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Profiling numeracy literacy among ninth-grade students: Empirical evidence from junior secondary education

Andes Safarandes Asmara[1*], Yusfita Yusuf[2], Anggy Giri Prawiyogi[1], Candra Zonyfar[3], Muhammad Akmal Alhamssyah[1], Muhammad Naufal Alfarid[1]
[1]Department of Elementary School Teacher Education, Universitas Buana Perjuangan Karawang, West Java, Indonesia
[2]Department of Mathematics Education, Universitas Sebelas April, West Java, Indonesia
[3]Department of Computer Science and Engineering, Sun Moon University, Asan, Republic of Korea
[*]Correspondence: andes.asmara@ubpkarawang.ac.id

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Abstract

Numeracy literacy in this study refers to students' capacity to interpret quantitative information in context, mathematize situations, use representations, justify their reasoning, select strategies, and employ symbols and tools to support defensible decisions. To address Indonesia's low performance on PISA tasks, we developed an operational profile of 9th-grade students using OECD indicators adapted to the Indonesian junior high school geometry curriculum through Candi Jiwa-based items. Using a descriptive qualitative design with quantitative support, we administered seven open-ended geometry problems to students in Karawang, Purwakarta, and Subang. Test scores were summarized to classify achievement levels. At the same time, classroom observations and semi-structured interviews with students and teachers were used to diagnose reasoning and strategy tendencies and recurring error patterns. Results show that 85.71% of students scored below 60 (low), 14.28% scored 60–80 (medium), and none exceeded 80 (high). Students' strongest area was written communication, mainly descriptive or procedural (restating givens and listing steps). Weaknesses clustered in mathematization, reasoning and argumentation, representation, strategy selection, and use of formal symbols and mathematical tools, indicating procedural competence with limited transfer to contextual modeling. Candi Jiwa serves as a place-based anchor that can lower entry barriers and guide culturally grounded, cognitively manageable task design aligned with OECD processes.

Keywords:
Candi Jiwa, Cognitive load theory, Junior secondary education, Local wisdom, Numeracy literacy

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1. INTRODUCTION

The digital era is characterized by extremely fast and easy access to information, both factual and misleading (Alenezi et al., 2023; Luscombe & Duncan, 2023; Peterson-

Salahuddin, 2024). In this environment, students need not only critical thinking and effective reasoning, but also numeracy literacy to evaluate the credibility of information that is increasingly conveyed through quantitative forms such as statistics, graphs, infographics, percentages, survey results, and algorithm-driven "data claims." Numeracy literacy integrates the ability to interpret everyday problems, analyze data, and communicate solutions using symbols and numbers (Mahmud & Pratiwi, 2019; Muniasari et al., 2024; Wardani & Siregar, 2023; Yerizon et al., 2025). With these competencies, students can interpret data accurately, detect misleading visualizations, question sampling and measurement quality, recognize inappropriate comparisons or causal inferences, and verify the plausibility of numerical statements skills that are central for confronting misinformation and disinformation in digital spaces (Loyens et al., 2023; Lukito & Madzkiyah, 2025; Pasquinelli & Richard, 2023; Ramírez-Montoya et al., 2022; Zlatkin-Troitschanskaia et al., 2020). Because it strengthens broader reasoning capacities, numeracy literacy is currently promoted as a key educational competence (Antoro, 2018; Asmara et al., 2024; Dewantara et al., 2023). Therefore, mastering numeracy literacy is not only important as an academic skill but also as an essential prerequisite for students to adapt, participate, and remain competitive amid the complexities of the digital age.

Numeracy literacy has a strategic contribution to multiple development agendas, yet its significance becomes more convincing when it is framed as a capability that enables evidence-based judgment rather than as a general "useful skill." In sustainability contexts, numeracy literacy equips individuals and communities to translate environmental and social conditions into measurable indicators, interpret trends, and evaluate trade-offs for planning, monitoring, and resource management (Ardoin et al., 2022; Reder et al., 2020). Similarly, in the global competitiveness agenda, numeracy literacy functions as a prerequisite for analytical capacity in the 21st century because it operationalizes data into problem solving and decision making capabilities consistently associated with productivity and innovation in contemporary economies (Grotlüschen et al., 2020; Krstić et al., 2020; Yekti & Mufarrihah, 2022). Conceptually, these roles can be synthesized into an integrated framework in which numeracy literacy connects: (1) contextual interpretation of quantitative information (numbers, graphs, statistical claims), (2) quantitative reasoning and analysis using mathematical representations to judge adequacy and plausibility of evidence, and (3) communication and justification of conclusions to support choices among alternatives. This integration positions numeracy literacy as a form of practical reasoning that turns quantitative evidence into actionable decisions across everyday and societal domains.

Consequently, numeracy literacy should be treated not merely as an academic outcome but as an epistemic foundation for navigating contemporary information environments, especially in the digital era where claims are increasingly legitimized through statistics, rankings, and data visualizations. In this setting, numeracy literacy shapes whether individuals can interrogate the credibility of quantitative claims, identify misleading representations, and make defensible decisions based on reliable evidence. This is precisely why numeracy literacy is theoretically central to sustainability and competitiveness: both agendas depend on the ability to evaluate data quality, interpret indicators, and select actions under uncertainty. Therefore, strengthening numeracy literacy is not simply about improving mathematical performance; it is about building the capacity to reason with data in ways that matter for public decisions and national development priorities an argument that provides a stronger theoretical basis for investigating numeracy literacy in the digital era.

Numeracy literacy has attracted sustained scholarly attention, with many studies examining how it can be strengthened through instructional designs, learning models, and classroom-based strategies. Empirical findings consistently suggest that students' numeracy improvement is closely associated with the suitability of the learning model and, crucially, teachers' capacity to select and implement the model effectively (Fauzan et al., 2024; Tabroni et al., 2022; Yerizon et al., 2025). Importantly, the scope has begun to expand beyond conventional schooling such as studies on homeschooling strategies (Dewantara et al., 2023) which signals an emerging recognition that numeracy literacy develops across varied learning ecosystems. However, without careful synthesis of thematic focus, contexts, and analytical depth, bibliometric figures alone risk becoming isolated statistics rather than evidence that strengthens theoretical arguments about what actually drives numeracy literacy outcomes.

Despite this proliferation of approaches and innovations, large-scale learning outcomes in Indonesia remain concerning, raising a critical question about the extent to which existing interventions have produced systemic impact. The PISA 2022 results show that Indonesia's mathematics score is 366, which is 106 points below the OECD average, and 82% of students perform below proficiency Level 2, representing the largest concentration of low-performing learners in mathematics/numeracy (OECD, 2023). This discrepancy suggests that the field cannot rely solely on claims that "the right learning model" will improve numeracy; rather, it must interrogate why improvements observed in limited settings do not consistently translate into broader learning gains. Therefore, the research agenda needs to move from merely cataloguing programs and methods toward a more critical examination of the enabling conditions especially the coherence between instructional innovations, teacher capacity, and contextual learning demands that determine whether numeracy literacy can be strengthened at scale in Indonesia (OECD, 2023).

Based on the presented data, there appears to be a gap between the objectives of school-based numeracy learning programs typically implemented through the Indonesian curriculum and classroom instructional innovations aimed at improving mathematics achievement and students' numeracy literacy performance as reflected in international assessments. This gap is not simply a matter of "different indicators," but rather a difference in competency focus. Many school programs still emphasize procedural mastery and routine problem solving, whereas the OECD/PISA framework conceptualizes numeracy as the ability to formulate, employ, and interpret mathematics in diverse real-life contexts. Consequently, success measures based on practice scores or school tests may not fully capture competencies required for contextual reasoning, modeling, and the use of quantitative information to support decision making. In addition, students may not yet be sufficiently accustomed to context-based problems that require integrating information, analyzing data, and interpreting results through symbols, numbers, and representations (e.g., tables and graphs) to justify decisions.

