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Tracing the Mathematical Literacy of Prospective Teachers: Teaching Readiness in 21st-Century Education

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ABSTRACT

Mathematical literacy is increasingly recognized as a key competency in 21st-century education, equipping individuals with the ability to apply mathematics in real-world contexts. While prospective teachers are expected to possess and foster this competency, limited research has explored their actual readiness and domain-specific literacy levels. This study aims to fill that gap by examining both the performance and perspectives of prospective teachers regarding mathematical literacy. A qualitative descriptive approach was used, involving 241 participants from various education programs. Data were collected through a mathematical literacy test and an open-ended questionnaire, then analyzed using descriptive statistics and thematic analysis. The results showed a generally low level of mathematical literacy (mean score: 44.69 out of 100), with the highest achievement in Numbers and Operations, and the lowest in Geometry and Measurement. Thematic findings revealed that while students value the importance of mathematical literacy, they encounter difficulties in applying mathematical concepts to real-life problems due to limited exposure and a lack of contextual understanding. Based on these findings, the study recommends integrating mathematical literacy across the curriculum, employing contextual and project-based learning, and providing targeted support in underperforming domains. These strategies can enhance teaching readiness and better prepare prospective teachers to implement literacy-oriented mathematics instruction in 21st-century classrooms.

Keywords: Mathematical Literacy, Prospective Teacher, Teaching Readiness

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Introduction

Mathematical literacy is one of the fundamental skills that is very important to adapt to modern life (Setiawan et al., 2024). Mathematical literacy is not only limited to the academic environment but also covers daily life and work (Serin, 2023). This skill includes understanding basic mathematical concepts and a wide range of competencies, including mathematical reasoning, communication, modelling, problem-solving, and using tools and technology (Rizki & Priatna, 2019). The Programme for International Student Assessment (PISA) has affirmed that mathematical literacy is key in shaping individuals who can think critically, solve problems, and make rational decisions in various contexts (OECD, 2023). Although math literacy varies in different countries, it aims to enable individuals to understand and apply mathematical information in real-world situations(Pillai, 2017; Serin, 2023).

Because of the importance of mathematical literacy for every individual, having good mathematical literacy is a must, especially for those who will become educators.

Overall, teacher competence plays a role in determining student achievement (Dirgantoro, 2018; Podungge et al., 2020). Teachers need to have adequate mathematical literacy skills to teach and guide students in developing mathematical literacy (Setiawan et al., 2022). Teachers with good mathematical literacy can develop more effective learning methods, better understand mathematics, and relate mathematical concepts to real life. Therefore, prospective teachers as teachers in the future must also be prepared to have strong mathematical literacy. In other words, good mathematical literacy for prospective teachers will help them convey mathematical concepts contextually and easily applied by students in the future. It also means contributing to improving the quality of mathematics learning in schools.

However, existing evidence suggests that mathematical literacy among prospective teachers still requires serious attention. Several studies, both national and international, have reported that many prospective teachers demonstrate low levels of mathematical literacy. For example, Laamena & Laurens (2021) found that prospective teachers struggled to demonstrate adequate literacy skills, while Lestari et al. (2017) identified limitations in mathematical literacy knowledge and awareness among prospective teacher students. Furthermore, As'ari et al. (2017) reported that most prospective mathematics teachers in Indonesia demonstrated a low propensity for critical thinking, a key aspect of mathematical literacy.

In terms of performance, previous research has shown that students and prospective teachers in Indonesia generally succeed in solving routine problems (Levels 1–3) but struggle with more complex, higher-level questions (Levels 4–6) (Ahmad et al., 2018; Istiandaru et al., 2021). These findings collectively highlight persistent gaps in both the conceptual understanding and application of mathematical literacy, underscoring the need for a more robust and targeted approach to teacher education. Strengthening these competencies is crucial, as pre-service teachers play a crucial role in shaping mathematics instruction and fostering literacy-oriented learning in the classroom.

Several studies have highlighted shortcomings in teacher education programs to develop mathematical literacy. However, many teacher education programs continue to struggle with effectively integrating mathematical literacy into their curricula. International research indicates that there are gaps in how prospective teachers, from various educational backgrounds, are prepared to teach mathematics relevant to real-life situations. For example, research in Chile found that differences in the number of hours of mathematics instruction and pedagogy had little impact on prospective teachers' learning outcomes (Avalos et al., 2010). Furthermore, cross-country comparison studies indicate that countries with better mathematics education outcomes than the United States have different focuses in preparing prospective teachers, particularly at the secondary school level (Schmidt et al., 2011). The TEDS-M

(Teacher Education and Development Study in Mathematics) study also noted significant differences between countries in the content and approaches to mathematics instruction (Tatto & Senk, 2011). These findings highlight one point: many teacher education programs do not adequately address mathematical literacy, leaving prospective teachers unprepared to connect mathematics learning to real-life situations.

