LUMAT
International Journal on Math, Science and Technology Education

Research article

Exploring the relationship between teachers' beliefs on the nature and learning of mathematics and self-efficacy in teaching mathematics at the primary school level

Kristi Pikk[1], Äli Leijen[1], Jelena Radišić[2] and Krista Uibu[1]

[1] University of Tartu, Estonia
[2] University of Oslo, Norway

Abstract: For more than 30 years, the study of teachers' beliefs has been crucial to the mathematics education field since teachers' beliefs may significantly influence students' learning of mathematics. This study included 127 Estonian in-service primary and secondary school mathematics teachers teaching grades three to five. We examined their beliefs about the nature of mathematics, learning of mathematics, and their confidence in their ability to teach the subject (self-efficacy). Moreover, we aimed to explore the relationships between these beliefs. We also investigated the possible differences between subject teachers and class teachers and possible differences regarding teacher work experience. Teachers' self-efficacy beliefs about goal setting, motivation, and cognitive activation were positively correlated. Self-efficacy beliefs on goal setting had positive effect on rules and procedures beliefs (nature of mathematics) and teacher-directed beliefs (learning of mathematics). In addition, the results showed a negative relationship between self-efficacy beliefs on cognitive activation and rules and procedures and teacher-directed beliefs. No statistically significant relationship was found between the teachers' beliefs and their years of experience. Nonetheless, a strong correlation was discovered between the type of teachers (i.e., class teacher or subject teacher) and self-efficacy beliefs related to cognitive activation. These findings draw attention to the intricate links between teachers' different beliefs and offer recommendations for teacher preparation programs and further study.

Keywords: teachers' beliefs, self-efficacy beliefs, mathematics education, primary school

Correspondence: kristi.pikk@ut.ee

1 Introduction

For over three decades, researchers have considered the investigation of teachers' beliefs a central focus in mathematics education (Ernest, 1989a; Guler & Celik, 2023). Teachers' beliefs significantly impact the quality of their instruction and are a critical component of their competence as mathematics teachers (Belbase, 2019; Kim et al., 2023). Teachers are the principal facilitators of classroom education (Aljaberi & Gheith, 2018; Kunter et al., 2013). In particular, other studies have demonstrated that educators who promote more constructivist viewpoints assign more compelling assignments and offer greater learning support (Dubberke et al., 2008; Staub & Stern, 2002). Moreover, there is a correlation between student higher motivation and accomplishment (Siwatu & Chesnut, 2014; Wyatt, 2014; Yang et al., 2020) and improved instructional management and student assistance (Demirci, 2023; Wellberg, 2024; Zee & Koomen, 2016) and teacher self-efficacy beliefs. Teachers' attitudes and behaviours toward mathematics are positively impacted by high mathematics self-efficacy beliefs, which also rise with experience in the classroom (Chung & Chen, 2018; Han et al., 2015). Furthermore, it is commonly assumed that a teacher`s years of experience directly correlate with the quality of their instruction in a straightforward, linear manner (Brandenburg et al., 2016; Hoy & Spero, 2005; Isiksal-Bostan et al., 2015; Wijesundera & Wijethunga, 2021).

Concepts in mathematics range from elementary to complex, and the subject is hierarchical, structured, and methodical. Because of this, it is essential that students begin studying mathematics in primary school (Selvianiresa & Prabawanto, 2017). Therefore, it is vital to comprehend the beliefs that primary school teachers hold toward mathematics. In Estonia, where this study was conducted, it is common for a single teacher to guide students through core subjects, including mathematics, during the initial three to four grades and sometimes up to the sixth grade. Estonian primary grade teachers, who hold high expectations and possess effective instructional skills, substantially impact students' academic outcomes (Uibu & Kikas, 2014). With an average age of 49, most Estonian teachers have much experience, and 81% have obtained all necessary official degrees (OECD, 2022). Examining their beliefs is crucial since primary schooling lays the groundwork for students' future performance in mathematics.

While the topic is critical, few studies have explored the beliefs of primary school teachers regarding teaching mathematics (Leijen et al., 2024; Nisbet & Warren, 2000; Radišić et al., 2024), and particularly, how their behaviours interact with ideas in the same subject (Esterly, 2003; Guler & Celik, 2023). Consequently, the present study explores the different views of in-service primary teachers concerning teaching and learning mathematics. Furthermore, prior studies have shown a relationship between teachers' beliefs and their years of experience (Hoy & Spero, 2005; Isiksal-Bostan et al., 2015) as well as their level of teaching (Nisbet & Warren, 2000). Thus, we are interested how these characteristics interact with different types of beliefs. Furthermore, the Programme for International Student Assessment (PISA) results have shown that Estonian students' achievement in mathematics is well above the OECD average (Tire, 2021). This highlights the effectiveness of the Estonian education system and underscores the importance of understanding primary school teachers' beliefs that might contribute to these high achievements. Given the hierarchical nature of mathematics and the critical role of primary education in laying the groundwork for later learning, it is important to explore the beliefs of Estonian primary school teachers that might contribute to students' subsequent achievements in mathematics.

2 Theoretical frameworks

2.1 Teachers' beliefs

The idea that beliefs affect how people interact with the world, impacting their perceptions, goals, and behaviours, is the foundation for research on teachers' beliefs (Fives & Buehl, 2012; Skott, 2014). The term "belief" in this study follows Philipp's (2007) definition, which describes beliefs as psychological understandings, assumptions, or statements about the world that are accepted as accurate. Teachers' beliefs are important because they act as filters through which teachers interpret their experiences, as frameworks for problem-solving, and as directives for their behaviour (Fives & Buehl, 2012; Fives & Gill, 2015; Jakimovik, 2018; Levin, 2014).

Hoy et al. (2006) distinguished teachers' beliefs based on the level of focus. On one level, beliefs involve teachers' self-assessments of their teaching abilities and roles, while on another level, they reflect views on teaching and learning processes. In mathematics education, these beliefs shape how teachers view the subject and its teaching processes (Yang et al., 2020). This study focuses on three main categories of mathematics teachers' beliefs: the nature of mathematics (Ernest, 1989a; Grigutsch et al., 1998; Kunter et al., 2013; Pajares, 1992), learning of mathematics (Barkatsas & Malone, 2005; Lerman, 2002; Op't Eynde & De Corte, 2003), and self-efficacy beliefs on teaching (Bandura, 1997; Tschannen-Moran & Hoy, 2007; Zee & Koomen, 2016). Table 1 provides an overview of examined beliefs and their subcategories.

Table 1. Dimensions of teachers' beliefs and their subcategories

Belief dimension	Subcategories	Description
Nature of mathematics	Rules-procedures	Emphasises procedural mastery and formalism (Grigutsch et al., 1998).
	Inquiry	Views mathematics as exploratory and creative (Ernest, 1989a).
Learning of mathematics	Teacher-directed	Focuses on repetition and procedural learning (Barkatsas & Malone, 2005).
	Active learning	Encourages collaboration and critical thinking (Lerman, 2002).
Self-efficacy	Cognitive activation	Confidence in fostering critical thinking (Bandura, 1997).
	Goal setting	Confidence in setting appropriate learning goals (Tschannen-Moran & Hoy, 2007).
	Motivation	Confidence in motivating students to engage with mathematics (Zee & Koomen, 2016).

The beliefs described in Table 1 are interconnected. For example, the beliefs that mathematics is a set of rules and procedures often align with teacher-directed beliefs, underscoring procedural mastery and structured teaching (Beswick, 2011; Pagiling & Taufik, 2022; Wellberg, 2024). In contrast, inquiry beliefs are more compatible with beliefs of active learning that foster exploration, collaboration, and critical thinking (Demirci, 2023; Tamba & Cendana, 2021). Similarly, self-efficacy beliefs shape how teachers apply these instructional methods (Çiftçi & Karadağ, 2020; Saracoglu, 2022; Zee & Koomen, 2016). The following sections delve deeper into each dimension, starting with beliefs about the nature of mathematics, then beliefs about learning of mathematics, and conclude with self-efficacy beliefs.

2.2 Teachers` beliefs on the nature of mathematics

Beliefs about the nature of mathematics fall into two main categories: rules-based and inquiry-based (Grigutsch et al., 1998). Rules-based beliefs focus on procedural mastery and formalism, while inquiry-based beliefs highlight creativity and problem-solving (Beswick, 2012; Ernest, 1989).