This gap provides the rationale for the present study, which aims to develop an operational profile of ninth-grade students' numeracy literacy using the OECD (2012) framework. In this study, "profile" is defined operationally as students' proficiency levels, typical reasoning strategies, and recurring error patterns when solving contextual numeracy tasks, interpreted in relation to the numeracy demands of the Indonesian lower secondary curriculum and assessment context. The study further seeks to identify students' strengths and weaknesses, as well as the specific difficulties they experience in solving contextual numeracy literacy problems particularly in quantitative reasoning, translating contexts into mathematical representations, selecting appropriate solution strategies, and using symbols and mathematical tools accurately.

2. METHOD

2.1. Research Design

This study utilised a descriptive qualitative research design complemented by quantitative data. The study employed a descriptive method to develop an operational profile of students' numeracy literacy. Geometry was selected as the focal domain because it provides rich, authentic contexts for numeracy tasks that require students to interpret spatial information, use representations (e.g., diagrams, nets, and 2D–3D models), and apply measurement-related concepts to solve real-life problems. These demands align closely with the OECD numeracy literacy framework, which emphasizes students' capacity to formulate, employ, and interpret mathematics in contextual situations. Accordingly, focusing on two-dimensional and three-dimensional geometry allows the study to examine key numeracy processes, including translating contexts into mathematical representations, selecting appropriate strategies, and justifying solutions based on quantitative reasoning, rather than treating the scope as an arbitrary topic choice. The qualitative approach focused on comprehending students' reasoning, strategies, and contextual applications, whereas the quantitative aspect offered quantifiable evidence through test scores (Creswell & Creswell, 2017; Sayehvand et al., 2025). Lester et al. (2021) argue that a qualitative design is appropriate when the research seeks to elucidate participants' perspectives, experiences, and problem-solving methodologies in authentic contexts.

2.2. Research Subjects and Objects

This study encompassed 194 ninth-grade students from junior secondary schools in three districts of West Java Province, Indonesia: Karawang, Purwakarta, and Subang. The participants were selected by purposive selection, a technique that allows the researcher to choose subjects based on particular criteria aligned with the study aims Memon et al. (2024). The inclusion criteria targeted students who had completed the geometry curriculum to ensure that their performance on the numeracy tasks reflected numeracy literacy competencies rather than mere unfamiliarity with basic content. In this study, geometry is treated not only as a curricular topic but as a vehicle for assessing OECD-aligned numeracy processes, including mathematical modeling in contextual situations, spatial reasoning, and the use of multiple representations (e.g., diagrams, nets, and 2D–3D visualizations). Therefore, selecting students who had already received core geometry instruction increased the validity of the analysis of how students formulate, employ, and interpret mathematics when solving real-life, geometry-based numeracy problems, both in classroom-type and contextual learning settings. Several mathematics instructors also served as supporting responders to augment the data, particularly in identifying problems in the advancement of numeracy literacy. The study's subjects included: (1) Students have taken essay assessments to evaluate how well they can read and write numbers in geometry; (2) The study also included interviews with students and instructors on how they deal with challenges and what kinds of problems they have; and (3) The observational data comes from Candi Jiwa's contextual learning activities, which are all about finding and utilising geometric concepts in items from the past.

2.3. Data Collection

Data collection in this study employed three techniques: an essay test, classroom observation, and semi-structured interviews. The essay test served as the primary instrument and consisted of seven open-ended, context-based geometry items administered in 80 minutes. The items were deliberately designed to span varying levels of problem complexity, ranging from relatively routine tasks (e.g., applying a known area formula with correct notation) to more complex tasks requiring unit conversion, verification of a quantitative claim, construction of representations, and multi-step decision making with justification. All items were developed and scored using an analytic rubric based on the OECD (2012) numeracy literacy indicators, namely communication, mathematization, representation, reasoning and argumentation, selecting problem-solving strategies, using formal language and symbols, and using mathematical tools.

The distribution of indicators was planned so that no single aspect dominated the assessment. Communication was elicited across all items because students were required to present their solution process and justification. Mathematization was emphasized in Items 1, 2, 4, 5, and 7 through tasks that required translating contextual situations into mathematical models (e.g., area and perimeter/spacing constraints). Representation was central in Item 3 (sketching with labeled measures) and was also involved in items that required interpreting or coordinating quantities and units. Reasoning and argumentation and strategy selection were primarily targeted in Items 1, 4, 5, and 7, which demanded verification, comparison of alternatives, or decision-oriented conclusions. Formal language and symbols were assessed in all items but were particularly explicit in Items 2 and 6 that required correct formulation and notation. Finally, the use of mathematical tools was explicitly embedded in Item 7, where students were instructed to use a calculator to support cost estimation and decision making. With this framework, each question not only demands a procedural answer but also encourages students to explain their reasoning, present alternative representations, and choose the appropriate strategy. Validation by the mathematics teacher was conducted to ensure the questions aligned with the 9th-grade junior high school curriculum and were relevant to the learning context. The data from this test then offers an in-depth assessment of students' level of mastery of numeracy literacy indicators, both in quantitative (score) and qualitative (thinking process and problem-solving strategies) terms.

In addition to the essay test, classroom observation and semi-structured interviews were conducted to enrich and triangulate the data. The observation was implemented as a non-participatory, structured classroom observation, where the researcher observed the lesson without intervening in instruction. It took place during mathematics learning on plane figures using the Candi Jiwa context, with the aim of capturing how students enacted numeracy literacy in real time, including how they communicated ideas, constructed or interpreted geometric representations, selected solution strategies, developed reasoning and justification, and used calculation tools when needed.

To ensure the consistency and reliability of the observation data, the researcher used an observation sheet guided by OECD numeracy literacy indicators as predefined categories for recording students' observable behaviors and learning artifacts. The observation categories were aligned with the OECD-based aspects of numeracy literacy, namely communication, mathematization, representation, reasoning and argumentation, strategy selection, use of formal language and symbols, and use of mathematical tools. Following the observation, semi-structured interviews were conducted with selected teachers and students using a prepared interview guide to confirm, clarify, and deepen interpretations of students' written work and observed difficulties during contextual problem solving. Semi-structured interviews with students serve to clarify written responses and further explore their communication skills, reasoning abilities, and any difficulties they may be experiencing. Interviews with teachers provide additional perspectives on the application of OECD indicators in daily learning while also highlighting the challenges in fostering students' numeracy literacy.

Through the integration of essay tests, classroom observations, and semi-structured interviews aligned with OECD indicators, this study enhances the credibility of its findings through method and source triangulation. Method triangulation was achieved by comparing evidence from students' written responses (test data) with their observed problem-solving processes during learning activities (observation data) and with their explanations and justifications during interviews. Source triangulation was conducted by drawing information from multiple participants and artifacts, including students' work, classroom interactions, and perspectives from both students and teachers. This triangulation strategy allows the study to cross-validate interpretations of students' numeracy literacy, identify consistent patterns of strengths and difficulties across data sources, and reduce the risk of relying on a single instrument to infer complex, multidimensional numeracy competencies.

2.4. Data Analysis

Data analysis in this study combined quantitative descriptive analysis of test results with qualitative diagnostic analysis of students' written work, classroom observations, and interview transcripts. The essay test consisted of seven open-ended geometry items presented within a coherent context to elicit OECD-aligned numeracy processes. The items were sequenced to progressively increase cognitive demand, moving from routine applications of geometric concepts to multi-step tasks requiring modeling, representation, and justification. Importantly, each item was designed to be answerable independently, so that students' responses to one item did not determine their performance on subsequent items. This structure was intended to maintain the validity of indicator measurement while providing consistent contextual framing for examining numeracy literacy across tasks. The question has been validated by teachers by referring to the OECD (2012) numeracy literacy indicators. The indicators used include communication skills, mathematization, representation, reasoning and argumentation, selection of problem-solving strategies, use of language and symbolic operations, formal, and the utilization of mathematical tools (see Table 1).

