its conceptual clarity, alignment with mathematics-specific meaning-making, and grounding in the Finnish educational context. The framework comprises the categories *Journey*, *Tool*, *Structure*, and *Language*. Journey metaphors portray learning as a process of challenges, rewards, and growth; Tool metaphors view mathematics as a specialized set of skills; Structure metaphors emphasize coherence and interconnectedness; Language metaphors highlight communication and reasoning.

Collectively, these categories signal underlying epistemological orientations (Portaankorva-Koivisto, 2013): exploratory or problem-solving (Journey), instrumentalist (Tool), or more Platonist and meaning-oriented perspectives (Structure and Language) (Ernest, 2010). Prior research links such orientations to classroom practices, shaping teachers' emphases on exploration, procedural mastery, conceptual structure, or communication (Ernest, 2010; Mahlios et al., 2010; Reeder et al., 2009). In this study, metaphors are not treated as a theoretical framework but as methodological elicitation tools and analytic devices for interpreting pre-service teachers' belief-related orientations.

Conceptual framework

Drawing on the literature, this study integrates three strands into a conceptual framework (Figure 1): (a) affective and experiential dimensions of learning mathematics (Lutovac, 2020; Machalow et al., 2022; Xenofontos & Andrews, 2023); (b) belief systems consisting of BM, PT, and SL (Hannula et al., 2005; Pehkonen, 1993; Skott, 2018); and (c) metaphors as tools for externalizing and interpreting beliefs, categorized into Journey, Tool, Structure, and Language (Falani et al., 2023; Portaankorva-Koivisto, 2013; Reeder et al., 2009).

Figure 1. *Conceptual framework illustrating how affective and experiential dimensions shape pre-service teachers' belief systems, how these beliefs are externalized and interpreted through metaphor analysis, and how resulting expressions inform belief profiles.*



As shown in figure 1, metaphor tasks serve a dual role: they enable pre-service teachers to express tacit interpretations of mathematics, and they provide an analytical lens for classifying beliefs about mathematics (BM). Two indicators of learning histories were analyzed: PT, reflecting memories of teaching approaches and classroom environments (Rösken et al., 2007); and SL, reflecting perceived ability, confidence, and emotions (Hannula et al., 2005). In contrast to earlier studies, this study adopts the term *mixed* instead of *neutral* to more accurately capture responses containing both positive and negative aspects, rather than implying indifference. Through this combined approach, metaphors provide an interpretive bridge between belief expressions and participants' learning histories, allowing implicit orientations to be analyzed systematically.

Research questions

Drawing on the conceptual framework, this study investigates the mathematical beliefs of Finnish pre-service teachers across two teacher education pathways (a conventional program and a career-changer program). The analysis is guided by the following research questions:

RQ1. What kinds of beliefs about mathematics are reflected in participants' metaphors?

RQ2. What kinds of beliefs do participants hold about their previous mathematics teachers' instructional methods (PT) and about oneself as a mathematics learner (SL), based on their prior learning experiences?

Methods

This study employed a qualitative approach in which participants' essay-format responses analyzed through iterative content analysis. Descriptive statistical summaries (frequency counts and percentages) were used to indicate the distribution of responses (Creswell & Creswell, 2023). In addition, visual and comparative analytic techniques, including word-cloud visualization and cross-tabulation analysis, were used to support pattern identification and comparison across teacher education pathways.

Participants

Participants were 97 pre-service teachers enrolled in compulsory first-year mathematics courses preparing them to teach Grades 1–6. They were recruited from two Finnish universities through convenience sampling and represented two distinct pathways into primary school teacher education: Cohort A (n = 56), students in a conventional five-year Teacher Education Program (BA + MA), typically entering directly after upper secondary school with little or no prior teaching experience; and Cohort B (n = 41): MA students in an Adult Education Program for career changers entering through open university pathways, bringing substantial professional backgrounds (e.g., early childhood education, special education, engineering, nursing, social services). This dual-cohort structure enables comparison of beliefs shaped by different learning and occupational trajectories.

