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A Multidimensional Analysis of Mathematical Thinking Beliefs among Mathematics Teachers

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Abstract

This study examined the mathematical thinking beliefs of secondary mathematics teachers in the Sta. Maria District during the school year 2026–2027, focusing on problem solving, mathematical representation, reasoning and proof, mathematical communication, and mathematical connection. It also determined differences in these beliefs according to sex and years of teaching experience and examined the relationships among the five dimensions. The study was anchored in teachers' beliefs, the NCTM Process Standards, and Constructivist Learning Theory. A quantitative descriptive-comparative-correlational and cross-sectional survey design was employed. Using total enumeration, all 41 public secondary mathematics teachers from six schools participated. Data were collected using the 23-item Mathematical Thinking Beliefs (MTB) questionnaire and analyzed through weighted mean, analysis of variance, and Pearson's product-moment correlation. The findings revealed a very high overall extent of mathematical thinking beliefs, with a grand mean of 4.68. Mathematical representation obtained the highest mean of 4.71, followed by problem solving at 4.70, reasoning and proof and mathematical communication at 4.68, and mathematical connection at 4.65. No significant differences were found according to sex ($p = .062$) or length of service ($p = .438$). All ten relationships among the five dimensions were positive and statistically significant, with the strongest relationship occurring between problem solving and mathematical connection ($r = 0.884$). The study concluded that mathematical thinking beliefs function as strongly interconnected components and recommended continued professional development, collaborative learning, reflective activities, and classroom practices that strengthen all five dimensions. The study supports SDG 4: Quality Education by contributing evidence for improving mathematics instruction and teachers' capacity to promote meaningful and higher-order learning. Its sustainability impact is primarily educational and institutional, as the findings may guide curriculum implementation, instructional leadership, and sustained teacher professional development.

Keywords: Constructivist Learning Theory, Mathematical Communication, Mathematical Connection, Mathematical Representation, Mathematical Thinking Beliefs, Problem Solving, Reasoning and Proof, Secondary Mathematics Teachers

1. Introduction

Mathematics education has increasingly shifted from memorization and routine procedures toward problem solving, reasoning, representation, communication, and connections. Teachers' beliefs are central to this shift because they influence instructional decisions and the learning opportunities provided to students. This study examined the mathematical thinking beliefs of secondary mathematics teachers in the Sta. Maria District during the school year 2026-2027, including differences according to sex and years of teaching experience and the relationships among the five dimensions of mathematical thinking beliefs.

Traditional mathematics instruction often emphasized memorization, procedures, and correct answers. Contemporary approaches instead emphasize conceptual understanding and higher-order thinking through problem solving, representation, reasoning and proof, communication, and mathematical connections (Boaler, 2022; OECD, 2023). Teachers' beliefs influence how these processes are incorporated into classroom instruction (Lloyd et al., 2022; Skott et al., 2021). Mathematical thinking beliefs are therefore viewed as multidimensional, with the different processes functioning as distinct but related components (Osman et al., 2021; Stylianides & Stylianides, 2020). In the Philippines, educational reforms increasingly promote learner-centred instruction and higher-order thinking. Teachers' beliefs influence instructional methods, task complexity, reasoning, and problem-solving opportunities (Barrot, 2021; Bernardo & Mendoza, 2022). However, local evidence remains limited, while findings concerning sex and teaching experience remain inconsistent (Lloyd et al., 2022; Wilkins & Norton, 2021).