The rules-based perspective aligns with Estonia's historically centralised education system, which emphasises standardisation and procedural mastery (OECD, 2022; Pedaste et al., 2019). However, modern pedagogy increasingly promotes inquiry-based approaches prioritising problem-solving and creative exploration, particularly in primary education (Peterson et al., 2016). These two perspectives can create tension in teachers' instructional practices, affecting how they engage students. For instance, teachers who emphasize inquiry-based learning are more likely to incorporate cognitive activation strategies, while those focusing on rules-based approaches often adopt transmissive, goal-oriented methods (Bandura, 1997; Cho & Shim, 2013; Lau, 2022; Zee & Koomen, 2016).

Differences in these perspectives are also evident between mathematics teachers and class teachers. Mathematics teachers often perceive the subject as abstract and theoretical, while class teachers adopt a more practical view, seeing mathematics as a tool for everyday problem-solving (Dede & Karakuş, 2014). These contrasting views reflect their professional roles, with subject teachers favouring structured pedagogy and class teachers integrating mathematics into a broader curriculum.

2.3 Teachers' beliefs about learning of mathematics

Teachers' beliefs about how mathematics is learned significantly influence their instructional strategies and classroom practices (Barkatsas & Malone, 2005; Beswick, 2011; Hughes et al., 2019). These beliefs typically range from teacher-directed instruction, which emphasises demonstration, repetition, and procedural mastery, to active learning, which prioritises exploration, collaboration, and critical thinking (Felbrich et al., 2008; Teo et al., 2008; Voss et al., 2013). These perspectives align with two primary theoretical frameworks: the transmissive perspective and the constructivist perspective (Barkatsas & Malone, 2005; Bunting, 1985).

Research highlights a paradox among Estonian mathematics teachers: although many endorse constructivist approaches, transmissive methods are often preferred due to curriculum constraints, class size, and limited training in inquiry-based methods (Lepik & Pipere, 2011). This duality is also evident internationally, as preservice teachers frequently adopt a mix of transmissive and constructivist beliefs (Chan & Elliott, 2004; Tamba & Cendana, 2021).

Perspectives on constructivist tendencies differ between mathematics teachers and class teachers. Some studies suggest that class teachers (i.e., teaching multiple subjects) hold more constructivist beliefs due to their interdisciplinary teaching approaches, which foster collaboration and active learning (Aljaberi & Gheith, 2018). Conversely, mathematics teachers often emphasise conceptual understanding and problem-solving, aligning with inquiry-based methods, while class teachers may focus on procedural knowledge, reflecting lower confidence in their mathematical abilities (Mulu et al., 2021).

Teachers' beliefs evolve with experience. Novice teachers often begin with transmissive approaches but may transition toward constructivist practices with increased confidence and exposure to progressive pedagogies (Çiftçi & Karadağ, 2020; Putnam & Borko, 1997). However, transmissive and constructivist beliefs can coexist throughout this transition (Black & Ammon, 1992; Torff & Sternberg, 2001). These dynamics are captured in the proposed model, which examines how teaching experience interacts with instructional beliefs to shape classroom practices.

In the proposed model (see Figure 1), teacher-directed learning beliefs are hypothesised to correlate with rules-based views of mathematics, emphasising structured and procedural approaches (Barkatsas & Malone, 2005; Pagiling & Taufik, 2022). Conversely, active learning beliefs are aligned with inquiry-based perspectives, fostering collaboration and critical thinking in mathematics instruction (Askew et al., 1997; Lepik & Pipere, 2011).

These relationships highlight how underlying beliefs influence instructional practices, providing a framework for professional development initiatives to encourage more student-centred methods (Çiftçi & Karadağ, 2020; Demirci, 2023).

2.4 Teachers` self-efficacy beliefs in teaching mathematics

As defined by Bandura's (1997) social cognitive theory (SCT), self-efficacy beliefs reflect teachers' confidence in planning and executing instructional tasks. The "person-in-context" perspective, central to SCT, underscores the importance of situational specificity in understanding self-efficacy beliefs (Zee et al., 2016). According to this view, domain specificity is critical when assessing self-efficacy, as different teaching domains involve distinct demands and skills (Bandura, 1997; Tschannen-Moran et al., 1998). In this study, we focus on the teaching and learning of mathematics, where self-efficacy is conceptualised as self-referent assessments of one's ability to plan and execute the tasks required for effective mathematics instruction. These tasks include cognitive activation, goal-setting, and inspiring students to engage with and learn the subject (Perera & John, 2020).

Teachers with high self-efficacy are more confident in employing inquiry-based methods that encourage critical thinking and problem-solving (Çiftçi & Karadağ, 2019; Holzberger et al., 2013; Nie et al., 2013). In contrast, low self-efficacy is often associated with reliance on rote memorisation and procedural methods, potentially limiting students` deeper conceptual understanding (Briley, 2012; Gresham, 2008). This dynamic is particularly relevant in Estonia, where the national curriculum emphasises inquiry-based approaches (Estonian Government, 2011/2014).

Experience plays a role in shaping self-efficacy (Boz & Cetin-Dindar, 2023). While experienced teachers often report higher self-efficacy due to accumulated success (Klassen & Chiu, 2010), studies show mixed findings, with some indicating stagnation or even decline over time (Ghaith & Yaghi, 1997). Mathematics teachers generally maintain stable self-efficacy, supporting innovative strategies, while class teachers may experience fluctuations due to their broader teaching responsibilities (Takunyacı, 2021).

In the proposed model (see Figure 1), self-efficacy beliefs are hypothesised to interact with teachers' beliefs about the nature and learning of mathematics. High self-efficacy in cognitive activation aligns with inquiry-based and active learning perspectives, encouraging collaboration and critical thinking (Berk & Cai, 2019; Çiftçi & Karadağ, 2019; Holzberger et al., 2013; Nie et al., 2013). Conversely, self-efficacy in goal-setting may correlate with rules-based and teacher-directed beliefs, promoting structured and goal-oriented instruction (Barkatsas & Malone, 2005; Perera & John, 2020). These interactions provide a conceptual framework for exploring how self-efficacy influences instructional decisions and aligns with broader pedagogical beliefs (Bandura, 1997; Tschannen-Moran & Hoy, 2007).

2.5 The background of primary education in Estonia

Estonia's educational system provides a crucial context for understanding teachers' beliefs, particularly in mathematics education. Estonia is renowned for its excellent early childhood education, which establishes a solid foundation for students' later learning experiences (Jiang, 2022; Peterson et al., 2016). Compulsory education begins at age seven. In the first three or four grades, a single teacher typically teaches subjects such as mathematics. This structure emphasises the critical role of primary school teachers (i.e., class teachers), who are expected to possess strong teaching skills to guide students during these formative years (Uibu & Kikas, 2014).

The Estonian national curriculum grants teachers significant autonomy regarding what and how they teach while emphasising student-centred and constructivist principles such as critical thinking and collaboration (Estonian Government, 2011/2014). However, the focus on standardised graduation exams prioritising factual knowledge can pressure teachers to adopt transmissive methods emphasising memorisation and procedural mastery (Rosin et al., 2021).

Empirical studies highlight the importance of constructivist principles in Estonian schools. For instance, school-based teacher educators employ both individual and collaborative teaching strategies to enhance students' cognitive and social development (Leijen et al., 2024; Uibu et al., 2023). These methods—promoting group work, discussions, and critical questioning—align with the broader national emphasis on cooperative and inquiry-based learning.

Teachers' qualifications and type (class teacher vs subject teacher) may significantly shape their beliefs (Lepik et al., 2013). According to Belbase (2019), class teachers may hold beliefs that prioritise student engagement and interdisciplinary learning over strict adherence to mathematical content. In contrast, subject teachers, particularly those specialising in mathematics, often possess more focused beliefs about the nature of mathematics and its teaching. Their training typically emphasises the importance of mathematical rigour and the development of specific skills, which can lead to a belief system that prioritises procedural knowledge and mastery of mathematical concepts (Karakus et al., 2018). This distinction is particularly relevant in Estonia, where class teachers often serve as both subject specialists and generalists.