Data collection

An essay-format survey was used to enable participants to elaborate on prior experiences and articulate belief-related orientations in their own words. Prompts were adapted from Krzywacki and Portaankorva-Koivisto (2018, p. 279) and aligned with the study's belief framework:

(1) Beliefs about mathematics (BM): "Mathematics is like ..." followed by elaboration on views of mathematics, learning, and teaching.

(2) Beliefs about previous teachers' teaching methods (PT): Descriptions of school mathematics instruction, including teaching styles, support, and classroom dynamics.

(3) Beliefs about oneself as a mathematics learner (SL): Reflection on school experiences and prompts such as "What kind of student were you?" and "How do you learn best?"

The survey was administered in Finnish, the participants' native language, to support comfort, clarity, and authentic expression. Data were collected at the beginning of the mathematics courses during scheduled teacher education curricula in 2023.

Data analysis

Qualitative analysis followed iterative content analysis, incorporating both theory-driven and open coding (Creswell & Creswell, 2023). Metaphors were categorized into Journey, Tool, Structure, and Language types. Essay responses also revealed beliefs about the necessity of mathematics; unlike Latterell and Wilson (2016), necessity was treated here as part of BM rather than a distinct metaphor category, as it emerged from the full reflective narratives rather than from the metaphor prompt alone. Coding proceeded through multiple rounds of discussion to ensure consistency, with discrepancies resolved through consensus. Representative examples illustrate key themes. Descriptive statistics summarized metaphor types and prior learning experiences across cohorts. A word cloud was used to visualize affective responses to school mathematics, color-coded as positive (blue), mixed (yellow), and negative (red) (Cooshna-Naik, 2022). A cross-tabulation analysis was conducted to identify patterns between belief profiles and metaphor types that may not be visible through qualitative analysis alone (Portaankorva-Koivisto, 2013).

Reliability, validity, and ethical considerations

Responses written in Finnish were translated into English by two bilingual authors using a cross-checking procedure to ensure accuracy. Reliability was supported by independent double-coding of 10% of the data (85% initial agreement), followed by discussion to resolve discrepancies. Triangulation was achieved by combining qualitative analyses with descriptive statistical summaries. Metaphors were treated as elicitation devices, while BM, PT, and SL provided the analytic structure for interpreting participants' cognitive, affective, and experiential meanings. Participation was voluntary, anonymous, and based on informed consent. Data were securely stored on an encrypted institutional server, and the study adhered to the ethical guidelines established by the Finnish National Board on Research Integrity (2019).

Results

Beliefs about mathematics reflected in metaphors (RQ1)

As shown in table 1, approximately one-third of the pre-service teachers (37%, n = 36) described mathematics as Journey, followed by Language (20%, n = 19), Structure (18%, n = 17), and Tool (7%, n = 7) type. Eleven expressions were categorized as Others, and seven pre-service teachers did not provide a metaphor. The Necessity category—emerging from essay-format reflections rather than directly from the metaphor prompt—was analyzed separately and may overlap with metaphor responses. Given the small subgroup sizes, statistical comparisons were not conducted.

Table 1. *Descriptive distribution of metaphor categories and necessity-related beliefs among pre-service teachers by cohorts.*

Category	Cohort A (n = 56)	Cohort B (n = 41)	Total (N = 97)
Metaphors			
Journey	20 (36%)	16 (39%)	36 (37%)
Tool	4 (7%)	3 (7%)	7 (7%)
Structure	8 (14%)	9 (22%)	17 (18%)
Language	11 (20%)	8 (29%)	19 (20%)
Others	9 (16%)	2 (5%)	11 (11%)
none	4 (7%)	3 (7%)	7 (7%)
Necessity	18 (32%)	35 (85%)	53 (53%)

Across cohorts (Cohort A: conventional teacher education; Cohort B: career-changer teacher education), the overall distribution of metaphors was broadly similar, with minor differences in the relative prevalence of Structure and Language metaphors. However, Others-type metaphors—those not fitting the four established categories—were more common in Cohort A (16%) than in Cohort B (5%). In contrast, reflections indicating the necessity of mathematics appeared far more frequently in Cohort B (85%) compared with Cohort A (32%).