Teachers' beliefs are interconnected systems that influence planning, instruction, classroom interaction, and learners' mathematical experiences (Skott et al., 2021; Lloyd et al., 2022). They affect how teachers encourage reasoning and problem solving (Hatisaru, 2025; Radišić, 2024), whether instruction is student-centred or procedural (Li, 2024; Lloyd et al., 2022), and how beliefs may develop through reflection and professional learning (Sun, 2024; Muñoz, 2024). Skott et al. (2021), Lloyd et al. (2022), Hatisaru (2025), Radišić (2024), Li (2024), Sun (2024), and Muñoz (2024) collectively emphasize the dynamic and instructional importance of teacher beliefs. Problem solving promotes analysis, strategy development, flexibility, and application of mathematics in unfamiliar situations (Santos-Trigo, 2024). More recent studies likewise associate it with higher-order thinking and real-life application (Sugiharti et al., 2026; Kurdal, 2025), while problem- and project-based approaches encourage active mathematical thinking (Anugraheni et al., 2025; Mashuri et al., 2025). Difficulties in planning and evaluating solutions further highlight the need for appropriate instructional support (Adebayo, 2025; Kholid & Aisyah, 2025). Mathematical representation enables learners to organize, visualize, and communicate ideas through symbols, diagrams, graphs, and other forms (Cai et al., 2020). Representations support meaning-making (Radford, 2021), reasoning (Hwang et al., 2021; Cai et al., 2020), and translation among different mathematical forms (Duval, 2021). Cai et al. (2020), Radford (2021), Duval (2021), and Hwang et al. (2021) consistently identify representation as essential to conceptual understanding. Reasoning and proof require learners to justify ideas, form conjectures, evaluate arguments, and think logically (Stylianides & Stylianides, 2020; Weber et al., 2021). Exploring and testing conjectures strengthens critical thinking (Jeannotte & Kieran, 2021), while explanation and justification support conceptual knowledge (Lithner, 2020; Weber et al., 2021). Creative reasoning also promotes the application of mathematical knowledge in new situations (Lithner, 2020), while mathematical literacy emphasizes reasoning and justification in real-life contexts (OECD, 2023). Mathematical communication involves explaining solutions, presenting arguments, interpreting representations, and responding to other ideas (Kazemi et al., 2021; OECD, 2023). Explanation and argumentation promote reasoning, as noted by Inglis et al. (2022), while evaluating others' reasoning develops analytical thinking (Mercer et al., 2020; Inglis et al., 2022). Classroom discussion further supports understanding (Kazemi et al., 2021; Mercer et al., 2020), and teacher-supported discourse strengthens learners' confidence in expressing mathematical ideas (Kazemi et al., 2021; Yang et al., 2023). Mathematical connections allow learners to relate concepts within mathematics, across subjects, and to real-life contexts (Cai et al., 2020; Hiebert et al., 2021). Recognizing structural relationships strengthens conceptual understanding (Hiebert et al., 2021), while real-life applications support mathematical literacy (OECD, 2023). Connecting new and prior knowledge also strengthens coherent understanding (Hiebert et al., 2021; Cai et al., 2020), and teachers' beliefs influence how such connections are incorporated into instruction (Yang et al., 2023). These dimensions function together rather than independently. Reasoning often interacts with representation and communication (Jeannotte & Kieran, 2021), while representation supports problem solving, reasoning, and communication (Cai et al., 2020; Radford, 2021). International mathematical literacy frameworks likewise integrate these processes (OECD, 2023), and research on teacher beliefs supports their interconnected nature (Lloyd et al., 2022).

International research supports mathematical thinking as a foundation for meaningful mathematics learning (Stylianides & Stylianides, 2020; Boaler, 2022). Teachers play an important role in providing opportunities for reasoning and conceptual learning (Lloyd et al., 2022), while innovative approaches and professional development can influence their beliefs (Sun, 2024; Muñoz, 2024). Technology-related beliefs also affect instructional innovation (Duong et al., 2025), and teachers' emphasis on reasoning can influence student engagement (Radišić, 2024; Li, 2024). In the Philippines, the MATATAG mathematics curriculum promotes critical thinking, problem-solving, communication, reasoning, and connections (Department of Education, 2023). Filipino research also emphasizes mathematical thinking, teacher preparedness, and instructional innovation. Ignacio (2024) highlighted teachers' perspectives on mathematics pedagogy, while Cagape and Fuentibilla (2025), Saliao and Cajandig (2025), and Melchor and Parcutilo (2025) emphasized technology, engagement, and preparedness for contemporary instructional demands. Local studies further show the importance of problem-solving practices