Table 1. Numeracy literacy indicators

Aspects of Numeracy Literacy	Indicators of Numeracy Literacy
Communication	1. Unable to write the process of reaching a problem solution. 2. Able to write the process of reaching a solution but incomplete. 3. Able to write the process of reaching a solution completely and correctly. 4. Able to conclude results and solutions but incomplete. 5. Able to conclude results and solutions completely and correctly.
Mathematization	1. Has no understanding related to the context of problem solving. 2. Has some understanding related to the context of problem solving but inaccurate. 3. Has a complete understanding related to the context of problem solving.
Representation	1. Unable to connect various types of representations when solving problems. 2. Able to connect various types of representations when solving problems but incomplete. 3. Able to connect various types of representations when solving problems completely and correctly.
Reasoning and Argumentation	1. Unable to explain justification in determining the process and procedures used to obtain mathematical results or solutions. 2. Able to explain justification in determining the process and procedures used to obtain mathematical results or solutions but incomplete. 3. Able to explain justification in determining the process and procedures used to obtain mathematical results or solutions completely and correctly.
Selecting Strategies in Problem Solving	1. Unable to use strategies through various procedures that lead to mathematical solutions and conclusions. 2. Able to use strategies through various procedures that lead to mathematical solutions and conclusions but incomplete. 3. Able to use strategies through various procedures that lead to mathematical solutions and conclusions completely and correctly.
Using Language, Symbolic, Formal, and Technical Operations	1. Unable to use formal symbols based on mathematical definitions and rules. 2. Able to use formal symbols based on mathematical definitions and rules but incomplete. 3. Able to use formal symbols based on mathematical definitions and rules completely and correctly.
Using Mathematical Tools	1. Unable to use mathematical tools to recognize mathematical structures or describe mathematical relationships. 2. Able to use mathematical tools to recognize mathematical structures or describe mathematical relationships but incomplete. 3. Able to use mathematical tools to recognize mathematical structures or describe mathematical relationships completely and correctly.

2.4.1. Quantitative analysis of test data

Students' responses were scored using an analytic rubric aligned with the OECD (2012) numeracy literacy indicators, namely communication, mathematization, representation, reasoning and argumentation, selecting problem-solving strategies, use of formal language and symbols, and use of mathematical tools. Each item produced an item-level score, and scores were also aggregated to obtain indicator-level scores by summing rubric components associated with each OECD indicator. Quantitative analysis employed descriptive statistics to summarize students' performance at the overall level, item level, and indicator level, including mean, median, standard deviation, minimum–maximum range, and percentage distribution across rubric levels. These results were used to construct students' numeracy literacy profiles and to identify indicators that were relatively strong or weak across the cohort. To support subsequent qualitative diagnosis, students were classified into high, medium, and low-achievement groups based on the distribution of total test scores (e.g., tertile cut points). This grouping was treated as a mapping of achievement levels rather than direct evidence of "difficulty." It was used to select representative cases for deeper analysis of the types and sources of difficulties reflected in students' solution processes.

Next, students are grouped based on their numeracy into low, moderate, and high categories (Safitri & Effendi, 2022), as shown in Table 2.

Table 2. Grouping of students' numeracy

No	Scale (%)	Categeory	Description
1	$0 < X \leq 60$	Low	Limited understanding and lacks basic numeracy skills
2	$60 < X \leq 80$	Medium	Adequate understanding, minor errors
3	$80 < X \leq 100$	High	Strong mastery in all indicators

2.4.2. Qualitative analysis of difficulties and solution processes

Qualitative analysis focused on identifying the types of difficulties indicated by students' written responses, observed behaviors, and interview explanations. Students' test work was examined to detect recurring patterns aligned with the OECD indicators, including (a) misinterpretation of contextual information, (b) weak mathematization or incorrect modeling assumptions, (c) representational errors (e.g., inaccurate diagrams or failure to link representations to quantities), (d) reasoning and justification gaps, (e) inappropriate strategy selection, and (f) inaccuracies in the use of symbols, units, and formal operations. For items requiring tools (e.g., calculator use), evidence of appropriate or inappropriate tool utilization was also coded. Observation notes were analyzed using the OECD indicator categories as an organizing framework to document how students communicated, represented, reasoned, and selected strategies during contextual learning activities. Semi-structured interview data were transcribed and analyzed to confirm interpretations of students' written work, clarify decision points in their reasoning, and uncover the rationale behind errors or strategy choices. Data coding proceeded through iterative cycles of categorization and refinement, with codes mapped explicitly to the OECD indicators and to common error types.

2.4.3. Trustworthiness through triangulation

To enhance validity, the study applied method triangulation and source triangulation. Method triangulation was conducted by comparing evidence from test responses (product data), classroom observations (process data), and interviews (explanatory data). Source triangulation was achieved by examining multiple sources, including students' written artifacts and perspectives from both students and teachers. Convergence across these sources was used to strengthen interpretations of students' numeracy literacy profiles and the identified difficulties, while discrepancies were treated as analytic cues to revisit scoring, coding, and contextual explanations.

The purpose of the test was to assess students' performance on contextual arithmetic word problems as an initial indicator of their numeracy literacy level. Rather than treating test scores as direct evidence of "difficulties," the scores were used to classify students into high-, medium-, and low-achievement groups and to guide a more diagnostic analysis of their numeracy literacy challenges. Specifically, difficulties were inferred by examining students' response patterns across items and OECD-aligned indicators, including recurring errors, incomplete reasoning steps, inappropriate strategy selection, and misinterpretation of representations or quantitative information. In this way, test scores functioned as a basis for mapping ability levels and selecting cases for deeper error and indicator-based analysis, allowing the study to identify the types and sources of numeracy literacy difficulties more systematically.

The researcher also observed the students as they worked on the tasks to understand how they solved math problems, how they thought, and how they applied mathematical principles to overcome challenges. Observations were utilized to identify the hurdles students encountered in understanding problem narratives and applying mathematical ideas during problem solving (Amalina & Vidákovich, 2023; Kolar & Hodnik, 2021; Ling & Mahmud, 2023). After the test, semi-structured interviews were conducted with 24 students and 6 mathematics teachers from six schools across three districts to verify students' written responses and to further explore the sources of their difficulties. We did semi-structured interviews to find out more about the difficulties students have and how they consider fixing them.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Exploration of Students' Numeracy

In the initial stage of the research, In the initial stage of the study, the researcher administered the numeracy literacy test to ninth-grade students from three districts in West Java, namely Karawang, Purwakarta, and Subang. The instrument comprised seven open-ended, context-based geometry items developed with reference to the OECD (2012) numeracy literacy framework. Each OECD indicator was operationalized through observable task demands embedded within the items rather than being measured by a single indicator per question. Specifically, communication was elicited across all items because students were required to show their work and provide written justification. Mathematization was assessed through items that required students to translate contextual situations into mathematical models or expressions, which was emphasized in Items 1, 2, 4, 5, 6, and 7. Representation was operationalized most explicitly in Item 3 through tasks that required students to construct a labeled sketch or interpret spatial information, and it was also involved in items requiring the coordination of quantities and units. Reasoning and argumentation were targeted primarily in Items 1, 4, 5, and 7, which required students to verify a quantitative claim, compare alternatives, or reach a decision supported by justification. Strategy selection was embedded in multi-step items (Items 1, 4, 5, and 7) that allowed for alternative solution pathways and required students to choose an efficient approach. The use of formal language and symbols was assessed across items through the correctness of notation, units, and mathematical expressions, with particular emphasis in Items 2 and 6 where students were expected to formulate or apply standard expressions accurately. Finally, the use of mathematical tools was operationalized explicitly in Item 7, where students were instructed to use a calculator to support estimation and decision making. This distribution ensures that the seven OECD indicators are represented in a planned manner across the test and supports the construct validity and balance of the measurement.