Journey metaphors

Journey metaphors were the most frequent, portraying mathematics as a process of growth, effort, and discovery. Participants described learning as dynamic and emotionally charged, involving both challenges and rewards, such as "Math is like a tree.... it remains thin without support and grows crooked, especially from shame and feelings of inferiority" (A15). Both cohorts emphasized progressions and persistence, using metaphors

such as *a tree*, *a roller coaster*, and *a labyrinth* to illustrate complexity and gradual mastery. Cohort A tended to frame mathematics as a personal struggle or evolving understanding within school contexts (e.g., "Math is like a step workout—difficult, even repulsive, but ultimately rewarding" [A54]), whereas Cohort B more often connected the journey to adult roles and everyday utility, with early-school anxiety later reframed through work or parenting (e.g., "Math is like a rocky fell terrain—I couldn't get back on track until I was an adult, when I realized in my work what it's all about." [B8]).

Language metaphors

Language metaphors depicted mathematics as a communicative system—sometimes accessible and meaningful, sometimes obscure or difficult to decode. Cohort A often described mathematics as *a foreign*, *unknown*, or *hidden language*, highlighting challenges in understanding meaning (e.g., "Mathematics is like a foreign language, which one learns only by doing" [A5]; "Mathematics is like an unknown language—repeat without understanding its meaning" [A29]). Cohort B, by contrast, frequently described mathematics as essential and omnipresent, intertwined with daily life, e.g., "Mathematics is like a way of looking at the world... now as a 43-year-old pedagogue, I see its beauty and necessity" (B18).

Structure metaphors

Structure metaphors portrayed mathematics as an organized system requiring strong foundations and sequential progression, such as "Math is like a well-organized cabinet... a calming language where things have their proper place" (A1). Both cohorts highlighted building knowledge step by step, often using construction-related imagery, where missing steps hinder progress, including *a ladder*, *a puzzle*, and *a building*. Cohort A emphasized logical order and conceptual clarity (e.g., "Math is like a ladder—you should not skip the steps, otherwise it will be heavy later" [A42]). Cohort B tended toward large-scale construction metaphors reflecting stability and long-term growth (e.g., "Mathematics is like a building, the foundations of which are laid at a very early stage in childhood" [B2]).

Tool metaphors

Tool metaphors portrayed mathematics as a practical resource for solving problems and navigating everyday life. Although relatively rare ($n = 7$), these metaphors emphasized functionality and support, such as *a toolbox*, *a key*, and *glasses*. Some framed mathematics as a tool requiring skill to unlock its potential, sometimes noting barriers to access (e.g., "Math-

ematics is like a great playbook that everyone should be able to read and use, but it does not open up to everyone" [A7]), while others emphasized perception and decision-making in daily contexts (e.g., "Math is like glasses—I need them so that I can explore the world and see different sides of it" [B37]).

Others metaphors

Metaphors in the Others category expressed diverse emotions and experiences, often signaling ambivalence or strong affective responses. These metaphors were more common in Cohort A (9 out of 11), reflecting mixed or polarized attitudes. Cohort A used culturally specific or dichotomous comparisons—*salmiakki* (a traditional Finnish salty licorice-flavored candy), *coriander*, and *a boundary* (can or cannot)—to symbolize contrasting feelings of attraction and aversion. Negative metaphors like *a black hole* and *a swamp* also appeared, reflecting frustration and stagnation. Cohort B used fewer such metaphors, but those present emphasized entrapment or challenges, such as *a swamp* or *a Rubik's cube*, emphasizing persistence and problem-solving.