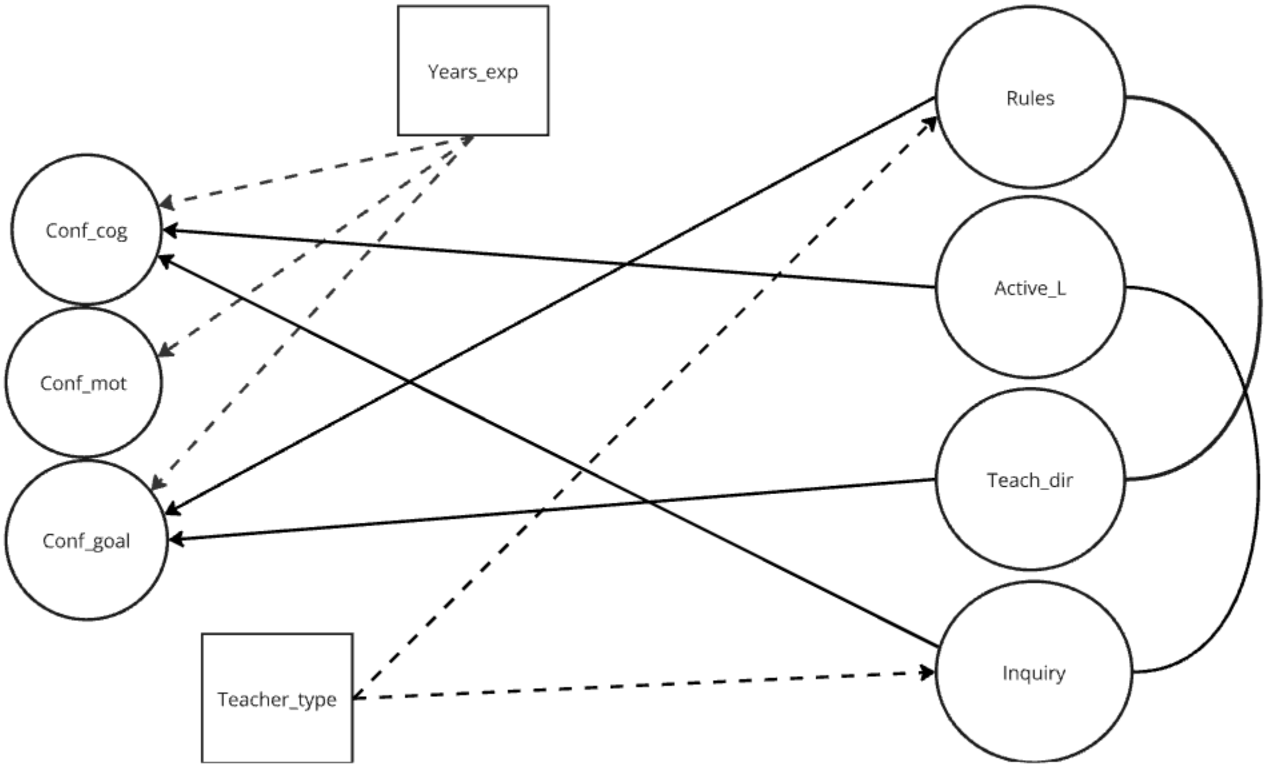
In the context of the proposed study, the Estonian educational system offers a unique setting to explore how historical influences and modern reforms interact to shape teachers' beliefs. The coexistence of rules-based and inquiry-based perspectives among Estonian teachers provides a foundation for analysing their impact on instructional practices, as illustrated in the theoretical framework and the relationships hypothesised in this study.

3 Aim and research questions

This study explores the relationship between teachers' beliefs about the nature and learning of mathematics and their self-efficacy. Drawing from the theoretical framework, the proposed model (Figure 1) hypothesises that specific belief dimensions link and reinforce each other. The study addresses the following research questions:

1. What is the relationship between teachers' beliefs about the nature of mathematics (rules and procedures vs. inquiry), learning of mathematics (teacher-directed vs. active learning) and self-efficacy beliefs (cognitive activation, goal-setting, and student motivation)? We hypothesise that rules-procedures beliefs will align with teacher-directed learning beliefs, while inquiry beliefs will correlate with active learning beliefs (Askew et al., 1997; Barkatsas & Malone, 2005; Pagiling & Taufik, 2022). Furthermore, self-efficacy belief, particularly in cognitive activation, is expected to align positively with inquiry and active learning beliefs. Conversely, self-efficacy in goal-setting is expected to correlate with rules-procedures and teacher-directed beliefs (Berk & Cai, 2019; Çiftçi & Karadağ, 2019; Holzberger et al., 2013; Saracoglu, 2022; Wellberg, 2024).
2. To what extent do teaching experience and teacher type (i.e., class teacher vs. subject teacher) moderate these relationships? Building on prior research, we predict that years of teaching experience positively correlate with self-efficacy beliefs (Boz & Cetin-Dindar, 2023; Klassen & Chiu, 2010; Mulu et al., 2021; Takunyacı, 2021; Tschannen-Moran & Hoy, 2007). Additionally, educational background and professional roles are expected to influence the alignment of rules-based and inquiry-based beliefs (Dede & Karakuş, 2014; Wellberg, 2024). The following model (Figure 1) has been hypothesised and tested based on the above.

Figure 1. Hypothesised model of interrelations among teachers' beliefs and self-efficacy



Note. Conf_cog – self-efficacy beliefs in mathematics related to cognitive activation; Conf_mot – self-efficacy beliefs in mathematics related to motivating students; Conf_goal– self- efficacy beliefs in mathematics related to goal settings; Active_L – belief on the learning of mathematics through active learning; Teach_dir – belief on the learning of mathematics through teacher directed instruction; Rules - beliefs on the nature of mathematics from a rules perspective; Inquiry – beliefs on the nature of mathematics from a inquiry perspective; Years_exp – Years of experience in teaching mathematics; Teacher_type – class teacher/subject teacher. Solid lines represent direct hypothesised relationships, while dashed lines indicate moderating effects.

4 Methods

4.1 Participants

The data collected in Estonia from a pilot phase of an international longitudinal research project on the development of mathematics motivation in elementary education MATH-Mot was used in this study. All collection took place in the spring of 2021. The participants comprised 127 in-service teachers from nine primary and secondary schools across Estonia—62 class teachers and 65 mathematics subject teachers—ensuring representation of both class and subject teachers. Teacher type (class teacher vs. subject teacher) was included as a variable to account for potential differences in teachers' beliefs (Dede & Karakuş, 2014). Participants' ages ranged from 23 to 75 years (M = 48.8, SD = 12.7), and 97% were female, reflecting the general gender distribution in Estonia, where approximately 90% of teachers are women (Jiang, 2022). Teaching experience ranged from less than five years to over 20 years, with a median of 17 years. Teacher experience was categorised on a five-step scale (1 = 1–5 years, 2 = 6–15 years, 3 = 16–25 years, 4 = 26–35 years, 5 = 36+ years). The average class size was 13 students (SD = 3.90). Approval was obtained from the University of Tartu's Ethics Committee. Participation was voluntary, and all participants provided informed consent.

4.2 Measures

The teacher survey comprised several sections, focusing on demographic information, teaching experience, and beliefs about mathematics, i.e., beliefs about the nature of mathematics, learning of mathematics, and self-efficacy in teaching mathematics. All measures were validated on samples used in the overall project as part of a generally established analytical approach.

4.2.1 Beliefs about the nature of mathematics

The scales are adapted from the Teacher Education and Development Study in Mathematics (TEDS-M) (Laschke & Blömeke, 2014) and include (a) Rules and Procedures (RULES): Six items (e.g., *"Mathematics means learning, remembering, and applying"*), and (b) Inquiry (INQUIRY): Six items (e.g., *"Mathematics involves creativity and new ideas"*). A 4-point Likert-type scale was used to score the items (1 strongly disagreed and 4 strongly agreed).

4.2.2 Beliefs about learning of mathematics

The scales are adapted from the TEDS-M(Laschke & Blömeke, 2014) and include: (a) Teacher-Directed Learning (TEACH_DIR): Four items (e.g., *"To be good in mathematics you must be able to solve problems quickly"*), and (b) Active Learning (ACTIVE_L): Four items (e.g., *"It is helpful for pupils to discuss different ways to solve particular problems"*). A 4-point Likert-type scale was used to score the items (1 strongly disagreed and 4 strongly agreed).