The OECD (2012) indicators adopted in this study comprise seven interrelated aspects: (1) communication, defined as students' ability to express mathematical ideas coherently in written (and, when relevant, oral) form; (2) mathematization, namely translating real-world situations into mathematical models; (3) representation, referring to the use of diagrams, tables, graphs, or symbolic forms to organize and present quantitative information; (4) reasoning and argumentation, which involves drawing logical conclusions and providing defensible justification; (5) strategy selection, defined as choosing an appropriate and efficient approach to solve a problem; (6) use of formal language and symbols, including accurate notation, units, and operations; and (7) use of mathematical tools, encompassing conventional instruments and digital tools such as calculators. Using these indicators as the analytic lens, the test results produced a differentiated picture of students' performance across Karawang, Purwakarta, and Subang, highlighting variations in strengths, weaknesses, and recurring difficulties when solving contextual problems. To provide an empirical basis for interpreting the numeracy literacy profile, the distribution of students' test scores across the three districts is summarized in Table 3.

Table 3. Students' numeracy scores

No	Scale (%)	Category	Percentage (%)	Indicator of Numeracy Literacy
1	$0 < X \leq 60$	Low	85.71	2,3,4,5,6 dan 7
2	$60 < X \leq 80$	Medium	14.28	1
3	$80 < X \leq 100$	High	0	-

Based on the distribution in Table 3, 85.71% of students were classified in the low category (total score < 60), 14.28% in the medium category (60–80), and 0% in the high category (> 80). However, this classification becomes more meaningful when interpreted through the OECD indicator profile derived from the test rubric. As shown in Figure 1, students' achievement is relatively higher on communication (60.50), whereas performance on the remaining indicators is consistently low, ranging from 18.80 to 23.27. In particular, the weakest aspects are using mathematical tools (18.80) and selecting strategies in problem solving (19.52), followed by reasoning and argumentation (20.85), mathematization (20.88), and representation (21.00). Students also show limited accuracy in using language, symbolic, formal, and technical operations (23.27). This pattern indicates that students' difficulties are not primarily in expressing answers, but in the core numeracy processes emphasized by the

OECD framework, namely translating contexts into mathematical models, coordinating representations, selecting efficient solution pathways, and justifying conclusions with valid quantitative reasoning.

Therefore, the finding does not stop at score categorization; it points to a substantive diagnostic conclusion that students' numeracy literacy challenges are concentrated in modeling, reasoning, representation, strategy selection, and tool use, rather than in communication alone. This indicator-level weakness supports the need for learning strategies that explicitly scaffold contextual modeling and multi-step reasoning, strengthen representational competence, and promote appropriate strategy and tool use during problem solving, so that improvements address the specific numeracy literacy dimensions assessed in this study.

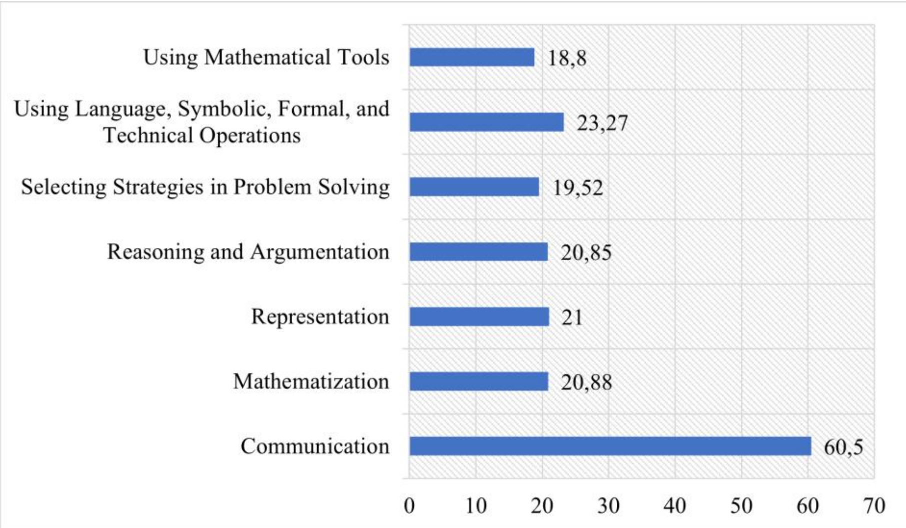


Figure 1. Average scores of students' numeracy literacy aspects

Figure 1 highlights a sharp contrast between the highest and lowest numeracy literacy indicators. The highest score appears in Communication (60.50), suggesting that many students can present their work in writing, restate known information, and describe procedural steps. This strength is likely supported by classroom routines that frequently require students to write solution steps and final answers in a structured format, making communication practices more familiar than other numeracy processes.

In contrast, the lowest score is found in Using Mathematical Tools (18.80), indicating that students rarely use tools such as calculators or measurement aids strategically to support estimation, checking, or decision making. This weakness may be caused by limited opportunities in instruction and assessment to integrate tool use as part of problem solving, since classroom tasks often emphasize manual computation and formula application rather than using tools to validate results or handle realistic numerical complexity.

3.1.2. Observation and Interview Results

Based on the interviews, teachers interpret numeracy literacy as students' ability to apply mathematical knowledge in everyday life, rather than merely a computational skill. The teachers emphasized that the main difficulty frequently encountered in the classroom lies in contextual problems, particularly when students are asked to model real-life situations into mathematical forms. Based on observations factors contributing to these difficulties include weak understanding of basic concepts, low learning interest, and limited instructional media. Consequently, the most common approach in classroom practice tends to remain teacher-centered, with teachers taking a more active role from the beginning to the end of the lesson. Teachers often explain the concepts drawn from textbooks, followed by providing examples and practice exercises, as they believe that the dense and extensive material may not be delivered effectively through other methods.

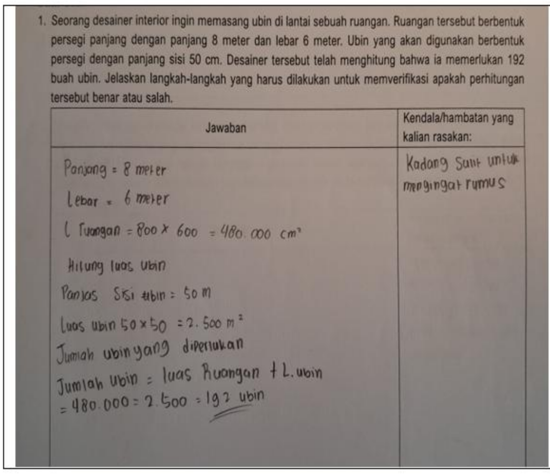
Several teachers stated that they had attempted to use digital media or e-learning, but its implementation has not yet been optimal in helping students master numeracy literacy. Nevertheless, teachers considered that the integration of local culture such as using the context of Candi Jiwa has the potential to facilitate student learning, as it brings the material closer to their real-life experiences. Teachers also expressed hope that the presence of an e-learning module based on Cognitive Load Theory could reduce students' cognitive burden, thereby making the understanding of numeracy tasks easier.

Interviews indicated that most students interpreted numeracy literacy primarily as the ability to perform calculations and apply formulas, even though they acknowledged its importance. Evidence for this procedural interpretation emerged from students' explanations of their test solutions, which often emphasized "computing the answer" without explicitly describing how they translated the context into a mathematical model, interpreted representations (e.g., diagrams, units, or given constraints), or justified decisions based on the reasonableness of results. Only a small number of students referred to OECD-aligned elements such as selecting an appropriate strategy, checking plausibility, or explaining why a conclusion was valid in the given context. This pattern suggests that students' perceptions and practices of numeracy literacy are still weakly connected to the broader OECD framework that emphasizes reasoning, modeling, interpretation, and decision making.

Students admitted that their greatest difficulties arose when facing word problems or tasks requiring deeper reasoning. The obstacles they reported included lengthy problem statements, complex numbers, and difficulties in visualizing the real-life situations described. Some students noted that the use of digital applications or e-learning was quite helpful, although it did not fully address their challenges. Interestingly, students felt more motivated when problems were connected to local culture, such as Candi Jiwa, because they perceived them as more concrete and easier to grasp. They also expressed hope for the development of a culture-based e-learning module equipped with visuals, stories, and authentic problems, so that the process of learning numeracy becomes more engaging, clear, and meaningful. Expressed was derived from most students' responses to interview question number 5, for example: "If a numeracy problem is linked to local culture, such as Candi Jiwa, do you find it easier or harder to understand? Why?"