In the Indonesian context, this challenge is also evident in various teacher education programs. Although mathematical literacy is a cross-disciplinary competency, its development remains fragmented and inconsistent in teacher training. Afifah et al., (2018) found that many prospective teachers define mathematical literacy narrowly, often reducing it to procedural skills rather than emphasizing contextual problem-solving. Supporting this, Jupri and Rosjanuardi (2020) reported that even active secondary school teachers demonstrated limitations in mathematical literacy tasks, indicating systemic gaps in prior training. These findings highlight the need for a more deliberate and inclusive integration of mathematical literacy across teacher education programs, regardless of students' disciplinary backgrounds.

In today's rapidly changing world, teacher readiness must also align with the evolving demands of 21st-century education. The concept of 21st-century education emphasizes the integration of cognitive, interpersonal, and intrapersonal skills, including critical thinking, creativity, collaboration, communication, digital literacy, and lifelong learning skills (Partnership for 21st Century Learning, 2019; Voogt & Roblin, 2012). These competencies are essential not only for students but also for teachers, who must be equipped to foster such skills in learners. In this context, teaching readiness encompasses the ability to plan and deliver instruction that connects content knowledge with real-world application, leverages digital tools effectively, promotes problem-solving, and encourages student autonomy (Binkley et al., 2012; Trilling & Fadel, 2009). Consequently, mathematical literacy and teaching readiness are interlinked: a teacher who possesses strong mathematical literacy is better positioned to model and facilitate critical thinking and problem-solving, aligning with the core values of 21st-century education.

Despite increasing global attention on mathematical literacy, most studies have focused on school students or in-service teachers, with less emphasis placed on prospective teachers. For instance, studies by OECD (2023) and Ahmad et al. (2018) primarily assess students' mathematical literacy through PISA-like instruments, while other research emphasizes professional development for practicing teachers (e.g., Avalos et al., 2010; Tatto & Senk, 2011). In comparison, fewer studies investigate mathematical literacy within the context of teacher preparation, particularly about teaching readiness within the 21st-century framework. This gap limits our understanding of how future educators are prepared to promote mathematical literacy in modern classrooms.

Mathematical literacy is not only about understanding mathematical formulas and how to use them to solve mathematical problems but also about using mathematics in real life. This skill can help hone

one's thinking skills. Laamena and Laurens (2021) state that mathematical literacy is essential for prospective teachers to guide students in critical thinking and problem-solving in the real world. However, research shows prospective mathematics teachers often lack critical thinking skills and dispositions (As'ari et al., 2017). This deficiency extends to math literacy, where prospective teachers show low proficiency levels (Laamena & Laurens, 2021). These limitations can hinder their ability to foster critical thinking and mathematical literacy in students. As a result, students will only memorize formulas without understanding their meaning, leading to their low competitiveness in education and work.

In preparing prospective mathematics teachers to face the challenges of 21st-century learning, it is crucial to evaluate not only their mathematical literacy skills but also their readiness to teach by today's educational demands. Prospective teachers play a crucial role in guiding students to develop the skills needed in the ever-changing information age. Therefore, a thorough understanding of prospective teachers' mathematical literacy strengths and weaknesses is a strategic step towards improving the quality of teacher education programs.

This study focuses on exploring the mathematical literacy of prospective teachers in general, not just those enrolled in undergraduate mathematics education programs. The study aims to assess their competencies in four core domains: Number and Operations, Algebra, Geometry and Measurement, and Data Analysis and Probability. At the same time, the study examines how prepared these prospective teachers are to apply their knowledge in teaching contexts that align with the goals of 21st-century education.

Compared with previous studies that tend to focus on the general student population or in-service teachers, this study makes a unique contribution by focusing on prospective teachers, an often overlooked yet crucial group in shaping the nation's next generation of mathematically literate students. While studies such as Tatto & Senk (2011) and Schmidt et al. (2011) have addressed international differences in teacher preparation, few have examined mathematical literacy in detail, particularly within domain-specific contexts, and linked it to teaching readiness. This study addresses this gap by combining domain-based assessment with a focus on pedagogical readiness, offering both diagnostic insights and practical implications for improving teacher education.