4.2.3 Self-efficacy beliefs about teaching mathematics

A custom measure was developed to assess teachers' confidence in three areas: (a) Goal-Setting (CONF_GOAL): Five items (e.g., *"Establishing appropriate learning goals in mathematics for students"*); (b) Motivation (CONF_MOT): Six items (e.g., *"Choosing mathematical content to foster student motivation"*) and (c) Cognitive Activation (CONF_COG): Four items (e.g., *"Challenging students to engage in critical thinking about mathematics"*). A 4-point Likert-type scale was used to score the items (1 not at all and 4 a major extent).

4.3 Analytical approach

Confirmatory Factor Analysis (CFA) using Mplus 8.11 was used to evaluate the teacher belief scale measurement model (Muthén & Muthén, 1998–2017). Table 2 summarises the CFA results for the scales measuring teachers' beliefs about the nature of mathematics, mathematics learning, and self-efficacy. Fit indices were evaluated based on widely accepted criteria. All subscales met acceptable fit thresholds, with most achieving excellent fit ($TLI \geq 0.95$, $CFI \geq 0.95$, $RMSEA \leq 0.08$) (Bowen & Guo, 2012; Brown, 2015; Kline, 2016). The global fit indices for the overall measurement model also indicated excellent fit, supporting the unified structure of the scale. Cronbach's alpha was calculated for each scale, with values > 0.7 indicating reliability. The measurement model aligns with the theoretical framework, reflecting interrelated dimensions of teachers' beliefs about the nature of mathematics, learning, and self-efficacy.

Table 2. Subscale model fit for teachers' beliefs dimensions

Belief dimension	**Subscale**	**Model fit statistics**	**Fit description**
Nature of mathematics	Rules-procedures (RULES)	$\chi^2(8) = 9.171$, $\chi^2/df = 1.146$, CFI = 0.998, TLI = 0.996, RMSEA = 0.034, SRMR = 0.032	Validates procedural beliefs about mathematics.
	Inquiry (INQUIRY)	$\chi^2(3) = 145.524$, $\chi^2/df = 48.508$, CFI = 1.000, TLI = 1.000, RMSEA = 0.000, SRMR = 0.000	Supports inquiry-oriented beliefs using parceling (Kryazos, 2018).
Learning of mathematics	Teacher-directed (TEACH_DIR)	$\chi^2(2) = 2.814$, $\chi^2/df = 1.407$, CFI = 0.999, TLI = 0.996, RMSEA = 0.040, SRMR = 0.020	Confirms teacher-directed beliefs.
	Active learning (ACTIVE_L)	$\chi^2(1) = 2.968$, $\chi^2/df = 2.968$, CFI = 0.996, TLI = 0.996, RMSEA = 0.088, SRMR = 0.017	Meets acceptable fit for active learning.
Self-efficacy	Cognitive activation (CONF_COG)	$\chi^2(2) = 2.076$, $\chi^2/df = 1.038$, CFI = 1.000, TLI = 1.000, RMSEA = 0.017, SRMR = 0.013	Indicates strong cognitive activation fit.
	Goal setting (CONF_GOAL)	$\chi^2(8) = 8.463$, $\chi^2/df = 1.058$, CFI = 0.999, TLI = 0.999, RMSEA = 0.021, SRMR = 0.029	Strong fit for motivation beliefs.
	Motivation (CONF_MOT)	$\chi^2(5) = 12.519$, $\chi^2/df = 2.504$, CFI = 0.986, TLI = 0.973, RMSEA = 0.109, SRMR = 0.048	Acceptable fit, though RMSEA slightly exceeds threshold.

Structural Equation Modeling (SEM) was conducted using Mplus version 8.11 and was used to test the hypothesised relationships between teachers' beliefs about the nature of mathematics (RULES, INQUIRY), learning mathematics (TEACH_DIR, ACTIVE_L), and self-efficacy beliefs (CONF_COG, CONF_MOT, CONF_GOAL). Aside from variables indicating teacher type (class teacher vs. subject teacher) and experience (measured on a five-step scale), which were included to account for potential differences in instructional beliefs based on role and tenure, the model also accounted for the ordinal nature of most variables. To address this, the weighted least square mean and variance adjusted (WLSMV) estimator was applied (Brown, 2015). The model fit indices were evaluated using standard criteria for SEM. The following thresholds were used to determine model adequacy (Brown, 2015; Kline, 2016): Comparative Fit Index (CFI): Values ≥ 0.95 indicate excellent fit, while values between 0.90 and 0.95 indicate acceptable fit (Hu & Bentler, 1999); Tucker-Lewis Index (TLI): Values ≥ 0.95 indicate excellent fit, while values between 0.90 and 0.95 indicate acceptable fit (Hu & Bentler, 1999); Root Mean Square Error of Approximation (RMSEA): Values ≤ 0.05 indicate close fit, and values between 0.05 and 0.08 indicate reasonable fit (Steiger, 1990); and Standardised Root Mean Square Residual (SRMR): Values ≤ 0.08 indicate a good fit (Bentler, 1995).

5 Results

The SEM analysis partially confirmed the hypothesised model, revealing significant relationships between teachers' beliefs and self-efficacy dimensions. While inquiry-based beliefs aligned with the hypothesised positive associations, rules-procedures beliefs demonstrated mixed results, with both positive and negative relationships observed. The SEM model demonstrated acceptable fit based on the following indices: $\chi^2(670.253)$, df = 493, $\chi^2/df = 1.360$, CFI = 0.948, TLI = 0.941, RMSEA = 0.053, and SRMR = 0.098. While the SRMR value slightly exceeded the ideal threshold, the overall indices suggest that the model adequately represents the relationships among the variables. The results are presented in the order of the research questions. This structure ensures a logical flow and directly addresses the hypothesised relationships within the study framework. The path coefficients (β) and their significance levels (p-values) are presented in Table 3.

Table 3. Path coefficients for relationships between teachers' beliefs and self-efficacy dimensions

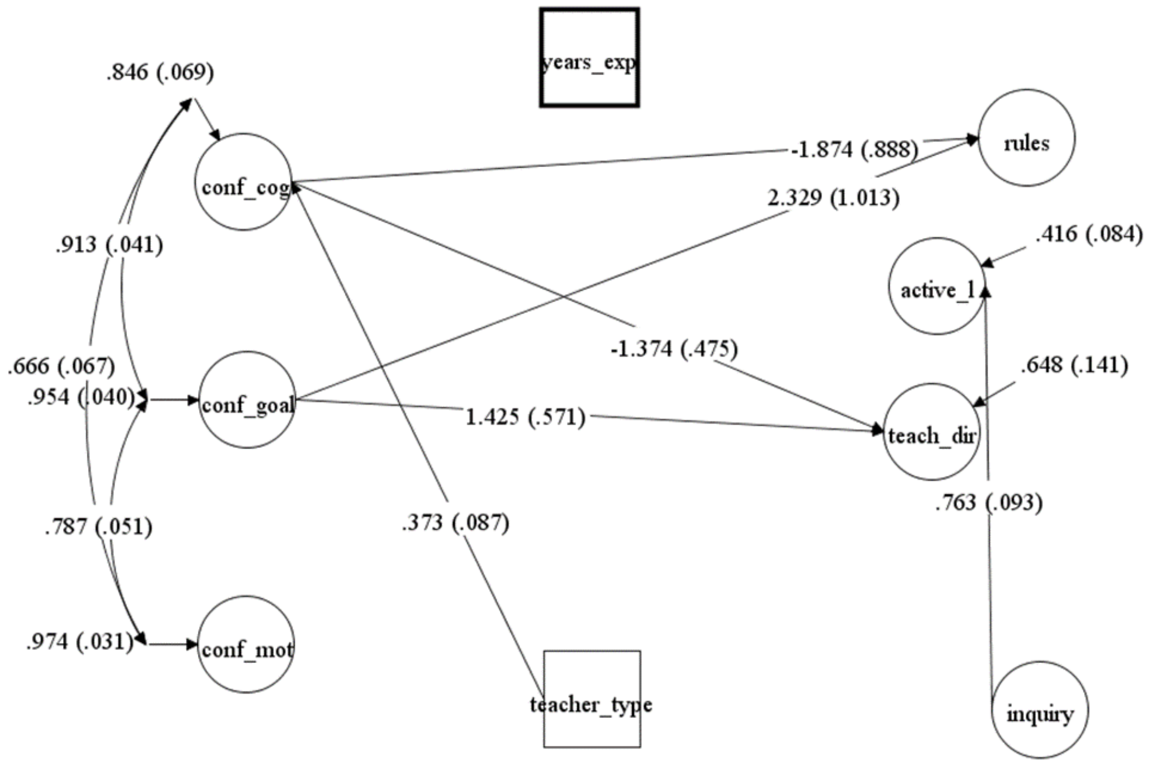
Path	β-coefficient	p-value	Interpretation
Inquiry → Cognitive activation	0.45	< 0.01	A strong positive association indicating that inquiry beliefs enhance confidence in cognitive activation.
Rules-procedures → Goal setting	0.30	<0.05	A positive association suggesting that rules-procedures beliefs align with confidence in goal-setting strategies.
Rules-procedures → Cognitive activation	- 0.22	<0.05	A negative association implying that structured beliefs may hinder confidence in fostering cognitive activation.
Teacher type → Cognitive activation	0.57	<0.01	Class teachers demonstrate higher confidence in cognitive activation compared to subject teachers.