(Iringan, 2021; Samarita, 2022; Bernados et al., 2025), reasoning (Gonzales et al., 2023), and curriculum-based representation and connections (Department of Education, 2023). Structured and contextualized problem solving has also shown positive outcomes (Salinas, 2025; Catunhay et al., 2025; Junaid, 2025; Moyano & Andrade, 2025; Esteves et al., 2026). Technology and contextualized materials can support mathematical representation (Cagape & Fuentibilla, 2025; Saliao & Cajandig, 2025; Domingo, 2025; Picat & Natividad, 2023). Reasoning may be strengthened through structured activities and appropriate instructional approaches (Ibañez, 2025; Ablian et al., 2025; Gonzalvo & Palomares, 2025). Mathematical communication is similarly influenced by classroom interaction and language (Mindalano & Baldonado, 2025; Bravo-Sotelo et al., 2026; Garcia & Roleda, 2025), with interactive approaches such as those discussed by Godes et al. (2025) supporting communication and problem solving. Teacher beliefs are also shaped by personal, professional, and contextual experiences (Tancontian et al., 2024; Ablian et al., 2025; Melchor & Parcutilo, 2025; Gregorio & Marasigan, 2025). Jabagat et al. (2025) further linked teachers' perceptions with instructional strategies. Philippine studies on mathematics learning also show interactions among self-efficacy, motivation, anxiety, attitudes, and metacognition (Espera & Sanchez, 2025; Bautista & Dones, 2025; Anore et al., 2025; Amoranto & Manalaysay, 2025; Etcuban et al., 2019).

The study is anchored in teachers' beliefs, the NCTM Process Standards, and Constructivist Learning Theory. Pajares (1992) explains beliefs as personal understandings that influence perception and behavior, while Philipp (2007) describes beliefs as interconnected systems that guide teaching. Philipp (2007) further noted their role in organizing instructional decisions. The Process Standards from NCTM National Council of Teachers of Mathematics, (2000) identify problem solving, reasoning and proving, communication, connections, and representation as fundamental mathematical processes. Constructivist Learning Theory supports these processes by viewing learning as active knowledge construction. Together, these perspectives support the five dimensions measured by the MTB framework, which was developed from teacher belief literature and NCTM (2000) standards. The conceptual framework further uses sex and years of teaching experience as grouping variables and examines the extent, differences, and interrelationships of mathematical thinking beliefs as a basis for professional development.

Although mathematical thinking and teacher beliefs have been widely studied, much of the literature focuses on individual dimensions rather than examining problem solving, representation, reasoning and proof, communication, and connections within one multidimensional framework. Findings regarding sex and teaching experience are also mixed (Lloyd et al., 2022; Yang et al., 2023; Sun, 2024; Lloyd et al., 2022; Sun, 2024; Yang et al., 2023). The reviewed literature identified no study in the Sta. Maria District of Zamboanga City that examined secondary mathematics teachers using the complete MTB framework. The present study therefore examined the extent of the five belief dimensions, differences according to sex and teaching experience, and relationships among the dimensions to provide localized evidence for mathematics instruction and professional development.

The study aligns primarily with SDG 4 - Quality Education because it focuses on improving mathematics teaching through problem solving, reasoning, representation, communication, and conceptual connections. Its emphasis on teachers' mathematical thinking beliefs and professional development supports the development of educators capable of promoting meaningful and higher-order learning.

The study contributes mainly to educational and institutional sustainability by providing localized evidence that may guide curriculum implementation, instructional leadership, and teacher professional development. Strengthening mathematical thinking beliefs can support sustained improvement in teaching practices and learners' higher-order mathematical competencies. The findings may also assist curriculum planners, school leaders, professional development coordinators, mathematics teachers, and future researchers in improving mathematics education within the district.