3.1.3. Students with Low Numeracy

Students with low numeracy literacy exhibited difficulties that were not merely incidental, but structural and systemic across nearly all OECD indicators. Their work typically reflected a learning orientation centered on recalling formulas and reproducing routine procedures, which allowed them to complete only simple, well-rehearsed tasks. When problems required interpreting contextual information, constructing a mathematical model, coordinating representations (e.g., diagrams, units, and spatial relations), selecting an efficient strategy, or providing justification, their performance tended to break down. This pattern suggests that students' weaknesses are rooted in learning experiences that may overemphasize memorization and procedural completion, while providing limited opportunities to practice contextual modeling, reasoning, and decision making. Consequently, low achievement should be understood as a systemic gap between the numeracy demands of contextual tasks and the procedural focus that dominates students' learning routines. Their responses were often incomplete, lacking explanations of the thought process, and in some cases amounted merely to guessing the final answer. Moreover, students in this category rarely employed alternative strategies or utilized mathematical tools. This pattern indicates that their critical thinking skills and ability to transfer concepts to real-life situations remain very limited. Signs of hesitation were also evident when responding to questions, as illustrated in Figure 2.


1. Seorang desainer interior ingin memasang ubin di lantai sebuah ruangan. Ruangan tersebut berbentuk persegi panjang dengan panjang 8 meter dan lebar 6 meter. Ubin yang akan digunakan berbentuk persegi dengan panjang sisi 50 cm. Desainer tersebut telah menghitung bahwa ia memerlukan 192 buah ubin. Jelaskan langkah-langkah yang harus dilakukan untuk memverifikasi apakah perhitungan tersebut benar atau salah.

Jawaban	Kendala/hambatan yang kalian rasakan:
Panjang = 8 meter Lebar = 6 meter L ruangan = 800 x 600 = 480.000 cm² Hitung luas ubin Panjas sisi ubin = 50 m Luas ubin 50 x 50 = 2.500 m² Jumlah ubin yang diperlukan Jumlah ubin = luas Ruangan + L. ubin = 480.000 = 2.500 = 192 ubin	Kadang sulit untuk mengingat rumus

1. An interior designer wants to install tiles on the floor of a room. The room is rectangular in shape with a length of 8 meters and a width of 6 meters. The tiles to be used are square in shape with a side length of 50 cm. The designer had calculated that he needed 192 tiles. Describe the steps to take to verify whether the calculation is correct or incorrect.

answer	Obstacles that you feel
length = 8 Meters Width = 6 meters L room = 800 x 600 = 480.00 cm^2 Calculate tile area tile side length = 50 m Tile area 50x50 = 2,500 m2 Number of tiles required number of tiles = room area + L. Tiles = 480,000 = 2,500 = 192 tiles	Sometimes it's hard to remember the formula

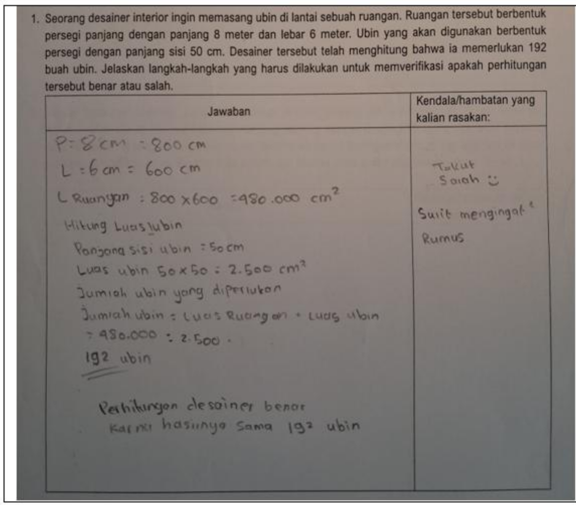
Figure 2. Example of student response with low numeracy skills

Students were not used to working on problems that were not directly related to a formula they had memorized, and they were often hesitant when they couldn't remember a formula. Students' uncertainty was often accompanied by a fear of making mistakes, and this tendency appears to be shaped by the learning practices they commonly experience. Classroom evidence from observations and student interviews suggests that mathematics learning is frequently dominated by teacher-led explanations, followed by demonstrations of formulas and fixed procedures, and then reinforced through repetitive practice questions with single correct answers. In such routines, students have limited opportunities to explore alternative strategies, discuss reasoning, or connect problems to meaningful real-life contexts. As a result, mathematics is perceived as a subject focused on avoiding errors and reproducing steps, rather than as a space to think, investigate, and solve contextual numeracy problems. This instructional pattern helps explain why students often describe mathematics as difficult, monotonous, and tiring, which in turn reinforces their reluctance to engage with tasks that require modeling, reasoning, and interpretation. This feeling of boredom made students less likely to participate in class, which made it harder for them to explain and show that they understood the math content (Bekker et al., 2022; Forsblom et al., 2022; Vuyk et al., 2024; Xie, 2021).

Similarly observed that the majority of students viewed mathematics education as tedious, predominantly comprising repetitive tasks, and that student success was frequently considered a matter of chance (e.g. Saha et al., 2024; Wen & Dubé, 2022; Wilkins et al., 2021). As a result, students exhibited a constrained capacity to transfer and apply their mathematical knowledge across varied problem contexts. Empirically, this limitation was evident when students could recall formulas or complete routine exercises, yet became uncertain once tasks were presented in authentic situations that required interpreting the narrative, identifying relevant quantities, selecting an appropriate representation, and justifying a decision. Classroom observations and interview responses suggest that mathematics learning is often experienced as completing predetermined procedures rather than using mathematics as a thinking tool to model and solve real-life problems. Because tasks and assessments tend to prioritize correct final answers and procedural compliance, students have limited exposure to activities that require exploration, contextual modeling, or evaluation of solution reasonableness. Consequently, they rarely develop the habit of asking “what does this situation mean mathematically?” or “is this result sensible?”, which weakens both their confidence and their ability to apply mathematics flexibly in contextual and authentic problem situations. (Armellini et al., 2021; Heilporn et al., 2021). further emphasized that systemic barriers to learning have emerged, wherein students’ classroom engagement is reduced to mere attendance rather than active learning.

3.1.4. Students with Medium Numeracy

Students with medium levels of numeracy literacy were characterized by difficulties in indicators that required higher-order reasoning. They were generally able to solve simple procedural problems and engage in basic modeling, and some were already capable of representation, yet they were still unable to handle tasks that demanded deeper reasoning. Their responses were often incomplete. In addition, students in the medium numeracy literacy group began to attempt alternative strategies and to use mathematical tools; however, the analysis shows that this use was not consistently appropriate or well-justified (see Figure 3). In several responses, students applied a tool or a different strategy mainly through trial-and-error, without clearly explaining why it fit the problem context or how it supported verification of results. For example, some students used calculators to speed up computations but did not use them to check plausibility or to validate multi-step reasoning, and others shifted strategies mid-solution when they encountered difficulty, rather than selecting a strategy based on the structure of the problem. Therefore, although these students demonstrate emerging flexibility, their strategy and tool use often remains experimental rather than strategic, which helps explain why their solutions were still accompanied by hesitation and fear of making mistakes. This suggests that their critical thinking skills and ability to transfer concepts to real-world situations remain very limited.


1. Seorang desainer interior ingin memasang ubin di lantai sebuah ruangan. Ruangan tersebut berbentuk persegi panjang dengan panjang 8 meter dan lebar 6 meter. Ubin yang akan digunakan berbentuk persegi dengan panjang sisi 50 cm. Desainer tersebut telah menghitung bahwa ia memerlukan 192 buah ubin. Jelaskan langkah-langkah yang harus dilakukan untuk memverifikasi apakah perhitungan tersebut benar atau salah.