Note: Only statistically significant paths ($p < 0.05$) are included in the table. Non-significant paths have been excluded for clarity.

The finalised SEM model (Figure 2) demonstrates significant relationships among the variables included in the study. Regarding the first research question, the SEM analysis showed mixed findings. Inquiry-based beliefs were positively associated with cognitive activation self-efficacy ($\beta = 0.45$, $p < 0.01$), aligning with the hypothesis and indicating that teachers who view mathematics as inquiry feel more confident supporting students' cognitive activation (Table 3, Figure 2). Similarly, rules-procedures beliefs were positively related to goal-setting self-efficacy ($\beta = 0.30$, $p < 0.05$), supporting theoretical expectations and suggesting that structured views of mathematics align with confidence in instructional planning. However, rules-procedures beliefs negatively correlated with cognitive activation ($\beta = -0.22$, $p < 0.05$), which contradicts the hypothesis and suggests that a structured view of mathematics might hinder confidence in fostering students' thinking. Furthermore, contrary to the hypothesis, rules-procedures beliefs did not significantly align with teacher-directed learning beliefs.

For the second research question, the analysis highlighted significant findings related to teacher type but not teaching experience. Class teachers demonstrated significantly higher cognitive activation self-efficacy compared to subject teachers ($\beta = 0.57$, $p < 0.01$, Table 3, Figure 2), supporting the hypothesis. Regarding teaching experience, no significant associations were observed for any of the self-efficacy dimensions, contrary to the hypothesis.

Figure 2. Finalised structural equation model of relationships between teachers' beliefs and self-efficacy



Note. Conf_cog – self-efficacy beliefs in mathematics related to cognitive activation; Conf_mot – self-efficacy beliefs in mathematics related to motivating students; Conf_goal– self-efficacy beliefs in mathematics related to goal settings; Active_L – belief on the learning of mathematics through active learning; Teach_dir – belief on the learning of mathematics through teacher-directed instruction; Rules - beliefs on the nature of mathematics from a rules perspective; Inquiry – beliefs on the nature of mathematics from a inquiry perspective; Teacher_type – class teacher/subject teacher;Years_exp – Years of experience in teaching mathematics.

6 Discussion

This study aimed to investigate the connections among the self-efficacy beliefs of in-service primary and secondary teachers in teaching mathematics, the nature of mathematics, and the learning of mathematics. The study further examined how these beliefs differed with respect to teacher type (i.e., class versus subject) and teaching experience.

The first research question explored the relationship between teachers' beliefs about the nature of mathematics (rules vs. inquiry), beliefs about learning mathematics (teacher-directed vs. active learning), and self-efficacy beliefs (cognitive activation, goal-setting, and student motivation). The findings revealed significant positive connections between self-efficacy beliefs in cognitive activation, goal-setting, and student motivation. This aligns with previous research indicating that teachers with high self-efficacy are more likely to implement effective teaching practices and foster student learning (Klassen et al., 2011; Zee & Koomen, 2016).

The results suggest that teachers who prioritise structured and goal-oriented instructional strategies feel more confident in achieving educational objectives, as reflected in goal-setting efficacy. The finding corresponds to the idea that clear instructional goals and structured approaches enhance teachers' confidence in their teaching abilities (Cho & Shim, 2013; Deemer, 2004). In the Estonian context, this alignment may reflect the historical emphasis on rules-based and procedural mastery in the national education system (OECD, 2022; Pedaste et al., 2019;). Despite the curriculum's emphasis on inquiry-based learning (Estonian Government, 2011/2014), many teachers still rely on transmissive methods due to systemic challenges such as large class sizes, limited professional development opportunities, and time constraints (Lepik & Pipere, 2011). This duality mirrors findings in international contexts, where teachers often endorse constructivist beliefs but rely on transmissive practices in the classroom (Chan & Elliott, 2004; Tamba & Cendana, 2021).

Significant negative relationships emerged between rules-procedures beliefs about mathematics and cognitive activation, highlighting the potential trade-offs between structured approaches and the ability to foster higher-order thinking and critical problem-solving skills. Teachers with rules-procedures perspectives may feel less prepared to engage students in inquiry-based activities, which require managing open-ended discussions and encouraging collaborative exploration (Briley, 2012; Lee et al., 2017). These findings align with prior research that underscores while many teachers endorse constructivist beliefs, they often revert to transmissive practices due to external constraints (Chan & Elliott, 2004; Tamba & Cendana, 2021). These findings align with prior research that underscores the challenges teachers face in reconciling structured teaching methods with more open-ended inquiry-based approaches.

Contrary to the hypothesis, no significant relationship was found between rules-based beliefs and teacher-directed learning. While the proposed model (Figure 1) hypothesised a correlation between these constructs, emphasising structured and procedural instruction (Barkatsas & Malone, 2005; Pagiling & Taufik, 2022), other factors may mediate this relationship. These results highlight the complexity of aligning beliefs with instructional practices, particularly in contexts where systemic constraints or varying teacher characteristics play a role. This underscores the need for further investigation into how external and contextual factors influence these relationships.

Teachers with high self-efficacy in cognitive activation were more likely to adopt inquiry-based methods, reflecting their confidence in fostering more profound learning outcomes and student engagement. This aligns with prior research suggesting that confidence in fostering students' cognitive engagement supports inquiry-based strategies (Çiftçi & Karadağ, 2019; Holzberger et al., 2013). In contrast, self-efficacy related to goal-setting was positively associated with structured and rules-based beliefs, indicating that teachers with a focus on procedural mastery feel more confident in planning and achieving instructional objectives (Barkatsas & Malone, 2005; Perera & John, 2020).

The second research question investigated how teaching experience and teacher type (class vs. subject teacher) moderated these relationships. We found no significant relationships between teachers' beliefs and their years of experience in teaching mathematics. This result aligns with the complexity highlighted in previous research, where teaching experience has been linked to both positive and negative self-efficacy outcomes (Boz & Cetin-Dindar, 2023; Ghaith & Yaghi, 1997). While accumulated experience often enhances self-efficacy due to mastery experiences (Klassen & Chiu, 2010), other research highlights potential stagnation or even decline in self-efficacy among experienced teachers, particularly in the absence of targeted professional development (Ghaith & Yaghi, 1997).

In this study, contextual factors such as the teaching environment, availability of resources, and opportunities for professional growth may have played a more significant role than years of experience. These findings emphasize the importance of ongoing professional learning to sustain and enhance self-efficacy throughout a teacher's career. For example, mathematics teachers often demonstrate stable self-efficacy supporting innovative strategies, whereas class teachers may experience fluctuations due to their broader teaching responsibilities (Takunyacı, 2021).

The significant relationship between cognitive activation beliefs and teacher type suggests that class teachers and subject teachers may differ in their confidence to engage students in critical thinking and cognitive activities. Class teachers, who typically teach a broader range of subjects and spend more time with the same group of students, may prioritise interdisciplinary approaches that foster student engagement and active participation (Belbase, 2019). This broader pedagogical scope might explain why class teachers often report higher confidence in fostering cognitive activation than subject teachers.