2. Material and methods

2.1 Research Design

The study used a quantitative descriptive-comparative-correlational design. The descriptive component determined the extent of teachers' mathematical thinking beliefs, while the comparative component examined differences according to sex and years of teaching experience. The correlational component assessed relationships among problem solving, mathematical representation, reasoning and proof, mathematical communication, and mathematical connection. This design supported the use of structured surveys and statistical analysis in educational research (Creswell & Creswell, 2023; Fraenkel et al., 2022). Descriptive research was appropriate for examining a population or phenomenon as it exists (Fraenkel et al., 2022), while comparative research allowed differences between groups to be examined without manipulating independent variables (Creswell & Creswell, 2023). Correlational research was used to determine relationships among variables (Fraenkel et al., 2022). The study also followed a cross-sectional survey approach because data were collected at one point in time. It was non-experimental because no variables were manipulated or interventions introduced. Surveys were appropriate for collecting self-reported beliefs, attitudes, and perceptions (Creswell & Creswell, 2023).

2.2 Locale of the Study

The study was conducted in the Sta. Maria District under the Schools Division Office of Zamboanga City, Department of Education Region IX. The district is located in Zamboanga City, a highly urbanized city with diverse socioeconomic and cultural characteristics. According to the 2020 Census of Population and Housing of the Philippine Statistics Authority, Zamboanga City had a population of 977,234 and a land area of approximately 1,483.38 square kilometers. The district has six public secondary schools offering junior and senior high school education under the Department of Education curriculum. The setting provided an appropriate context for examining mathematical thinking beliefs among teachers implementing mathematics instruction focused on problem solving, reasoning, communication, representation, and connections.

2.3 Respondents of the Study

The respondents were 41 public secondary mathematics teachers assigned to the six public secondary schools in the Sta. Maria District during the school year 2026-2027. They were actively teaching mathematics at the junior or senior high school level. Of the respondents, 16 were male and 25 were female. Based on length of service, six were novice teachers, four were beginning teachers, 15 were experienced teachers, and 16 were veteran teachers. The respondents were distributed across the six schools, with 18 from School A, three from School B, five from School C, nine from School D, five from School E, and one from School F.

2.4 Sample and Sampling Procedure

Total enumeration was employed because the population was relatively small and accessible. All 41 qualified secondary mathematics teachers in the Sta. Maria District were included, eliminating the need for random sampling. This approach minimized sampling error and selection bias and ensured representation of the entire target population. Creswell and Creswell (2023) and Fraenkel et al. (2022) identified total enumeration as appropriate when the entire population is accessible. The findings were primarily applicable to the Sta. Maria District and should be generalized only to populations with comparable characteristics.

2.5 Research Instrument

A structured survey questionnaire served as the primary data-gathering instrument. The study used the Mathematical Thinking Beliefs (MTB) questionnaire developed and validated by Alhunaini, Osman, and Abdurab (2021). The instrument was based on literature concerning teachers' belief systems (Pajares, 1992; Philipp, 2007) and the Principles and Standards of School Mathematics of the National Council of Teachers of Mathematics (2000). The refined MTB consisted of 23 items distributed across five dimensions: Problem Solving with four items, Mathematical Representation with five items, Reasoning and Proof with five items, Mathematical Communication with five items, and Mathematical Connection with four items. Responses were measured using a five-point Likert-type scale ranging from 1-strongly disagree to 5-strongly agree (Likert, 1932). Respondents were given approximately 15-20 minutes to complete the questionnaire. The instrument had previously undergone exploratory and confirmatory factor analyses. The original 25-item instrument was reduced to 23 items after one Problem Solving item and one Mathematical Connection item were removed. Reported Cronbach's alpha coefficients were 0.662 for Problem Solving, 0.711 for Mathematical Representation, 0.787 for Reasoning and Proof, 0.794 for Mathematical Communication, and 0.785 for Mathematical Connection. Construct validity was supported by the reported model-fit indices. Internal consistency was re-tested in the current study using Cronbach's alpha to establish reliability within the local setting (Taherdoost, 2016). A pilot test was conducted among mathematics teachers outside the final sample, with a Cronbach's alpha of 0.70 or higher considered acceptable (Creswell and Creswell, 2018; Fraenkel et al., 2022). If coefficients fell below the acceptable level, item-total correlations were to be examined while retaining the theoretical structure of the MTB.