Methods

This study uses a qualitative descriptive method. Sugiyono (2013) states that qualitative methods are categorized as a more artistic approach, with research processes that tend to be less structured. This method is interpretive, where the data results depend on interpreting the data collection process in the field. The descriptive qualitative method in this study aims to analyze and describe prospective teachers' mathematical literacy levels based on the data obtained.

The participants in this study were prospective teachers enrolled in undergraduate education programs within one of the Faculties of Education. A total of 241 individuals participated, representing various study programs and coming from different provinces across Indonesia. This diverse composition was intentionally selected through purposive sampling to capture a broad range of educational backgrounds and regional contexts, thereby aiming to reflect the characteristics of prospective teachers at the national level. The rationale for this sampling approach was to ensure diversity in institutional affiliation, geographical origin, and academic specialization, which are important factors in portraying the broader landscape of teacher preparation in Indonesia. The following table presents the demographic distribution of the participant.

Table 1. *Demographics of research subjects*

		N	%
Gender	Man	52	21.58
	Woman	189	78.42
Courses	Religious Teacher Education	15	6.22
	Indonesian Language Education	16	6.64
	English Language Education	20	8.30
	Biology Education	27	11.20
	Social Studies Education	37	15.35
	Elementary School Teacher Education	95	39.42
	Mathematics Education	31	12.86
Province	North Sumatra	92	38.17
	Riau	9	3.73
	Bengkulu	5	2.07
	Lampung	13	5.39
	Banten	23	9.54
	Jakarta	10	4.15
	DIY	2	0.83
	West Java	5	2.07
	Central Java	8	3.32
	East Java	4	1.66
	West Kalimantan	8	3.32
	Central Kalimantan	4	1.66
	North Kalimantan	1	0.41
	Bali	1	0.41
	South Sulawesi	15	6.22
	Central Sulawesi	7	2.90
	West Sulawesi	1	0.41
	North Sulawesi	4	1.66
	Ambon	5	2.07
	São Paulo	21	8.71
	Papua	3	1.24

Data collection in the study was carried out using two instruments, namely a mathematical literacy test and an open questionnaire. The mathematical literacy test includes 30 multiple-choice questions designed based on mathematical literacy indicators that refer to the PISA framework develop by OECD, (2023). The test questions provided include four main concepts: Numbers and operations, Algebra, Geometry and Measurement, and Data Analysis and Probability. These questions aim to measure core aspects of mathematical literacy, such as problem-solving ability, the application of mathematics in real-life contexts, and deep conceptual understanding. The instrument was developed through an extensive process, including expert consultation and reference to validated PISA-based items. Before implementation, the instrument underwent a rigorous validation process involving content validation by mathematics education experts and readability testing through pilot trials with pre-service teachers. First, content validation was conducted by three experts in mathematics education who reviewed each item for alignment with mathematical literacy indicators, content accuracy, cognitive level, and contextual relevance. Suggestions provided by the experts led to several revisions, such as refining the wording of questions and adjusting distractors to improve plausibility. Second, a readability test was conducted through a pilot trial involving 30 prospective teachers from a similar population as the main study participants. Respondents were asked to complete the test and provide feedback on the clarity, language difficulty, and contextual familiarity of each item. Based on the feedback, minor revisions were made to improve the interpretability of several items without altering their cognitive demands. This process ensures the appropriateness and quality of the instrument for assessing mathematical literacy. The following is an example of the mathematical literacy questions problems.

Table 2. *Examples of Mathematical Literacy Test Questions*

Example Question	Standard Content
Mr. Suratman is a farmer who applies the mina padi system, a farming method that utilizes flooded rice fields for rice cultivation and fish farming. Mr. Suratman uses a 1.5-hectare rice field to stock goldfish and tilapia fingerlings, each measuring 5–8 cm in length. It is known that the fish stocking density is 5,000 fish per hectare. The ratio of goldfish to tilapia fingerlings that Mr. Suratman stocks is 3:2. Therefore, the total number of goldfish fingerlings stocked in Mr. Suratman's rice field is…. a. 2,500 fish b. 3,000 fish c. 3,500 fish d. 4,000 fish e. 4,500 fish	Numbers and operations
Ina is following a dietary program to maintain her eating habits. Each day, she must consume at least 200 mg but no more than 250 mg of vitamin C. She then looks up the vitamin C content of some of her favorite fruits, as shown in a given table.	Algebra

Fruit	Weight	Vitamin C
	200 gr	124 mg
	1 kg	310 mg
	0,5 kg	140 mg
	100 gr	9 mg

If she can consume a maximum of 500 grams of fruit daily, then what should she eat daily to meet her required vitamin C intake?