In contrast, subject teachers, particularly those specialising in mathematics, often hold more focused beliefs about the nature of mathematics and its teaching, emphasising mathematical rigour and procedural mastery (Karakus et al., 2018). Their training typically prioritises the development of specific mathematical skills, which can align with a belief system centred on rules-based approaches. This distinction, particularly relevant in Estonia, reflects a dual role for class teachers, who frequently serve as both subject specialists and generalists (Lepik et al., 2013). Such roles can influence the alignment of inquiry-based and rules-based beliefs, potentially leading to differences in how teachers approach cognitive activation (Dede & Karakus, 2014).

These findings underscore the need for tailored professional development initiatives that address the distinct needs of class and subject teachers. For class teachers, support could focus on enhancing interdisciplinary teaching strategies and integrating cognitive activation across various subjects. For subject teachers, particularly in mathematics, professional development could aim to balance the emphasis on procedural mastery with inquiry-based approaches that foster critical thinking and student collaboration (Holzberger et al., 2013).

Moreover, the emphasis on rule-based perspectives and teachers' beliefs about the learning of mathematics - teacher direction in the national curriculum might need re-evaluation. Encouraging a more balanced approach that includes inquiry-based learning can help teachers feel more confident in fostering higher-order thinking skills among students. Promoting student-centered and constructivist teaching practices can enhance the overall teaching quality and student outcomes in mathematics. These shifts in teaching practices are crucial for developing a learning environment that supports both cognitive and motivational aspects of student learning.

Teacher training institutions should consider these findings when designing programs and professional development initiatives. Ensuring teachers are well-equipped with rule-based and inquiry-based approaches can help them effectively balance goal-setting and cognitive activation in their instructional practices. This holistic approach to teacher training is essential for preparing teachers to meet diverse classroom challenges and to foster an engaging and dynamic learning environment.

Limitations and conclusions

The study has several limitations that should be addressed in future research. Firstly, the relatively small sample size and its representation of only a fraction of Estonian schools limit the generalizability of the findings. Subsequent studies should include more extensive and more diverse samples to validate these results and offer further insights into the relationships captured by the current investigation. Secondly, the cross-sectional design captures only a snapshot in time, which limits understanding of changes over time. Longitudinal studies are needed to examine how teachers' beliefs and self-efficacy evolve with experience and professional development. Thirdly, relying on self-reported survey data may introduce biases, such as social desirability or recall bias, where teachers may respond in ways they believe are expected or favourable. Future investigations could benefit from incorporating observational and performance-based measures. Fourthly, this study's sample reflects the gender distribution in Estonia, where teaching is predominantly a female profession, with approximately 90% of teachers being women. While this imbalance mirrors the demographic reality, it limits the generalisability of the findings to male teachers. Further research with more balanced samples is needed to explore potential gender differences in teaching beliefs and self-efficacy.

Continued research should investigate these dynamics in various educational contexts and evaluate the long-term impact of professional development on teachers' self-efficacy and instructional practices. Addressing these limitations will provide a more comprehensive understanding of the factors that affect teachers' beliefs and efficacy, leading to more optimal educational outcomes. By recognising these limitations, future studies can fill these gaps and build on the current study's findings to further advance our understanding of the relationships between teachers' beliefs, self-efficacy, and instructional practices in mathematics education.

This study highlights the complex interplay of beliefs among Estonian primary teachers regarding mathematics and teaching efficacy. The significant positive relationships among teachers' self-efficacy beliefs related to goal setting, motivating students, and cognitive activation, as well as the differences between class and subject teachers, suggest that targeted support and professional development are essential. Additionally, the lack of significant relationships between teaching experience and self-efficacy beliefs indicates that factors other than experience, such as professional development opportunities, play a part that we are yet to detangle thoroughly.

Research ethics

Author contributions

K.P.: conceptualisation, methodology, investigation, project administration, writing—original draft preparation, writing—review and editing;

Ä.L.: supervision, validation, writing—review and editing;

J.R.: formal analysis, writing—review and editing;

K.U.: supervision, validation, writing—review and editing.

All authors have read and agreed to the published version of the manuscript.

Artificial intelligence

Artificial intelligence was used solely for spelling and wording suggestions in the preparation of this article. Specifically, ChatGPT by OpenAI was employed to enhance language clarity and correct typographical errors. All AI-assisted edits were reviewed and approved by the authors to ensure accuracy and alignment with the research content.

Funding

This work was supported by Co-constructing mathematics motivation in primary education - A longitudinal study in six European countries (MATHMot) has received funding from the Research Council of Norway within the FINNUT Programme for Research and Innovation in the Educational Sector (grant number 301033).

Institutional review board statement

The study received approval from the Research Ethics Committee of the University of Tartu (approval numbers 335/T-15 and 356/M-26), in accordance with the ethical guidelines recommended by the Finnish National Board on Research Integrity (TENK). Written informed consent was obtained from all participants before their participation. Participants were thoroughly informed about the study's purpose, procedures, and their right to withdraw at any time without any consequences.

Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

The data are restricted and may be available on request. For further inquiries, please contact Jelena Radisic at jelena.radisic@ils.uio.no.

Acknowledgements

I would like to thank my supervisors for their assistance with language editing and quantitative data analysis.

Conflicts of interest

The authors have no relevant financial or non-financial interests to disclose. The authors have no competing interests to declare that are relevant to the content of this article.

References

Aljaberi, N. M., & Gheith, E. (2018). In-Service Mathematics Teachers' Beliefs about Teaching, Learning and Nature of Mathematics and Their Mathematics Teaching Practices. *Journal of Education and Learning, 7*(5), 156–173.

Bandura, A. (1997). Self-efficacy: The exercise of control. Macmillan.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191.

Barkatsas, A., & Malone, J. (2005). A typology of mathematics teachers' beliefs about teaching and learning mathematics and instructional practices. *Mathematics Education Research Journal, 17*(2), 69–90.

Belbase, S. (2019). Meanings, dimensions, and categories of mathematics teacher beliefs: A navigation through the literature. *International Journal on Emerging Mathematics Education*, *3*.

Berg, D. A., Ingram, N., Asil, M., Ward, J., & Smith, J. K. (2024). Self-efficacy in teaching mathematics and the use of effective pedagogical practices in New Zealand primary schools. *Journal of Mathematics Teacher Education*, 1–21.

Boz, Y., & Cetin-Dindar, A. (2023). Teaching concerns, self-efficacy beliefs and constructivist learning environment of pre-service science teachers: a modelling study. *European Journal of Teacher Education*, *46*(2), 274–292.

Brandenburg, R., McDonough, S., Burke, J., & White, S. (Eds.). (2016). Teacher education: innovation, intervention and impact. Springer.

Berk, D., & Cai, J. (2019). Mathematics teacher beliefs. *Encyclopedia of teacher education. Singapore: Springer.* https://doi. org/10.1007/978-981-13-1179-6_236-1.

Beswick, K. (2012). Teachers' beliefs about school mathematics and mathematicians' mathematics and their relationship to practice. *Educational Studies in Mathematics, 79*(1), 127–147.

Black, A., & Ammon, P. (1992). A developmental-constructivist approach to teacher education. *Journal of teacher education, 43*(5), 323–335.

Bowen, N.K., & Guo, S. (2012): Structural Equation Modelling. Oxford University Press, Oxford

Briley, J. S. (2012). The relationships among mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs for elementary preservice teachers. *Issues in the undergraduate mathematics preparation of school teachers*, 5.

Brown, T. (2015). Confirmatory factor analysis for applied research (2nd ed.). The Guilford Press.

Bunting, C. E. (1985). Dimensionality of teacher educational beliefs: A validation study. *The Journal of Experimental Education, 53*(4), 188–192.

Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 709–725).

Caleon, I. S., Tan, Y. S. M., & Cho, Y. H. (2018). Does teaching experience matter? The beliefs and practices of beginning and experienced physics teachers. *Research in Science Education, 48*, 117–149.

Chan, K. W., & Elliott, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and teacher education, 20*(8), 817–831.

Cho, Y., & Shim, S. S. (2013). Predicting teachers' achievement goals for teaching: The role of perceived school goal structure and teachers' sense of efficacy. *Teaching and teacher education, 32*, 12–21.