Jawaban	Kendala/hambatan yang kalian rasakan:
P = 8 cm = 800 cm L = 6 cm = 600 cm L Ruangan : 800 x 600 = 480.000 cm² Hitung Luas ubin Panjang sisi ubin = 50 cm Luas ubin 50 x 50 = 2.500 cm² Jumlah ubin yang diperlukan Jumlah ubin = Luas Ruangan : Luas ubin = 480.000 : 2.500 192 ubin Perhitungan desainer benar karna hasilnya sama 192 ubin	Takut Salah Sulit mengingat Rumus

1. An interior designer wants to install tiles on the floor of a room. The room is rectangular in shape with a length of 8 meters and a width of 6 meters. The tiles to be used are square in shape with a side length of 50 cm. The designer had calculated that he needed 192 tiles. Describe the steps to take to verify whether the calculation is correct or incorrect.

answer	Obstacles that you feel
P = 8 cm = 800 cm L = 6 cm = 600 cm L room = 800 x 600 = 480,000 cm^2 Calculate the area of the tiles Tile side length = 50 cm Tile area 50 x50 = 2,500 cm^2 Number of tiles required Number of tiles = room area x tile area 480.000 : 2.500 192 tiles The design calculation is correct because the result is the same 192 tiles	Afraid of making mistakes Difficulty remembering formulas

Figure 3. Example of student response with medium numeracy skills

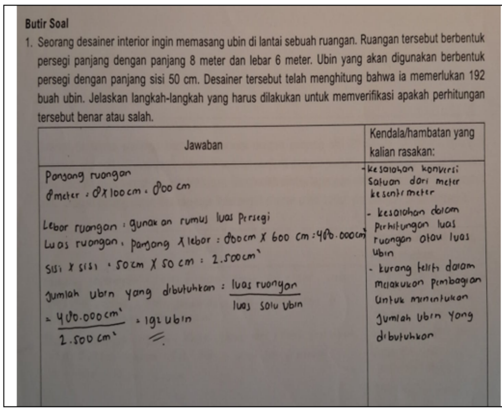
3.1.5. Students with High Numeracy

Students with high levels of numeracy literacy demonstrated more comprehensive and consistent abilities across various indicators. They were able to understand contextual problems, translate the situations into mathematical models, and present solutions using appropriate representations. In this study, "modeling" refers not merely to applying a familiar formula, but to a sequence of higher-level processes: identifying relevant information and constraints from the context, defining the quantities or variables needed, making reasonable simplifying assumptions when necessary (e.g., treating an object as an ideal geometric shape), and selecting a representation or formula that matches the situation. Importantly, these students also showed evidence of checking model suitability by revisiting the original context to verify whether their assumptions, units, and resulting values were consistent and whether the solution was plausible for the problem conditions.

In addition, students in this category were able to construct logical arguments, select efficient strategies, and correctly use mathematical symbols and tools. Evidence of their argumentation can be seen in how they explicitly justified each step and linked it to the problem conditions, for example by stating why a particular formula was relevant to the given geometry, explaining how the known quantities and units were used, and then checking whether the result was reasonable in the original context. Their reasoning typically followed a coherent pattern: identifying the goal, selecting a strategy based on the structure of the task, carrying out computations accurately, and concluding with a justification such as verifying coverage against required area, confirming that the number of objects matched spacing constraints, or comparing the calculated cost to the available budget. This indicates that their "logical arguments" were not limited to stating an answer, but involved context-based justification and plausibility checking that aligns with OECD-oriented numeracy literacy.

Although the number of students in this category was limited, their presence indicates that strong numeracy literacy potential does exist when learning conditions support contextual reasoning and modeling. The use of local heritage contexts such as Candi Jiwa is pedagogically relevant because it can function as a cognitive trigger and visualization medium that helps students bridge abstract geometry with meaningful real-life situations. In the observed learning activities, the Candi Jiwa context provides concrete spatial references (shapes, boundaries, surfaces, and measurements) that prompt students to identify relevant quantities, construct representations (e.g., sketches and labeled diagrams), and translate contextual features into mathematical models. By grounding tasks in familiar cultural artifacts, students are more likely to connect formulas to what they represent, interpret results in relation to realistic constraints, and transfer mathematical knowledge to decision-oriented problems. Therefore, culturally contextualized learning based on local heritage is not merely an attractive setting, but a mechanism that supports conceptual understanding, mathematical modeling, and the application of numeracy literacy in authentic contexts.

Furthermore, the students in this category demonstrated greater confidence when responding to the tasks because they were able to deploy multiple models and representations strategically, as illustrated in Figure 4. Their solutions typically involved selecting an appropriate geometric model, translating contextual information into a workable representation (for example, a labeled sketch or structured computation), and then cross-checking the reasonableness of the result against the problem conditions. This pattern is consistent with international scholarship on culturally responsive and place-based approaches, which argues that learning becomes more meaningful and cognitively accessible when mathematical ideas are anchored in learners' cultural experiences and local contexts, thereby supporting deeper sense-making rather than routine procedure-following.


Butir Soal

1. Seorang desainer interior ingin memasang ubin di lantai sebuah ruangan. Ruangan tersebut berbentuk persegi panjang dengan panjang 8 meter dan lebar 6 meter. Ubin yang akan digunakan berbentuk persegi dengan panjang sisi 50 cm. Desainer tersebut telah menghitung bahwa ia memerlukan 192 buah ubin. Jelaskan langkah-langkah yang harus dilakukan untuk memverifikasi apakah perhitungan tersebut benar atau salah.

Jawaban	Kendala/hambatan yang kalian rasakan:
Panjang ruangan 8 meter = 8 x 100 cm = 800 cm Lebar ruangan : gunakan rumus luas persegi Luas ruangan = panjang x lebar = 800 cm x 600 cm = 480.000 cm² sisi x sisi = 50 cm x 50 cm = 2.500 cm² Jumlah ubin yang dibutuhkan = luas ruangan / luas satu ubin = 480.000 cm² / 2.500 cm² = 192 ubin	- kesalahan konversi satuan dari meter ke sentimeter - kesalahan dalam perhitungan luas ruangan atau luas ubin - kurang teliti dalam melakukan pembagian untuk menentukan jumlah ubin yang dibutuhkan

1. An interior designer wants to install tiles on the floor of a room. The room is rectangular in shape with a length of 8 meters and a width of 6 meters. The tiles to be used are square in shape with a side length of 50 cm. The designer had calculated that he needed 192 tiles. Describe the steps to take to verify whether the calculation is correct or incorrect.

answer	Obstacles that you feel
Room length 8 meters = 8 x 100 cm = 800 cm width of room = use square area formula room area = length x width = 800 cm x 600 cm = 480,000 cm^2 Sides x Sides = 50 cm x 50 cm = 2,500 cm^2 Number of tiles required = room area/area of one tile = 480,000 cm^2/2,500 cm^2 = 192 tiles	• Eror unit conversion error from meters to centimeters • errors in the calculation of room area or tile area • lack of thoroughness in dividing to determine the number of tiles needed

Figure 4. Example of student response with high numeracy skills

In the present study, the local heritage context of Candi Jiwa can be interpreted as more than a motivational "setting." It functions as a cognitive and representational resource that helps students visualize spatial relationships, determine relevant quantities, and validate their models in relation to a recognizable real-world object. This mechanism aligns with ethnomathematics, which positions cultural artifacts and practices as legitimate entry points for mathematization and modeling, and with research on culturally responsive mathematics teaching that emphasizes the integration of community knowledge and lived experience to strengthen reasoning, justification, and transfer to authentic situations. This suggests that when students are encouraged to be creative and explore multiple solution pathways, their opportunities to achieve the broader goals of learning and education are significantly enhanced (Nufus et al., 2024; Suherman et al., 2025).