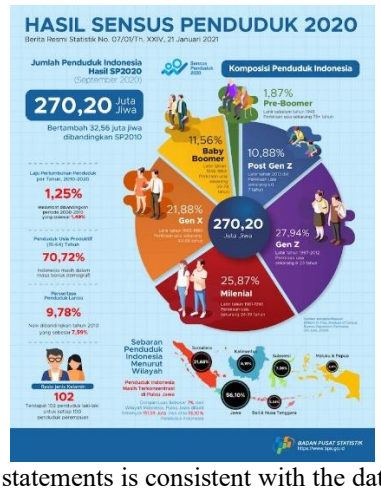
a. 200 grams of papaya, 200 grams of orange, and 100 grams of avocado
b. 200 grams of orange and 300 grams of mango
c. 200 grams of papaya, 200 grams of orange, and 100 grams of mango
d. 200 grams of papaya, 200 grams of mango, and 100 grams of avocado
e. 300 grams of orange, 100 grams of mango, and 100 grams of avocado

A cat feeder consists of a storage container and a cup (green) used to serve the food, with dimensions measured in inches (in.), as shown in the following image: Geometry and Measurement

Shinta has a cat that regularly eats using this feeder. Every day, Shinta scoops Whiskas from the fully filled storage container into the cup, which has a volume of 14.4 in^3, for her cat to consume. If the cat eats 1⁄3 of a cup twice a day, then the storage container will be empty in approximately...

a. 12 days
b. 14 days
c. 16 days
d. 18 days
e. 20 days

Observe the population census results released by BPS (Statistics Indonesia) below. Data Analysis and Probability



Which of the following statements is consistent with the data above?

a. The number of Millennials is less than ¼ of the population
b. The combined number of Millennials and Gen X is greater than the number of Gen Z, Baby Boomers, and Pre-Boomers
c. The number of Post-Gen Z is below 27 million
d. The number of Millennials has reached 67 million
e. e. More than 90% of the population is under the age of 56

Meanwhile, the open-ended questionnaire collects information regarding prospective teachers' views on mathematical literacy. The questions focused on the importance of mathematical literacy and its relationship to their educator role. Data from this questionnaire will be collected and analyzed using a qualitative approach to understand the perspective of prospective teachers more deeply. The data in this study was collected through Microsoft Forms. The prospective teacher students were gathered at a predetermined time in the rooms to take the test online. The test is done using an electronic device like a laptop or *smartphone*. During the implementation, the test is supervised by more senior prospective teacher students to ensure the order and validity of the results. Each participant was given 90 minutes to complete the test. After that, they were asked to fill out an open questionnaire. Ethical approval was secured from the university's research ethics committee, and measures were taken to ensure anonymity and confidentiality of all responses, including the use of coded identifiers and secure data storage.

To present a structured overview of the emerging themes from the open-ended responses, this study developed a thematic blueprint of readiness based on open-ended responses, which maps key aspects of prospective teachers' readiness to their views on mathematical literacy. This thematic blueprint is not derived from a pre-existing theoretical framework but was constructed inductively through thematic analysis of the qualitative data. It maps key aspects of prospective teachers' readiness to their views on mathematical literacy and their perceived roles in fostering it in the classroom. While the themes emerged from the participants' narratives, their alignment with core competencies of 21st-century teaching was

also considered during interpretation (Binkley et al., 2012; Voogt & Roblin, 2012). The 21st-century teacher readiness perspective emphasizes not only content mastery but also the ability to facilitate deeper learning through real-world applications, technology integration, and student-centered pedagogies (Partnership for 21st Century Learning, 2019; Trilling & Fadel, 2009). Table 3 presents the thematic categories derived from open responses, which reflect prospective teachers' awareness, challenges, and perceived needs about mathematical literacy in 21st-century classrooms.

Table 3. *Thematic Blueprint of Readiness Based on Open-Ended Responses*

Theme	Description	Relates 21st-Century Competency
Recognition of Importance	Prospective teachers acknowledge the value of mathematical literacy in education.	Global Awareness; Lifelong Learning
Perceived Educational Function	Mathematical literacy is seen as aiding critical thinking and real-world problem solving.	Critical Thinking and Problem Solving; Learning and Innovation Skills
Pedagogical Implication	Literacy supports development of engaging and meaningful teaching strategies.	Creativity and Innovation
Need for Further Preparation	Recognition of need for more training and support to teach literacy effectively.	Self-Directed Learning; Adaptability
Misalignment with non-math roles	Some prospective non-math teachers do not see the relevance to their teaching role.	Cross-Disciplinary Thinking; Metacognition
Conceptual Confusion	Difficulty in understanding the scope and implementation of mathematical literacy.	Critical Thinking; Metacognition
Student Resistance Concern	Fear that students' negative attitudes toward math may hinder literacy instruction.	Communication; Social and Cross-Cultural Skills

Quantitative data obtained from the mathematical literacy test were analyzed using descriptive statistical techniques, including calculating means, standard deviations, and percentage distributions. Microsoft Excel was used as the primary tool for organizing, calculating, and visualizing data through tables and charts, facilitating the interpretation of the results.