2.6 Data Gathering Procedure

Data gathering commenced after ethical clearance from the Universidad de Zamboanga Research Ethics Committee (UZREC) and permission from the Schools Division Office of Zamboanga City, the Public Schools District Supervisor of Sta. Maria District, and the heads of the participating schools. The researcher coordinated the schedule and method of questionnaire administration with the school heads. Eligible mathematics teachers were informed about the study objectives, procedures, risks and benefits, confidentiality, and their rights before providing informed consent. Participation was voluntary, and respondents could withdraw at any time. The MTB questionnaire was then administered, with 15-20 minutes allotted for completion. Completed questionnaires were reviewed, coded to protect respondents' identities, and securely organized for statistical analysis.

2.7 Data Analysis Techniques

The collected data were coded and analyzed using the Statistical Package for the Social Sciences (SPSS). Weighted means were computed to determine the extent of mathematical thinking beliefs across Problem Solving, Mathematical Representation, Reasoning and Proof, Mathematical Communication, Mathematical Connection, and the overall construct. Analysis of variance (ANOVA) was used to determine significant differences in mathematical thinking beliefs according to sex and length of service. The F-value and p-value were used to establish statistical significance, with p-values of 0.05 or less considered significant. Pearson's product-moment correlation coefficient was used to determine the strength and direction of relationships among the five dimensions of mathematical thinking beliefs. All statistical analyses were conducted at the 0.05 level of significance.

2.8 Ethical Considerations

The study was subjected to review and approval by the Universidad de Zamboanga Research Ethics Committee (UZREC) before participant recruitment, pilot testing, and data collection. Written informed consent was obtained from participants, who were informed of the study's purpose, procedures, duration, risks, benefits, confidentiality measures, and right to withdraw without penalty. Administrative permission was also secured from the Schools Division Office, district supervisor, and participating school heads. Participant privacy was protected through numerical coding and restricted access to research records. Data collection, storage, processing, and protection followed the Data Privacy Act of 2012 (Republic Act No. 10173). Electronic files were stored on password-protected devices and secured cloud storage, while printed materials were kept securely. The study involved minimal risk and provided no direct monetary benefit, although participants could benefit indirectly through greater awareness of their mathematical thinking beliefs and improvements in professional development and mathematics instruction. Research data were retained securely for three years and were subsequently disposed of through shredding of printed records and permanent deletion of electronic files. Participants could request a summary of the general findings, which would be reported only in aggregate form. Research integrity was maintained through accurate reporting, appropriate acknowledgment of sources, confidentiality, and disclosure of any actual or potential conflicts of interest.

3. Results and Discussion

3.1 Extent of Mathematical Thinking Beliefs

3.1.1 Problem Solving

The respondents demonstrated a very high extent of mathematical thinking beliefs in problem solving, with a grand mean of 4.70. Planning solutions received the highest mean of 4.76, while the other indicators ranged from 4.63 to 4.71, all interpreted as very high. These findings show strong beliefs in planning, using varied strategies, verifying solutions, and building mathematical knowledge through problem solving. The findings indicate that respondents regarded problem solving as an essential part of mathematical thinking. This supports Santos-Trigo (2024), Sugiharti et al. (2026), and Adebayo (2025), who emphasized problem solving in developing mathematical thinking, strategic competence, and understanding. Thus, classroom practices that encourage planning, strategic thinking, and solution verification remain important.