The interviews with students and teachers reinforced the findings presented in Table 2. The majority of students (85.71%) fell into the low category, with dominant weaknesses in the indicators of mathematization, representation, reasoning and argumentation, strategy selection, use of formal/technical symbols, and application of mathematical tools. From the interviews, students reported feeling more comfortable with routine procedural tasks than with contextual problems, because the latter required them to construct a mental representation of a real-life situation and then translate that representation into a mathematical model. This difficulty can be interpreted through cognitive perspectives on abstraction and transfer: routine exercises rely on well-rehearsed schemas that reduce cognitive demands, whereas contextual problems increase the need to filter relevant information, make simplifying assumptions, coordinate representations (text, diagrams, units), and justify why a chosen model fits the situation. In terms of cognitive load, the contextual layer can raise intrinsic and extraneous processing demands, so even higher-performing students may hesitate when they cannot immediately map the situation to a familiar mathematical structure, despite having the procedural knowledge to execute calculations once a model is established. Teachers also emphasized that students tended to memorize solution steps without understanding the rationale behind the strategies used. This aligns with the data showing weak mastery across the six main indicators.

In contrast, only 14.28% of students were categorized as moderate, with their highest relative performance in the communication indicator. In this study, the communication observed at the moderate level was predominantly descriptive and procedural, rather than argumentative. Interview and written-response evidence shows that these students could restate given information from the problem, identify what was being asked, and write basic solution steps in a simple format. However, their communication rarely developed into justified mathematical argumentation, such as explaining why a particular model or formula was appropriate, articulating assumptions, or checking the plausibility of results against the context. Therefore, although these students demonstrate an emerging ability to communicate mathematically, the communication is still at an early stage and has not consistently met the requirements of logical coherence and truth justification that characterize numeracy literacy in the OECD framework. Teachers observed that students' communication skills had begun to develop, but these were not yet supported by strong reasoning or problem-solving strategies.

Notably, none of the students achieved the high category (0%), a result that was also confirmed through the interviews. Both students and teachers acknowledged that tasks requiring the integration of multiple indicators-such as mathematization, reasoning, and representation-remained particularly challenging. Taken together, the interview data corroborate the test results, indicating that students' relative strength is mostly limited to basic, descriptive communication, whereas their main weaknesses occur in mathematization, reasoning, and strategic problem solving. Importantly, this pattern points to a structural issue in students' learning experiences, not merely individual shortcomings. Across interviews and classroom observations, students frequently described mathematics learning as following teacher-demonstrated procedures, applying formulas, and completing sets of routine exercises, with limited opportunities to engage in contextual modeling, justify solutions, compare alternative strategies, or reflect on the reasonableness of results. As a consequence, learning tends to become procedural and fragmented, and students are rarely trained to integrate multiple numeracy literacy indicators within one meaningful task. This helps explain why students can write down given information and steps, yet struggle when tasks require them to connect context, representation, modeling, reasoning, and decision making in an integrated way.

3.2. Discussion

This study aimed to describe the numeracy literacy profile of ninth-grade students using the OECD (2012) indicators within the local cultural context of Candi Jiwa. The main findings revealed that the majority of students were in the low category, a small proportion in the medium category, and none in the high category. This pattern indicates that students' numeracy literacy has developed unevenly across the OECD indicators. Performance is relatively stronger in basic communication (mainly descriptive or procedural writing), while key OECD processes that define numeracy literacy, such as mathematization, representation, reasoning and argumentation, strategy selection, and the purposeful use of mathematical tools, remain weak. This imbalance suggests that students' competence is still dominated by procedural execution, meaning they can follow familiar steps once a formula is identified, but struggle to translate real-world contexts into mathematical models, coordinate representations, justify conclusions, and choose efficient solution pathways. Consequently, the dominance of procedural ability has direct implications for low reasoning and problem-solving performance: students tend to treat contextual problems as "formula-matching" tasks rather than as situations requiring integrated modeling, interpretation, and decision making, which is precisely the core of numeracy literacy in the OECD framework.

These results are consistent with the research objective of mapping students' strengths, weaknesses, and obstacles in solving contextual problems. More importantly, the findings reveal a substantive gap between students' numeracy literacy achievement and twenty-first-century demands that require critical reasoning and context-based problem solving. This gap is not only reflected in overall low performance, but more specifically in the indicator profile showing weaknesses in mathematization, reasoning and argumentation, strategy selection, representation, and the use of mathematical tools, while communication remains comparatively stronger. Therefore, the instructional implication is not simply to "make learning more contextual," but to strengthen the key stages of contextual problem solving where students most frequently break down.

First, learning tasks need to explicitly scaffold the mathematization stage, guiding students to extract relevant information, define variables, state assumptions, and translate contexts into mathematical models before computation begins. Second, activities should systematically develop reasoning and argumentation, for example by requiring students to justify why a model or formula fits the situation, compare alternative solution strategies, and perform plausibility checks against the original context. Third, task design should integrate representation and tool use as purposeful supports for thinking, such as using sketches, tables, or unit conversions to clarify relationships and using calculators not only for computation but also for estimation and verification. By structuring contextual learning around these stages and embedding prompts that require explanation, justification, and checking, classroom activities can encourage a more balanced integration of OECD numeracy literacy indicators and directly target the specific weaknesses identified in this study.

Positioned within culturally responsive pedagogy, ethnomathematics, and place-based learning, the integration of a local heritage context such as Candi Jiwa is not treated in this study as a decorative "setting," but as a pedagogical mechanism that can mediate students' access to numeracy literacy. Conceptually, this approach leverages culturally familiar artifacts as a cognitive anchor and visualization resource that helps students (a) construct meaningful mental images of geometric relationships, (b) translate contextual features into mathematical representations and models, and (c) interpret results against realistic constraints, which are core processes in the OECD numeracy framework (formulate, employ, interpret). Empirically, the observation records and interview accounts indicate that when tasks were framed through the Candi Jiwa context, students more readily produced sketches and labeled representations, identified relevant quantities from the narrative, and articulated why particular formulas or steps were appropriate. These data patterns suggest that the local context helped increase task engagement and reduced "entry barriers" to modeling by making the situation easier to imagine and discuss, thereby supporting deeper participation in mathematization, representation, and justification rather than mere procedural completion.

Based on field data from teacher interviews, it was revealed that because students' foundational understanding was weak, teachers tended to focus on delivering concepts through lectures drawn from textbooks, followed by examples and practice exercises. This reliance on teacher-centered instruction was frequently mentioned as one of the reasons students were able to complete only simple procedural tasks. Jiang and Li (2023) found that Chinese students responded positively to the use of textbooks, perceiving that their basic skills were strengthened and that they were able to further develop higher-order reasoning abilities. This suggests the importance of selecting textbooks that align with students' characteristics in order to foster broader competencies, particularly mathematical reasoning and, by extension, numeracy literacy. A growing body of research emphasizes the role of teachers as mediators who determine which textbooks are used, which sections are emphasized, how topics are sequenced, how students interact with the text, and the level and type of teacher intervention between students and the textbook (Jiang & Li, 2023; Pepin & Haggarty, 2001; Rezat, 2010; Weinberg et al., 2012).

Based on the assessment results, the majority of students were classified in the low category (85.71%) because they experienced difficulties in six out of seven numeracy indicators, namely mathematization, representation, reasoning and argumentation, strategy selection, the use of formal symbols, and the use of mathematical tools. Only in the communication indicator did a small proportion of students demonstrate relatively stronger abilities. This phenomenon can be interpreted through learning transfer theory in contextual problem solving. Classroom instruction that primarily emphasizes procedures and memorized solution steps tends to produce context-bound or inert knowledge, in which students can execute routines in familiar formats but struggle to recognize when and how the same ideas apply in new situations. In transfer terms, students may achieve near transfer (solving problems that closely resemble practiced examples) yet fail to demonstrate far transfer, which requires re-representing a real-life situation, selecting an appropriate model, and adapting prior knowledge to unfamiliar contexts (e.g., translating narratives into quantities, assumptions, and representations). When learning experiences provide limited opportunities to compare multiple contexts, articulate underlying principles, and practice mathematization and justification, students have fewer “bridges” for retrieving and adapting concepts beyond routine exercises. As a result, they become proficient at procedural completion but remain unable to transfer mathematical understanding to authentic, decision-oriented problems. Such difficulties often stem from a shallow understanding of fundamental concepts and limited fluency in recalling multiplication facts (Muñez et al., 2023; Ouyang et al., 2023). Without a strong foundation, students encounter obstacles in performing numerical operations, particularly in word problems that demand deeper reasoning. The low levels of mathematization and representation further indicate that students struggle to connect problem statements with mathematical models, while weaknesses in reasoning and strategy reflect the absence of critical thinking habits.