Necessity of mathematics

The perceived necessity of mathematics was grounded in contexts such as classrooms, daily life, and society. More than half of the participants highlighted its practical importance (55%, $n = 53$), with Cohort B far more likely to do so (85%, $n = 35$) compared with Cohort A (32%, $n = 18$). Cohort B often connected mathematics to work experiences or parenting roles, as illustrated by one participant:

> Mathematics is like a way of looking at the world. What kind of mathematical things, phenomena, and laws as well as mathematical connections do we see in the world? It creates explanations and structures, helps to perceive the world, but also challenges thinking in an interesting way. When I got into working life, my mathematical world was revolutionized... I began to understand how beautiful and interesting the world of mathematics is around us. (B4)

By contrast, Cohort A tended to view mathematics as essential for everyday life, often describing it as a formal discipline primarily to learn in school, as in: "Mathematics is work. It is not always meaningful, but still important and rewarding." (A25)

These variations in metaphor use and perceived necessity highlight how pre-service teachers interpret differently the role of mathematics in their lives. To understand how these interpretations were shaped, the next section examines their previous learning histories.

Beliefs about previous teachers' teaching methods (PT) and beliefs about oneself as a mathematics learner (SL) (RQ2)

Belief profiles of PT and SL

Table 2 summarizes participants' beliefs about their previous teachers' instructional methods (PT) and beliefs about oneself as a mathematics learner (SL) across both cohorts.

Table 2. *Descriptive distribution of beliefs about previous teachers' teaching methods (PT) and beliefs about oneself as a mathematics learner (SL) across cohorts.*

Category	Cohort A (n = 56)	Cohort B (n = 41)	Total (N = 97)
PT			
Positive	7 (13%)	18 (44%)	25 (26%)
Mixed	31 (55%)	17 (41%)	48 (49%)
Negative	18 (32%)	6 (15%)	24 (25%)
SL			
Positive	35 (62%)	8 (20%)	43 (44%)
Mixed	16 (29%)	16 (39%)	32 (33%)
Negative	5 (9%)	17 (41%)	22 (23%)

Mixed PT responses (n = 48) were most common, indicating that many participants recalled a blend of supportive and ineffective instructional practices rather than clearly positive or negative ones. Positive PT responses (n = 25) were more frequent in Cohort B (18 out of 25), likely reflecting the broader professional and life experiences of career-change candidates, who may interpret past instruction through a more mature or contextualized lens. Negative PT responses (n = 24) were more common in Cohort A (18 out of 24), many of whom entered teacher education directly after school and retained vivid memories of frustration or insufficient support.

In contrast, SL responses were more positive overall (n = 43 positive; n = 22 negative), suggesting that many pre-service teachers—despite exposure to traditional or ineffective teaching—perceived themselves as resilient learners. Notably, however, Cohort B exhibited a high proportion of negative SL (17 out of 22), revealing that career-changers often carried difficult learner identities despite recognizing positive instructional practices in retrospect.

Beliefs about previous teachers' teaching methods (PT)

Approximately 87% of the participants ($n = 84$) indicated that traditional methods dominated their school mathematics classrooms—a pattern consistent across school eras from the 1980s to the 2020s. According to the word cloud analysis (see appendix), "traditional methods" were characterized by teacher-led instruction, textbook-driven lessons, homework checks and repetitive explanations, and solitary practice. Resources for diverse learners were limited, and many teachers were perceived as lacking time to offer individual support. Participants also noted that the pace of instruction accelerated significantly in upper secondary school, causing many to feel overwhelmed or left behind. Some recalled competitive environments, such as rewarding faster learners ($n = 4$, Cohort A) or grouping students by ability level ($n = 4$, Cohort B). Participants described varied teaching styles across their schooling, leaving distinct impressions of different approaches. Teacher-centered methods were considered beneficial for students who preferred independent repetition and practice: "I learned best through self-study, and teachers' traditional teaching styles suited me." (A9)