Meanwhile, qualitative data from the open-ended questionnaire were analyzed using a content analysis approach. Participants' responses were read thoroughly, and then initial codes were created based on frequently occurring ideas or phrases. These codes were grouped into main themes through an iterative process. To ensure reliability, two researchers conducted the coding separately and agreed on the results through discussion. The validity of the findings was strengthened by triangulating relevant literature.

Results and Discussion

Table 4 represents the results of the mathematical literacy test of prospective teachers in general. The average score on the mathematics literacy test was 44.69 out of a maximum score of 100. This score indicates that the mathematics literacy level of prospective teachers in this study was still below expectations. When compared with the minimum competency standards generally set for prospective teachers or the results of previous studies (OECD, 2023), this achievement indicates the need for greater

attention to strengthening mathematics literacy in teacher education programs. The relatively high standard deviation of 23.14 also indicates significant variation among participants. The wide range of scores, from 6.67 to 100, reflects differences in educational background, exposure to curriculum materials, and conceptual understanding among participants. This finding highlights the importance of providing suitable support and ensuring the equitable quality of mathematics learning for prospective teachers.

Table 4. *Mathematical Literacy Test Results*

Statistics	Value
Flattening	44,69
St. deviation	23,14
Maximum value	100
Minimum score	6,67

Remarks: maximum value = 100

These results are in line with previous research where many aspiring teachers have difficulty understanding math concepts in depth; they tend to memorize formulas and use formula-based approaches rather than understanding the underlying concepts (Novikasari et al., 2024; Sen Zeytun et al., 2024). Prospective teachers also often have difficulty connecting mathematical concepts to real-world situations, even though these skills are essential for developing mathematical literacy (Sen Zeytun et al., 2024; Sümen & Çalışıcı, 2016). Difficulties are also found in mathematical modelling (Sen Zeytun et al., 2024). In addition, although some prospective teachers can solve basic math problems, their ability to handle more complex problems is still limited, especially in high-level math literacy tasks (Yustitia et al., 2020; Zulkarnain & Hidayanto, 2021). Overall, prospective teachers' lack of math literacy can be influenced by inadequate conceptual understanding or problem-solving and difficulties in applying mathematics to real-world contexts.

Furthermore, the mathematical literacy test results reviewed from the mathematics material/topic are as follows.

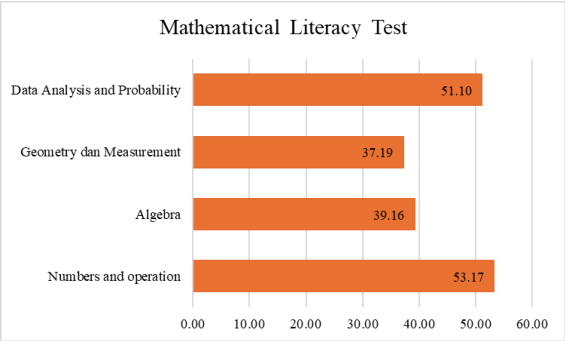


Figure 1. *Comparison of Mathematical Literacy Test Results*

The results of the mathematical literacy test of prospective teachers show variations in the level of understanding in various domains of mathematics. The highest score was found in Numbers and Operations, with a value of 53.17%. These results show that prospective teachers are relatively more proficient in the basic concepts of numbers and numerical operations learned early. Data Analysis and Probability also had a fairly good score, 51.10%, which indicates a sufficient understanding of descriptive statistics and basic probabilities. However, a lower score was seen in Algebra, with a score of 39.16%, indicating difficulties in manipulating expressions and modelling equations in algebra. The lowest score was in the Geometry and Measurement material, which was 37.19%, reflecting prospective teachers' weak understanding of spatial concepts and measurement.

Regarding the NCTM standard, geometry and measurement have been taught from preschool to grade 12. Geometry and measurement materials have also been studied in the national curriculum since elementary school. Consequently, prospective students have been studying geometry for a long time.