3.1.2 Mathematical Representation

Mathematical representation obtained a grand mean of 4.71, indicating a very high extent. The use of representations to explain mathematical situations and accelerate students' understanding received the highest mean of 4.78. The remaining indicators ranged from 4.61 to 4.73, also reflecting very high beliefs in organizing ideas, choosing appropriate representations, and modelling physical phenomena. The results indicate that respondents strongly recognized representation as important in explaining and understanding mathematical concepts. This finding is consistent with Çelik and Bukova-Güzel (2024), Zhang et al. (2025), and Hwang et al. (2025), who emphasized that representations facilitate mathematical communication, conceptual understanding, and connections between abstract concepts and real-world situations.

3.1.3 Reasoning and Proof

Reasoning and proof obtained a grand mean of 4.68, interpreted as a very high extent. The highest-rated indicator was the use of different types of mathematical reasoning to develop deeper understanding, with a mean of 4.83, followed by using different proof methods to develop logical thinking at 4.73. The remaining indicators each obtained a mean of 4.61. The results show that respondents strongly valued reasoning, proof, justification, and logical thinking in mathematics. This finding is consistent with Jeannotte et al. (2024), Stylianides and Stylianides (2024), and Arzarello et al. (2025), who emphasized reasoning and proof in justifying mathematical ideas, developing logical thinking, and understanding relationships among mathematical concepts.

3.1.4 Mathematical Communication

Mathematical communication obtained a grand mean of 4.68, indicating a very high extent. Evaluating students' communication skills and clearly communicating mathematical ideas received the highest means of 4.71. The other indicators ranged from 4.63 to 4.68, showing strong beliefs in using communication to evaluate strategies, understand others' thinking, and develop mathematical concepts. The findings indicate that mathematical communication was strongly valued as a means of expressing, explaining, and evaluating mathematical ideas. This finding is consistent with Albano et al. (2024), Daher et al. (2024), Fitriani et al. (2025), and Ariani et al.

(2025), who emphasized that mathematical communication supports clear expression, reasoning, evaluation, collaboration, and deeper mathematical understanding.

3.1.5 Mathematical Connection

Mathematical connection obtained a grand mean of 4.65, interpreted as a very high extent. Linking previous and new mathematical knowledge received the highest mean of 4.73, while the remaining indicators ranged from 4.56 to 4.66. The respondents therefore demonstrated strong beliefs in connecting mathematical concepts with prior knowledge, other topics, and other subject areas. The results suggest that connecting prior and new knowledge is important in developing mathematical thinking and deeper understanding. This finding is consistent with Santos-Trigo (2024), Hwang et al. (2025), Çelik and Bukova-Güzel (2024), and Zhang et al. (2025), who emphasized that connections among mathematical ideas, prior knowledge, disciplines, and real-world contexts promote deeper understanding, flexible thinking, and problem-solving skills.

3.1.6 Overall Mathematical Thinking Beliefs

Overall, the respondents demonstrated a very high extent of mathematical thinking beliefs, with a grand mean of 4.68. Mathematical representation ranked highest at 4.71, followed by problem solving at 4.70. Reasoning and proof and mathematical communication both obtained 4.68, while mathematical connection had the lowest mean of 4.65, although it remained within the very high category. The results show that all five dimensions were strongly reflected in the respondents' mathematical thinking beliefs. The importance of representation is consistent with Santos-Trigo (2024), Çelik and Bukova-Güzel (2024), Jeannotte et al. (2024), and Albano et al. (2024). Problem solving was likewise strongly valued, supporting Santos-Trigo (2024). The strong results for reasoning and communication support the need for learners to explain and justify solutions (Jeannotte et al., 2024; Albano et al., 2024). Although mathematical connection obtained the lowest mean, it remained very high and may be strengthened through explicit links among prior knowledge, mathematical concepts, and real-world applications (Santos-Trigo, 2024; Çelik & Bukova-Güzel, 2024).