However, these methods often proved ineffective for students who needed additional time or diverse supplementary materials: "There was no explanation for understanding. The teaching was very top-down and did not include common problem solvers or opening up the root causes of things. Studying was independent work." (A11)

A small subset emphasized features of "good teaching," such as clarity, variation, and encouragement. They noted methods such as drawing, hands-on activities, and peer collaboration as particularly effective. Positive reflections often featured terms like *inspire*, *encourage*, *enthusiasm*, *motivation*, and *support*. Conversely, negative reflections underscored poor communication and limited pedagogical skill: "They were boring people who were interested in the subject themselves but were not able to inspire students." (B57)

Beliefs about oneself as a mathematics learner (SL)

Word cloud analysis revealed 131 unique descriptors (see appendix), with negative expressions ($n = 70$) outnumbering positive ones ($n = 53$), although positive terms appeared more frequently overall (254 vs. 160 mentions). Negative descriptions included *bad*, *stupid*, *failure*, *frustrated*, *distressing*, *disgrace*, *mistakes*, *dare not to ask*, and *invisible student* (B35). Despite this, many participants described themselves as conscientious and persistent learners, diligently completing assignments and striving to maintain good grades: "I was diligent and enjoyed problem-solving, even when tasks were challenging." (A18)

Participants expressed mixed challenges and successes, varying in whether they struggled with basic calculations, descriptive problems, or advanced reasoning. Some noted difficulty keeping up with the fast pace in secondary school, leading them to switch from advanced to basic mathematics. Nearly half ($n = 44$) reported learning mathematics best through practice; others preferred independent study ($n = 14$), direct instruction ($n = 12$), or language-based approaches ($n = 28$). Six participants valued a calm environment for deep thinking.

Cross-tabulation of belief profiles and metaphor types

To examine how participants' beliefs about mathematics (BM) were reflected in metaphors aligned with their prior learning experiences, a cross-tabulation was conducted following Portaankorva-Koivisto's (2013) approach. Belief profiles were based on PT (Beliefs about previous teachers' teaching methods) and SL (Beliefs about oneself as a mathematics learner). Each was coded as Positive (P), Mixed (M), or Negative (*N*), producing nine PT × SL clusters (e.g., Cluster 1 = P-P; Cluster 8 = N-M). The purpose of this analysis was to examine how PT × SL profiles relate to metaphor types (BM), with cohorts combined to allow clearer identification of qualitative patterns while avoiding overinterpretation of small subgroup frequencies (see table 3).

Table 3. *Distribution of metaphor types across PT × SL beliefs clusters (PT = Beliefs about previous teachers' teaching methods; SL = Beliefs about oneself as a mathematics learner; P = Positive, M = Mixed, N = Negative).*

Cluster (PT × SL)	Journey	Language	Structure	Tool	Other	Row totals
Cluster 1 (P, P)	2	5	5	1	0	13
Cluster 2 (P, M)	0	1	0	1	0	2
Cluster 3 (P, *N*)	0	0	0	0	0	0
Cluster 4 (M, P)	13	8	4	2	0	27
Cluster 5 (M, M)	5	1	3	1	4	14
Cluster 6 (M, *N*)	0	0	0	0	1	1
Cluster 7 (*N*, P)	5	1	2	0	0	8
Cluster 8 (*N*, M)	6	2	2	1	5	16
Cluster 9 (*N*, *N*)	5	1	1	1	1	9
Column totals	36	19	17	7	11	90

Note: Seven participants did not provide a metaphor and were excluded from the table.

Several patterns emerged:

1. Journey metaphors appeared across nearly all clusters, particularly in mixed (Clusters 4 and 5) and negative PT clusters (Clusters 7–9).

2. Positive PT-SL combinations (Cluster 1) were associated primarily with Language and Structure metaphors, suggesting that supportive learning histories may foster beliefs about mathematics as coherent, meaningful, or communicative.