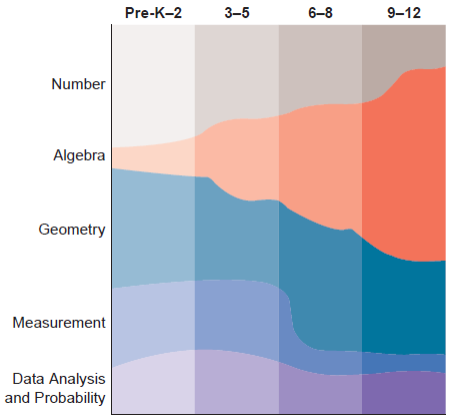


Figure 2. *Distribution of math content through the grade level (NCTM)*
Source: (Reys et al., 2009)

Geometry and measurement are fundamental topics in mathematics education that bridge everyday reality and mathematical concepts. Geometry and measurement help us analyze and understand the physical aspects and the surrounding space so that through geometry and measurement, mathematical concepts become easier to understand (Gravemeijer et al., 2007). In addition, these two topics serve as foundations in primary and secondary education, which will later become the basis for further understanding of mathematical concepts and applications in various fields (Rivera, 2015). However, some studies show that geometry and measurement are quite challenging subjects. In Indonesia, teachers have difficulty teaching this material due to the complexity of the concept and obstacles in adapting curriculum standards into the lesson plan (Syafriandi & Fitria, 2018). In Malaysia, the learning of geometry and

measurement is still moderate and ineffective in increasing students' understanding and interest (Shaimi et al., 2023).

Meanwhile, for students with significant cognitive disabilities, recent research shows an increase in geometry learning but a decrease in teaching measurement concepts (Hudson et al., 2018). In addition, prospective mathematics teachers also face challenges in understanding the geometry of transformations, such as difficulties in applying concepts, visualizing objects, understanding problems, and building mathematical proofs (Noto et al., 2019). These findings suggest that learning geometry and measurement still face various constraints across different groups of students and levels of education, which in turn affects the mathematical literacy of both students and prospective teachers.

An analysis of the open questionnaire was conducted to understand how prospective teachers view mathematical literacy in their role as educators. The question posed was: *"How do you, as a prospective teacher, view mathematical literacy?"* From the 241 respondents, 203 prospective teacher students (84.06%) indicated an understanding that mathematical literacy is important. However, 38 respondents (15.94%) still did not see the connection between mathematical literacy and their role as non-mathematics teachers. These percentage values were derived by categorizing and analyzing the respondents' written answers. To analyze the qualitative data, this study employed a thematic analysis approach as outlined by Braun & Clarke (2006). The analysis followed several steps. First, all written responses were read repeatedly to familiarize the researchers with the data. Second, initial codes were generated inductively based on recurring expressions, keywords, and phrases that reflected participants' perspectives on mathematical literacy. Third, related codes were grouped into potential themes, which were then refined and named to capture the essence of the participants' views. Examples of resulting themes include: Recognition of Importance, Pedagogical Implication, and Conceptual Confusion. To ensure the trustworthiness of the analysis, two researchers independently coded the data and then discussed the coding results to reach inter-coder agreement. Discrepancies were resolved through discussion until consensus was achieved. Additionally, peer debriefing with an external expert in qualitative educational research was conducted to validate the consistency of theme interpretations. This process increased the credibility and rigor of the thematic findings.

Specifically, 84.06% of respondents described mathematical literacy not merely as a numerical skill but as a critical thinking and problem-solving competence. Respondents emphasized that mathematical literacy can help students understand concepts more deeply and apply them in various contexts. For example, one of the respondents stated:

> *"Mathematical literacy is very important because it helps students understand the relationships between concepts, not just memorize formulas. Students with a good understanding can more easily solve applicative problems."*

In addition, other prospective teachers highlighted the importance of mathematical literacy in guiding students to solve real problems with the right mathematical approach. One respondent wrote:

"As a prospective teacher, I see mathematical literacy as a skill that must be instilled in students from an early age."

Furthermore, some responses also show that mathematical literacy supports teachers in developing more effective learning strategies, especially in improving students' understanding of numeracy concepts. One of the respondents opined:

> *"Teachers must be able to teach mathematics interestingly and meaningfully. Mathematical literacy helps students understand and apply mathematical concepts in their daily lives."*

From these responses, prospective teachers are highly aware of the importance of mathematical literacy and their role in improving students' mathematical literacy in the future. They see mathematical literacy as one of the foundations in education that is contextual, applicative, and meaningful for students. Such a perspective aligns with previous research that prospective teachers are generally aware of the importance of math literacy, even though their abilities may be limited (Laamena & Laurens, 2021; Tanase & Lucey, 2017). Research Laitochová et al. (2021) and Dofková & Chudý (2019) also state that prospective teachers view mathematical literacy as crucial for the practical application of mathematics in daily life. Many prospective teachers have also expressed interest in further training to improve their ability to develop mathematical literacy in students (Laitochová et al., 2021).