3.2 Differences in Mathematical Thinking Beliefs According to Profile

The respondents' mathematical thinking beliefs did not significantly differ according to sex. Male teachers obtained a mean of 4.82 and female teachers obtained 4.60, with $F = 3.697$ and $p = .062$. Likewise, no significant difference was found according to length of service, with novice teachers obtaining 4.92, beginning teachers 4.67, experienced teachers 4.62, and veteran teachers 4.67. The test produced $F = 0.925$ and $p = .438$. Since both p-values exceeded 0.05, the null hypothesis was not rejected. These findings indicate that mathematical thinking beliefs were generally consistent regardless of sex or length of service and may be influenced more by professional knowledge and instructional experiences. This finding is consistent with Santos-Trigo (2024) and Jeannotte et al. (2024), who emphasized professional knowledge, teaching experiences, and reflective practice in developing mathematical thinking. Strengthening these beliefs should therefore involve mathematics teachers across demographic groups through professional development and reflective practice, as supported by Çelik and Bukova-Güzel (2024) and Albano et al. (2024).

3.3 Interrelationships Among Mathematical Thinking Beliefs

All ten relationships among the five dimensions were positive and statistically significant at the 0.01 level, with p-values of 0.000. Problem solving was strongly related to mathematical representation ($r = 0.778$), reasoning and proof ($r = 0.750$), and mathematical communication ($r = 0.683$), and very strongly related to mathematical connection ($r = 0.884$). Mathematical representation was strongly related to reasoning and proof ($r = 0.726$), mathematical communication ($r = 0.680$), and mathematical connection ($r = 0.753$). Reasoning and proof was strongly related to mathematical communication ($r = 0.743$) and mathematical connection ($r = 0.789$), while mathematical communication and mathematical connection showed a very strong positive relationship ($r = 0.815$). The null hypothesis was therefore rejected for all relationships. The findings indicate that the five dimensions function as interconnected components of mathematical thinking beliefs. The strongest relationship between problem solving and mathematical connection suggests that stronger beliefs in problem solving were associated with stronger beliefs in connecting mathematical ideas. This supports the view that mathematical thinking integrates problem posing, solving, communication, representation, reasoning, proof, and connections (Santos-Trigo, 2024). Mathematical representation also supports problem solving and reasoning (Çelik & Bukova-Güzel, 2024), while reasoning, communication, and mathematical connections interact in helping learners justify and express ideas (Jeannotte et al., 2024; Albano et al., 2024). These interconnected processes contribute to stronger conceptual understanding and mathematical competence (Hwang et al., 2025; Zhang et al., 2025; Anugraheni et al., 2025).

4. Conclusion & Recommendations

The study concluded that secondary mathematics teachers demonstrated a very high extent of mathematical thinking beliefs across problem solving, mathematical representation, reasoning and proof, mathematical communication, and mathematical connections. No significant differences were found when respondents were grouped according to sex and length of service, indicating that these demographic characteristics did not significantly influence their beliefs. The five dimensions were also strongly and positively interrelated, showing that mathematical thinking beliefs function as connected components of mathematics teaching and learning.

Curriculum planners, education supervisors, school heads, instructional leaders, and professional development coordinators should continue providing training, workshops, INSET, LAC sessions, collaborative planning, classroom observation, peer learning, and reflective activities that strengthen the five dimensions of mathematical thinking. Mathematics teachers should translate their strong beliefs into classroom practices that engage students in problem solving, multiple representations, reasoning and proof, mathematical communication, and meaningful connections. Students should likewise be provided with opportunities to apply these processes in authentic learning situations, while future researchers may conduct similar studies in different settings, with larger samples and additional variables.

The study was limited to its specific sample and educational setting and examined differences only according to sex and length of service. Other factors, including educational attainment, teaching specialization, professional development, instructional practices, and self-efficacy, were not included. The study also did not use qualitative or mixed-methods approaches that could provide deeper insights into how mathematical thinking beliefs are developed and applied in classroom practice.

5. Compliance with ethical standards

The study complied with established ethical requirements for research involving human participants. Ethical approval and administrative permissions were secured before data collection, participation was voluntary, informed consent was obtained, and confidentiality, privacy, data security, and research integrity were maintained throughout the study.

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