3. Negative PT experiences (Clusters 7–9) aligned with Journey or Other metaphors, reflecting struggle, ambivalence, or emotional complexity.

4. Mixed PT clusters (Clusters 4–5) displayed subtle differences depending on SL. Cluster 4 (positive SL) mirrored overall metaphor distribution, whereas Cluster 5 (mixed SL) included more Others-type metaphors, indicating uncertain or fragmented conceptualizations of mathematics.

5. Cluster 3 (positive PT, negative SL) contained no participants, suggesting it is uncommon to hold negative SL beliefs when PT memories are consistently positive.

Overall, the cross-tabulation demonstrates that metaphors, PT, and SL are meaningfully interconnected, offering a nuanced picture of how pre-service teachers interpret mathematics through both intertwined cognitive and affective dimensions.

Discussions

The contribution of this study is primarily methodological and contextual, demonstrating how metaphor-based elicitation combined with belief profiling can provide nuanced insight into pre-service primary school teachers' interpretations across different teacher education pathways. By integrating an essay-format survey, metaphor tasks, and cross-tabulation, the study shows how experiential histories are reflected in pre-service teachers' developing professional beliefs. The comparison between conventional and career-change cohorts further highlights how differing trajectories relate to variations in how mathematics is interpreted, particularly within the Finnish context.

The results align with prior research emphasizing the interplay between teachers' beliefs and their affective and experiential dimensions (Hannula, 2020; Lutovac, 2020; Machalow et al., 2022; Xenofon-

tos & Andrews, 2023). Consistent with Lutovac and Kaasila (2022), participants' narratives suggest that these beliefs are rooted in long-term schooling experiences rather than emerging as abstract constructs. The predominance of Journey metaphors reflects effort-oriented and process-based interpretations of learning, supporting Hannula et al.'s (2005) view of belief systems as integrated structures combining cognitive, emotional, and social components.

Cohort B's emphasis on the necessity of mathematics is consistent with research indicating that career-changers often draw on prior occupational experiences that are pragmatic and socially grounded (Baeten & Meeus, 2016; Hodgen & Askew, 2007; Richardson & Watt, 2005). In this study, such participants more frequently connected mathematics to professional and everyday contexts, suggesting that prior experience shapes how relevance is perceived and articulated.

Conversely, the persistence of traditional instructional memories across both cohorts mirrors earlier findings that rigid norms remain influential despite curricular reforms (Latterell & Wilson, 2016; Portaankorva-Koivisto, 2013). This pattern indicates that prior experiences continue to frame interpretations of teaching and learning, even when alternative pedagogical models are introduced (Machalow et al., 2022).

Rather than proposing new belief categories, this study demonstrates how combining metaphor analysis with PT and SL profiles can make visible more differentiated patterns within established classifications (Hannula et al., 2005). For example, configurations such as mixed PT with positive SL highlight how participants may retain resilient learner orientations despite less supportive instructional experiences. This illustrates how cognitive and affective dimensions are intertwined in participants' interpretations of mathematics.

Implications for teacher education

The findings offer several implications for teacher education practice.

1. Metaphor-based reflection: Metaphor tasks can support both reflection and analysis by making belief system visible (Mahlios et al., 2010; Portaankorva-Koivisto, 2013; Reeder et al., 2009). Integrating structured metaphor activities into coursework may help pre-service teachers articulate tacit interpretations and examine how prior experiences shape their views .

2. Connecting mathematics to lived contexts: Career-changers' emphasis on the necessity of mathematics appears closely linked to their prior professional and life experiences—contexts in which

mathematics is applied authentically and purposefully (Baeten & Meeus, 2016; Hodgen & Askew, 2007; Richardson & Watt, 2005). These findings suggest that teacher education could more intentionally embed real-world and interdisciplinary applications of mathematics through case-based tasks, workplace-inspired scenarios, or inquiry into everyday numeracy to help conventional-entry pre-service teachers similarly appreciate mathematics as useful and meaningful.