However, some prospective teachers (15.94%) still have a less optimistic view of mathematical literacy, especially about implementation in the classroom. Prospective non-math teachers view that they do not need mathematics to teach students. The following was conveyed by one of the respondents:

> *"I am not a math teacher, so I do not think mathematical literacy is useful for me to teach students later."*

Some students also feel that mathematical literacy is still challenging to understand. One of the respondents revealed:

> *"Mathematical literacy is a broad concept but often only focuses on calculations and story problems. I am still confused about how to teach it effectively."*

Some respondents also express challenges in developing students' mathematical literacy, especially when students already have a negative mindset towards mathematics. A prospective teacher wrote:

> *"Many students have been afraid or disliked mathematics since the beginning, so if I teach mathematical literacy, I am worried that it will only add to the burden on students."*

Some highlight the uneven support from the education system in developing mathematical literacy effectively. One respondent expressed his concerns:

> *"I feel that the existing courses are not optimal in helping me develop mathematical literacy as a prospective non-mathematics teacher."*

Based on these various responses, some prospective teachers face difficulties understanding and applying mathematical literacy. They feel that mathematical literacy is still tricky and adequate support is lacking in preparing them as teachers. These results are in line with several previous studies. Ball (1990) found that prospective teachers still enter the world of education with a limited understanding of mathematics and tend to follow the rules mechanically. Genc & Erbas (2019) identifies seven categories of teachers' understanding of mathematical literacy, which shows the diversity of concepts and potential ambiguity in their interpretation. Mbekwa (2006) reported that some teachers found the mathematical literacy material challenging. Moreover, Jupri and Rosjanuardi (2020) found that only a quarter of the teachers surveyed understood mathematical literacy issues, indicating a lack of readiness to teach this concept.

In addition, research conducted by Pourdavood and Liu (2017) shows that prospective primary school teachers often lack confidence in teaching mathematics, which can be attributed to negative previous learning experiences. This low confidence can affect the quality of their teaching in the future. Other research shows a positive correlation between the self-efficacy of mathematics of prospective teachers and the efficacy of teaching mathematics (Bates et al., 2011). Furthermore, research revealed that would-be teachers with lower levels of math anxiety were more confident in teaching elementary math and science compared to their counterparts with higher math anxiety (Bursal & Paznokas, 2006).

In this study, while many participants acknowledged the value of mathematical literacy for real-world problem-solving and critical thinking, they expressed uncertainty about how to implement it in their future classrooms. This concern was particularly pronounced among participants from non-mathematics education programs, some of whom perceived mathematical literacy as less relevant to their future roles. However, this view raises critical questions about the broader role of numeracy across disciplines. Rather than being confined to mathematics education, mathematical literacy should be regarded as a cross-cutting competence essential for informed decision-making, data interpretation, and quantitative reasoning in various subject areas.

Despite this, the current discussion only presents these perspectives as findings without more profound reflection. For instance, participants' difficulties in geometry or mathematical reasoning are reported but not examined in terms of possible cognitive, curricular, or pedagogical explanations. A more critical discussion could explore whether these challenges stem from gaps in previous learning, limited

exposure to real-life mathematical applications, or insufficient integration of mathematical literacy into the teacher education curriculum. Furthermore, the resistance or ambivalence shown by non-mathematics participants calls for a rethinking of how mathematical literacy is positioned within initial teacher education—emphasizing its relevance not only for teaching math, but also for fostering interdisciplinary numeracy skills.

Ultimately, these findings reflect key dimensions of 21st-century teaching competencies, such as critical thinking, instructional adaptability, and cross-disciplinary awareness. This aligns with frameworks such as the P21 Framework (Partnership for 21st Century Learning, 2019) and the OECD Learning Compass 2030 (OECD, 2018), both of which emphasize the importance of all teachers—not just mathematics educators—to incorporate mathematical literacy into their professional development. This study thus contributes to the ongoing discourse by highlighting both shared challenges and overlooked gaps in supporting prospective teachers across programs to develop this crucial competency.