Chung, T. Y., & Chen, Y. L. (2018). Exchanging social support on online teacher groups: Relation to teacher self-efficacy. *Telematics and Informatics, 35*(5), 1542–1552.

Çiftçi, S. K., & Karadağ, E. (2019). Analysis of mathematics teachers' beliefs on mathematics instruction and teaching self-efficiencies within the scope of flow theory. *Annales Universitatis Paedagogicae Cracoviensis| Studia ad Didacticam Mathematicae Pertinentia*, *11*, 73–87.

Dede, Y., & Karakus, F. (2014). The Effect of Teacher Training Programs on Pre-Service Mathematics Teachers' Beliefs towards Mathematics. *Educational Sciences: Theory and Practice*, *14*(2), 804–809.

Deemer, S. (2004). Classroom goal orientation in high school classrooms: Revealing links between teacher beliefs and classroom environments. *Educational research, 46*(1), 73–90.

Dellinger, A. B., Bobbett, J. J., Olivier, D. F., & Ellett, C. D. (2008). Measuring teachers' self-efficacy beliefs: Development and use of the TEBS-Self. *Teaching and teacher education, 24*(3), 751–766.

Demirci, S. Ç., Kul, Ü., & Sevimli, E. (2023). Turkish adaptation of the Mathematics Teachers' Beliefs Scale. *Journal of Pedagogical Sociology and Psychology*, *5*(2), 92–104.

Dubberke, T., Kunter, M., McElvany, N., Brunner, M., & Baumert, J. (2008). Lerntheoretische Überzeugungen von Mathematiklehrkräften: Einflüsse auf die Unterrichtsgestaltung und den Lernerfolg von Schülerinnen und Schülern. *Zeitschrift für pädagogische Psychologie, 22*(34), 193–206.

Dunekacke, S., Jenßen, L., Eilerts, K., & Blömeke, S. (2016). Epistemological beliefs of prospective preschool teachers and their relation to knowledge, perception, and planning abilities in the field of mathematics: a process model. *ZDM, 48*, 125–137.

Ernest, P. (1991). The philosophy of mathematics education. London: The Falmer Press.

Ernest, P. (1989a). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of education for teaching, 15*(1), 13–33.

Ernest, P. (1989b). The impact of beliefs on the teaching of mathematics. Mathematics teaching: *The state of the art, 249*, 254.

Esterly, E. J. (2003). A multi-method exploration of the mathematics teaching efficacy and epistemological beliefs of elementary preservice and novice teachers (Doctoral dissertation, The Ohio State University).

Estonian Government. (2011/2014). National Curriculum for Basic Schools (Vol. 1). Riigi Teataja I. https://www.riigiteataja.ee/en/eli/524092014014/consolide. Accessed 24 Nov 2023

Felbrich, A., Kaiser, G., & Schmotz, C. (2014). The cultural dimension of beliefs: An investigation of future primary teachers' epistemological beliefs concerning the nature of mathematics in 15 countries. *International perspectives on teacher knowledge, beliefs and opportunities to learn: TEDS-M results*, 209–229.

Felbrich, A., Müller, C., & Blömeke, S. (2008). Epistemological beliefs concerning the nature of mathematics among teacher educators and teacher education students in mathematics. *ZDM, 40*, 763–776.

Fives, H., & Gill, M. G. (Eds.). (2015). *International handbook of research on teachers' beliefs* (pp. 13–30). Routledge.

Fives, H., & Buehl, M. M. (2012). Spring cleaning for the "messy" construct of teachers' beliefs: What are they? Which have been examined? What can they tell us?.

Ghaith, G., & Yaghi, H. (1997). Relationships among experience, teacher efficacy, and attitudes toward the implementation of instructional innovation. *Teaching and Teacher education, 13*(4), 451–458.

Gresham, G. (2008). Mathematics anxiety and mathematics teacher efficacy in elementary preservice teachers. *Teaching Education, 19*(3), 171–184.

Grigutsch, S., Raatz, U., & Törner, G. (1998). Einstellungen gegenüber mathematik bei mathematiklehrern. *Journal für Mathematik-Didaktik, 19*, 3–45.

Guler, M., & Celik, D. (2023). Are beliefs believable? An investigation of novice mathematics teachers' beliefs and teaching practices. *European Journal of Science and Mathematics Education, 11*(3), 410–426.

Han, S., Liou-Mark, J., Yu, K. T., & Zeng, S. (2015). Self-efficacy and attitudes towards mathematics of undergraduates: A US and Taiwan comparison. *Journal of Mathematics Education, 8*(1), 1–15.

Handal, B. (2003). Teachers' mathematical beliefs: A review. *The mathematics educator, 13*(2).

Henson, R. K. (2001). Teacher self-efficacy: Substantive implications and measurement dilemmas.

Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of educational psychology, 105*(3), 774.

Hoy, A. W., Hoy, W. K., & Davis, H. A. (2009). Teachers' self-effi cacy beliefs. *In Handbook of motivation at school* (pp. 641–668). Routledge.

Hoy, A., Davis, H., & Pape, S. (2006). Teachers' knowledge, beliefs, and thinking. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (pp. 715–737). Mahwah, NJ: Erlbaum

Hoy, A. W., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and teacher education, 21*(4), 343–356.

Hughes, P., Swars Auslander, S., Stinson, D. W., & Fortner, C. K. (2019). Elementary teachers' mathematical beliefs and mathematics anxiety: How do they shape instructional practices?. *School Science and Mathematics*, *119*(4), 213–222.

Isiksal-Bostan, M., Sahin, E., & Ertepinar, H. (2015). Teacher Beliefs toward Using Alternative Teaching Approaches in Science and Mathematics Classes Related to Experience in Teaching. *International Journal of Environmental and Science Education, 10*(5), 603–621.

Jakimovik, S. S. (2018). Prospective Primary School Teachers' and Pre-school Teachers' Beliefs about the Nature of Mathematics and Mathematics Learning. *Teaching Innovations/Inovacije u Nastavi*, *31*(1).

Karakuş, H., Akman, B., & Ergene, Ö. (2018). The Turkish adaptation study of the mathematical development beliefs scale. *PEGEM EGITIM VE OGRETIM DERGISI*, *8*(2).

Kim, E., Mallat, E., & Joutsenlahti, J. (2023). A systematic review of primary school class teachers views of mathematics teaching and learning. *LUMAT: International Journal on Math, Science and Technology Education, 11(*2), 60–87.

Klassen, R. M., Tze, V., Betts, S. M., & Gordon, K. A. (2011). Teacher efficacy research 1998–2009: Signs of progress or unfulfilled promise?. *Educational psychology review, 23*(1), 21–43.

Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of educational Psychology, 102*(3), 741.

Kline, R. B. (2023). *Principles and practice of structural equation modeling*. Guilford publications.

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teachers: effects on instructional quality and student development. *Journal of educational psychology, 105*(3), 805.

Laschke, C., & Blömeke, S. (Eds.). (2014). *Teacher education and development study: Learning to teach mathematics (TEDS-M 2008). Dokumentation der Erhebungsinstrumente*. Waxmann Verlag.

Lee, C. W., Walkowiak, T. A., & Nietfeld, J. L. (2017). Characterisation of mathematics instructional practices for prospective elementary teachers with varying levels of self-efficacy in classroom management and mathematics teaching. *Mathematics Education Research Journal, 29*, 45–72.

Leijen, Ä., Baucal, A., Pikk, K., Uibu, K., Pajula, L., & Sõrmus, M. (2024). Opportunities to develop student's math-related agency in primary education: the role of teacher beliefs. *European Journal of Psychology of Education*, 1–23.

Leijen, Ä., & Pedaste, M. (2018). Pedagogical beliefs, instructional practices, and opportunities for professional development of teachers in Estonia. In H. Niemi, A. Toom, A.

Lepik, M., & Pipere, A. (2011). Baltic-Nordic Comparative Study on Mathematics Teachers' Beliefs and practices. *Acta Paedagogica Vilnensia, 27.*

Levin, B. B. (2014). The development of teachers' beliefs. In *International handbook of research on teachers' beliefs* (pp. 60–77). Routledge.