3. Addressing persistent traditional norms: The strong presence of traditional teaching memories suggests a need for opportunities to critically reflect on prior classroom experiences. Approaches such as inquiry-based learning, collaborative problem-solving, and multimodal strategies may provide alternative models that challenge these established patterns (Kang & Keinonen, 2016; Metsäpelto et al., 2022).

4. Differentiated support based on experience profiles: The PT–SL combinations indicate variation in how participants interpret their learning histories. For example:

    - Positive PT–SL: These pre-service teachers may favor structured approaches; they can be encouraged to experiment with flexibility and innovation.

    - Mixed or Negative PT with Positive or Mixed SL: Often linked to emotional reactions to teaching; they may benefit from supportive environments that validate their experiences and strengthen pedagogical confidence.

    - Negative PT–SL: Associated with dichotomous or negative views of mathematics; these pre-service teachers may require more intensive interventions, such as growth-mindset practices, scaffolded success experiences, and formative feedback.

Such differentiation may help teacher education programs respond more effectively to diverse experiential backgrounds.

Limitations and future studies

This study has several limitations. First, background variables (e.g., age, gender, prior teaching experience) were not analyzed, although they may influence beliefs. Second, the cross-sectional design captured beliefs at one point in time, limiting insights into their development. Third, trans-

lation from Finnish to English may have introduced minor inaccuracies despite cross-checking. Future studies should incorporate demographic and experiential variables. Longitudinal research following pre-service teachers into the profession would help clarify belief trajectories. In addition, experimental or design-based studies could examine how metaphor-based reflection, inquiry-oriented activities, or multimodal approaches contribute to changes in belief-related orientations. Comparative research across cultural or institutional contexts would further illuminate how systemic factors shape mathematical beliefs.

Conclusion

This study highlights the value of metaphors as both research and pedagogical tools in teacher education, offering insight into how pre-service primary school teachers conceptualize mathematics and interpret their prior learning experiences. It underscores the importance of creating reflective spaces in which such interpretations can be articulated and examined. Supporting pre-service teachers in engaging with these perspectives may contribute to more responsive and inclusive approaches to mathematics teaching.

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Appendix

Beliefs about previous teachers' teaching methods (PT)

Note. Keywords were extracted from participants' descriptions and color-coded by valence: blue = positive, yellow = mixed, red = negative.

Beliefs about oneself as a mathematics learner (SL)

Note. Keywords were extracted and color-coded by valence: blue = positive, yellow = mixed, red = negative.

Eunji Kim

Eunji Kim is a doctoral researcher at the Faculty of Education and Culture at Tampere University, Finland. Her research focuses on teachers' beliefs and instructional qualities aimed at enhancing students' mathematical thinking and learning through multimodal language approaches. https://orcid.org/0000-0002-1064-4972

eunji.kim@tuni.fi

Daranee Lehtonen

Daranee Lehtonen is a senior researcher with a multidisciplinary background in educational design and STEAM, particularly mathematics, education. Her research interests include technology-enhanced learning and multimodality in STEAM subjects. https://orcid.org/0000-0002-9695-0056

daranee.lehtonen@utu.fi

Päivi Perkkilä

Päivi Perkkilä is an associate professor at the Department of Teacher Education at University of Turku, Finland. Her main research interests are mathematical thinking, conceptual understanding in mathematical learning, especially in grades 1-6, and multimodal language approaches to mathematical thinking. https://orcid.org/0000-0001-7680-6420

pperkkila@gmail.com

Jorma Joutsenlahti

Jorma Joutsenlahti is an associate professor at the Faculty of Education and Culture at Tampere University, Finland. His main research interests are mathematical thinking, conceptual understanding in mathematical learning, and multimodal language approaches to mathematical thinking. https://orcid.org/0000-0002-6043-5255

jorma.joutsenlahti@tuni.fi