Building on these findings and the results of this study, several actionable strategies are recommended to enhance prospective teachers' mathematical literacy: (1) embed mathematical literacy across disciplines: teacher education curricula should explicitly integrate mathematical literacy components not only in mathematics pedagogy courses but also across interdisciplinary contexts. This approach can help prospective teachers from non-mathematics majors recognize the relevance of mathematical literacy in their future teaching; (2) strengthen instructional modelling and scaffolding: providing prospective teachers with project-based modelling tasks (Nguyen et al., 2019) and opportunities to engage in literacy-infused lesson planning can reduce conceptual confusion and support the development of authentic, real-world instructional strategies; (3) provide structured exposure to literacy tasks: as suggested by Lestari et al. (2018), students should be systematically introduced to contextualized mathematical tasks—such as PISA-type problems—through coursework and teaching practice, to build familiarity with literacy-oriented assessment and instruction; (4) incorporate reflective metacognitive training: encouraging prospective teachers to reflect on their own mathematical literacy competencies and their practical application can enhance metacognitive awareness, which is a critical dimension of 21st-century teaching readiness (Binkley et al., 2012); (5) offer support for affective barriers: programs should also address affective challenges such as math anxiety and low teaching confidence. This program can be done through structured peer teaching sessions, confidence-building workshops, and mentoring opportunities (Bursal & Paznokas, 2006), particularly targeting those with negative prior experiences in learning mathematics. These recommendations not only respond to the challenges highlighted in the data but also align with the expectations of 21st-century education frameworks, which advocate for teachers who are not only content-competent but also adaptive, collaborative, and reflective practitioners.

Conclusion

This study revealed significant variation in prospective teachers' mathematical literacy across content domains. While participants demonstrated relatively strong understanding in Numbers and Operations, as well as Data Analysis and Probability, their performance in Algebra, and especially in Geometry and Measurement, was notably lower. The consistent struggles in spatial reasoning and geometric conceptualization are particularly concerning given the foundational role of geometry in real-world contexts such as architecture, engineering, and technology integration in classrooms.

A key insight from the open-ended questionnaire is that many non-mathematics prospective teachers perceive mathematical literacy as less relevant to their future roles. This perception gap not only limits their engagement with mathematical thinking but also reflects a broader disconnect between teacher education programs and the interdisciplinary demands of 21st-century education. Together, the quantitative and qualitative findings underscore a dual challenge: the need to address conceptual weaknesses in core mathematical domains and to foster positive, relevant perceptions of mathematical literacy among all pre-service teachers, regardless of disciplinary background.

To respond to these challenges, we recommend several targeted and actionable strategies. First, interdisciplinary curriculum development should be prioritized—embedding mathematical literacy within both content and pedagogy courses through modules that integrate real-world, context-based problems. Second, teacher education programs should adopt project-based modeling tasks and PISA-type contextual problems to develop flexible, transferable mathematical thinking. Third, reflective practices should be explicitly integrated into coursework to promote metacognitive growth and self-awareness. Fourth, practice-oriented formative assessments that simulate classroom scenarios can help bridge the gap between theory and application. Finally, tailored support programs—including workshops to reduce math anxiety—should be offered, particularly for non-mathematics majors. These approaches align with international frameworks, such as the OECD Learning Compass 2030 and the P21 Framework, which emphasize instructional adaptability, critical thinking, and lifelong learning as essential competencies for future teachers.

However, several limitations should be acknowledged. This study employed a descriptive design and a relatively limited sample, which may affect the generalizability of the findings. Future research should utilize more representative sampling methods, such as stratified random sampling across institutions and regions, to enhance external validity. Additionally, the reliance on multiple-choice items may have constrained the exploration of higher-order reasoning. Future studies are encouraged to incorporate open-ended tasks, think-aloud protocols, or classroom-based performance assessments to gain a deeper understanding of mathematical and pedagogical readiness.

Future research could also take the form of longitudinal studies to track the development of mathematical literacy across different stages of teacher education. Moreover, experimental designs could be employed to test the effectiveness of specific interventions—such as interdisciplinary training modules or reflective teaching simulations—in enhancing mathematical literacy among both mathematics and non-mathematics prospective teachers.

In summary, this study underscores the pressing need to bridge content knowledge gaps and reframe perceptions of mathematical literacy within teacher education. A combined approach—addressing cognitive skill development and affective engagement through explicit, interdisciplinary, and context-rich instruction—is essential. By aligning curriculum, pedagogy, and assessment with real-world demands, we can better prepare future educators to foster mathematically literate students who are ready to thrive in a knowledge-based global society.

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