Mulu, H., Kurnila, V. S., & Ningsi, G. P. (2021, November). Mathematics Teaching Efficacy: Differences in Beliefs of Preservice and In-Service Teachers. In *ICHELAC 2021: First International Conference on Humanities, Education, Language and Culture, ICHELAC 2021, 30–31 August 2021, Flores, Indonesia* (p. 99). European Alliance for Innovation.

Muthén, L. K., & Muthén, B. O. (1998–2017). Mplus user's guide (8th ed.). Muthén & Muthén.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of curriculum studies, 19*(4), 317–328.

Nie, Y., Tan, G. H., Liau, A. K., Lau, S., & Chua, B. L. (2013). The roles of teacher efficacy in instructional innovation: Its predictive relations to constructivist and didactic instruction. *Educational Research for Policy and Practice, 12*, 67–77.

Nisbet, S., & Warren, E. (2000). Primary school teachers' beliefs relating to mathematics, teaching and assessing mathematics and factors that influence these beliefs. *Mathematics Teacher Education and Development, 2*(34–47).

OECD (2022). PISA 2022 mathematics framework. https://pisa2022-maths.oecd.org/ca/index.html. Accessed 24 Nov 2024

Op't Eynde, P., & De Corte, E. (2003). Students' Mathematics-Related Belief Systems: Design and Analysis of a Questionnaire.

Pagiling, S. L., & Taufik, A. R. (2022). Unveiling belief and pedagogical content knowledge of prospective secondary mathematics teachers. *Jurnal Elemen, 8*(2), 411–426.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research, 62*(3), 307–332.

Pedaste, M., Leijen, Ä., Poom-Valickis, K., & Eisenschmidt, E. (2019). Teacher professional standards to support teacher quality and learning in Estonia. *European journal of education*, *54*(3), 389–399.

Perera, H. N., & John, J. E. (2020). Teachers' self-efficacy beliefs for teaching math: Relations with teacher and student outcomes. *Contemporary Educational Psychology, 61*, 101842.

Perkkilä, P. (2003, February). Primary school teachers' mathematics beliefs and teaching practices. In *Proceedings of the Third Conference of the European Society for Research in Mathematics Education* (pp. 1–8).

Peterson, T., Veisson, M., Hujala, E., Härkönen, U., Sandberg, A., Johansson, I., & Bakosi, E. K. (2016). Professionalism of preschool teachers in Estonia, Finland, Sweden and Hungary. *European Early Childhood Education Research Journal, 24*(1), 136–156.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. *Second handbook of research on mathematics teaching and learning, 1*, 257–315.

Plummer, B. A. (2000). *To parcel or not to parcel: The effects of item parceling in confirmatory factor analysis.* University of Rhode Island.

Putnam, R. T., & Borko, H. (1997). Teacher learning: Implications of new views of cognition. In *International handbook of teachers and teaching* (pp. 1223–1296). Dordrecht: Springer Netherlands.

Radišić, J., Buchholtz, N., Yang-Hansen, K., Liu, X., & Kaarstein, H. (2024). Do teachers' beliefs about the nature and learning of mathematics affect students' motivation and enjoyment of mathematics? Examining differences between boys and girls across six countries. *European Journal of Psychology of Education*, 1–27.

Saracoglu, M. (2022). Reflective thinking and inquiry skills as predictors of self-efficacy in teaching mathematics. *Problems of Education in the 21st Century*, *80*(1), 213–231.

Schoenfeld, A. H., Minstrell, J., & van Zee, E. (1999). The detailed analysis of an established teacher's non-traditional lesson. *The Journal of Mathematical Behavior, 18*(3), 281–325.

Selvianiresa, D., & Prabawanto, S. (2017, September). Contextual teaching and learning approach of mathematics in primary schools. In *Journal of Physics: Conference Series* (Vol. 895, No. 1, p. 012171). IOP Publishing.

Siwatu, K. O., & Chesnut, S. R. (2014). The career development of preservice and inservice teachers why teachers' self-efficacy beliefs matter. In *International handbook of research on teachers' beliefs* (pp. 212–229). Taylor and Francis.

Skott, J. (2014). The promises, problems, and prospects of research on teachers' beliefs. In *International handbook of research on teachers' beliefs* (pp. 13–30). Routledge.

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of educational psychology, 94*(2), 344.

Zee, M., & Koomen, H. M. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational research, 86*(4), 981–1015.

Zee, M., Koomen, H. M., Jellesma, F. C., Geerlings, J., & de Jong, P. F. (2016). Inter-and intra-individual differences in teachers' self-efficacy: A multilevel factor exploration. *Journal of School Psychology, 55*, 39–56.

Zuya, H. E., Kwalat, S. K., & Attah, B. G. (2016). Preservice Teachers' Mathematics Self-Efficacy and Mathematics Teaching Self-Efficacy. *Journal of education and practice, 7*(14), 93–98.

Tamba, K. P., & Cendana, W. (2021). The Relationship between pre-service elementary school mathematics teachers' beliefs about epistemology of mathematics, teaching and learning, and mathematics assessment. *Premiere Educandum: Jurnal Pendidikan Dasar Dan Pembelajaran*, *11*(1), 40.

Teo, T., Chai, C. S., Hung, D., & Lee, C. B. (2008). Beliefs about teaching and uses of technology among pre-service teachers. *Asia-Pacific Journal of Teacher Education, 36*(2), 163–174.

Thompson, A. (1992). Teachers' beliefs and conceptions. Handbook of research on mathematics teaching and learning: *A project of the National Council of Teachers of Mathematics*, 127–146.

Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics, 15*(2), 105–127.

Tire, G. (2021). Estonia: a positive PISA experience. *Improving a Country's Education: PISA 2018 Results in 10 Countries,* 101–120.

Torff, B., & Sternberg, R. J. (2001). Conceptual change in teachers' intuitive conceptions of learning, motivation, and instruction: The role of motivational and epistemological beliefs. In *Understanding and teaching the intuitive mind* (pp. 129–156). Routledge.

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and teacher Education, 23*(6), 944–956.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and teacher education, 17*(7), 783–805.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of educational research, 68*(2), 202–248.

Törner, G., & Grigutsch, S. (1994). „Mathematische Weltbilder" bei Studienanfängern—eine Erhebung. *Journal für Mathematik-Didaktik, 15*, 211–251.

Uibu, K., Salo, A., Ugaste, A., & Rasku-Puttonen, H. (2023). Observed teaching practices interpreted from the perspective of school-based teacher educators. *European Journal of Teacher Education, 46*(2), 203–221.

Uibu, K., & Kikas, E. (2014). Authoritative and authoritarian-inconsistent teachers' preferences for teaching methods and instructional goals. Education 3–13: International Journal of Primary, *Elementary and Early Years Education, 42*(1), 5–22.

Voss, T., Kleickmann, T., Kunter, M., & Hachfeld, A. (2013). Mathematics teachers' beliefs. In *Cognitive activation in the mathematics classroom and professional competence of teachers: Results from the COACTIV project* (pp. 249–271). Boston, MA: Springer US.

Wellberg, S. (2024). An examination of pre-service mathematics teachers' course-taking, beliefs, and preferred assessment practices. *Journal of Mathematics Teacher Education*, 1–40.

Wijesundera, S., & Wijethunga, K. (2021). The association between teachers' mathematical beliefs, teacher characteristics and student achievements at the junior secondary level of education in Sri Lanka. *Sri Lanka Journal of Social Sciences*, *44*(2).

Wolters, C. A., & Daugherty, S. G. (2007). Goal structures and teachers' sense of efficacy: Their relation and association to teaching experience and academic level. *Journal of educational psychology, 99*(1), 181.

Wyatt, M. (2014). Towards a re-conceptualisation of teachers' self-efficacy beliefs: Tackling enduring problems with the quantitative research and moving on. *International Journal of Research & Method in Education, 37*(2), 166–189.

Xie, S., & Cai, J. (2021). Teachers' beliefs about mathematics, learning, teaching, students, and teachers: Perspectives from Chinese high school in-service mathematics teachers. *International Journal of Science and Mathematics Education, 19,* 747–769.

Yang, X., Kaiser, G., König, J., & Blömeke, S. (2020). Relationship between preservice mathematics teachers' knowledge, beliefs and instructional practices in China. *Zdm, 52*(2), 281–294.