Similarly, students’ low performance in the use of formal symbols and mathematical tools indicates that the technical dimension of mathematics learning has not been sufficiently developed. In this study, “mathematical tools” refers to both conventional tools (e.g., rulers or measurement aids when constructing or interpreting geometric figures) and digital tools, particularly the calculator, which was explicitly required in the cost-estimation item. Evidence from students’ written work and interview explanations shows that many students either did not use the calculator as instructed or used it only to compute numbers mechanically, without employing it for estimation, checking plausibility, or verifying multi-step results. In addition, weaknesses in formal symbols were observed in frequent inaccuracies in notation, unit writing, and the formulation of expressions (e.g., inconsistent units, missing symbols, or incorrect substitution into formulas). Taken together, these patterns suggest that students have limited experience using tools and formal notation as supports for modeling, verification, and decision making, rather than as peripheral add-ons to routine computation.

The findings of this study are consistent with the 2022 PISA report, which indicated that more than 80% of Indonesian students performed below Level 2 in mathematics, meaning they were only capable of solving simple procedural problems without engaging in complex reasoning (OECD, 2023). Wijaya et al. (2024) likewise reported that Indonesian students’ numeracy literacy remains stagnant despite the implementation of various literacy programs, largely due to the limited integration of contextual problems. Furthermore, the study by Larasati et al. (2025) demonstrated that ethnomathematics-based instruction can improve numeracy literacy, particularly in the areas of communication and representation.

However, the present findings do not fully align with several international studies that report culturally grounded learning as strengthening a broad range of numeracy literacy indicators. In this study, the cultural context appears to support students mainly at the “entry” level, particularly by improving engagement and helping them communicate and describe problem information, while weaknesses persist in mathematization, reasoning, strategy selection, and tool use. This divergence invites a more reflective interpretation that considers contextual conditions that may differentiate the Indonesian setting from those international implementations.

One plausible explanation relates to teacher readiness and pedagogical traditions. If classroom practice remains dominated by teacher-led explanation and routine exercises, cultural contexts may be introduced only as a story wrapper rather than as a structured scaffold for modeling, justification, and decision making. In such conditions, students can talk about the context but are not systematically guided to translate it into variables, assumptions, representations, and argumentation aligned with OECD processes. A second factor concerns curriculum and assessment pressures that may prioritize procedural fluency and correct answers over reasoning quality, making it less likely that teachers allocate time for multi-step exploration, strategy comparison, and plausibility checking. A third factor is students' limited prior experience with context-based tasks, which increases cognitive load and reduces their ability to benefit fully from contextualization unless explicit supports are provided (e.g., modeling prompts, representation templates, and tool-use routines).

Rather than being viewed solely as a local limitation, these findings offer a theoretical and practical opportunity: they suggest that cultural context alone is insufficient to strengthen numeracy literacy comprehensively unless it is paired with pedagogical mechanisms that deliberately target the weaker indicators. In other words, the contribution of this study is to highlight that the effectiveness of cultural contextualization is conditional on instructional design, teacher capacity, and students' exposure to contextual modeling. This insight can inform the development of more robust culturally responsive numeracy interventions that explicitly integrate modeling, reasoning, representation, strategy selection, and tool use, not only communication.

These findings are important as they reveal a substantial gap between the OECD (2012) international standards and the actual state of students' numeracy literacy in Indonesia. The results demonstrate that such global indicators cannot be readily achieved without adaptation to local contexts. In this regard, integrating local culture, such as the Candi Jiwa heritage site in Karawang, plays a strategic role not only as a motivational context but also as a cognitive support for numeracy processes. Empirical evidence from classroom observations shows that when tasks were framed around the Candi Jiwa context, students were more likely to produce concrete geometric representations, such as drawing and labeling plane figures, identifying relevant dimensions from the story, and organizing information into a clearer structure before calculating. For example, in geometry tasks that required students to visualize spatial layouts or compare coverage areas, several students spontaneously used sketches and labeled measures to translate the cultural artifact into a mathematical representation, which helped them move from abstract formulas to a more meaningful interpretation of quantities and relationships.

Interview responses also indicated that the Candi Jiwa context made the problem situation easier to imagine, which supported students' initial steps of mathematization, such as determining what information was relevant and what geometric model should be used. Although the indicator-level results still show that higher-order processes such as reasoning and strategy selection remain challenging for many students, these observation and interview patterns suggest that cultural contextualization can reduce entry barriers in understanding the problem narrative and stimulate representational activity. Therefore, the integration of local culture in this study demonstrates a tangible contribution by supporting students' visualization and initial modeling, which are essential foundations for developing stronger reasoning and problem-solving in contextual numeracy tasks. This approach not only facilitates conceptual understanding but also enhances learning motivation and fosters pride in cultural identity. Accordingly, this study contributes to the literature by showing that the use of local cultural contexts can serve as a bridge between international standards and the realities of education in Indonesia. More broadly, the findings advance the proposition that cultural contextualization is not merely an instructional supplement but a necessary mediating factor for achieving global benchmarks of numeracy literacy in emerging economies. This perspective offers both theoretical insight and practical direction, underscoring the importance of aligning international frameworks with culturally grounded pedagogies.

From a theoretical perspective, this study advances the discourse on numeracy literacy by situating OECD indicators within a local cultural context. The findings highlight that international frameworks require contextual adaptation to remain meaningful in developing-country settings with distinct sociocultural characteristics. From a practical standpoint, the results offer clear guidance for teachers to design mathematics instruction that is both contextualized and meaningful. Specifically, the integration of e-learning modules based on Cognitive Load Theory and enriched with the cultural context of Candi Jiwa can reduce students' cognitive load, since tasks are presented in ways that resonate with their environment and lived experiences. Beyond the classroom, these findings offer implications for curriculum developers and policymakers by clarifying how culturally grounded approaches relate to students' numeracy literacy development. Specifically, the study suggests that integrating local cultural contexts such as Candi Jiwa can enhance students' engagement and accessibility to tasks, which in turn supports early-stage numeracy processes, particularly communication and representation, and facilitates students' initial steps in mathematization. However, the indicator profile also shows that gains do not automatically extend to higher-order indicators such as reasoning and argumentation, strategy selection, and tool use unless these are deliberately scaffolded through instructional design. Therefore, national strategies should not only promote "culture-based learning" in general terms, but should embed cultural contexts as structured learning resources that explicitly target and balance OECD-aligned numeracy literacy indicators, linking cultural relevance, student engagement, and measurable competency development.

Future research could extend these insights through comparative studies across different cultural regions in Indonesia and other developing countries, thereby testing the generalizability of the findings. Longitudinal investigations would also be valuable to examine whether culturally contextualized interventions produce lasting effects on students' reasoning, problem-solving strategies, and overall numeracy literacy. Such research would not only deepen theoretical understanding but also provide stronger empirical foundations for scaling culture-based pedagogical innovations.

Overall, this study confirms that junior high school students' numeracy literacy remains at a low level, with the most prominent weaknesses in mathematization, reasoning, and strategy. Nevertheless, the findings also open opportunities for innovative solutions through contextual approaches grounded in local culture.

The integration of the Candi Jiwa heritage context with the OECD indicator framework offers a two-pronged novelty with both local and global relevance. Locally, grounding numeracy tasks in a culturally familiar setting provides students with concrete experiential references that can support conceptual understanding, representation, and initial mathematization. From a cognitive perspective, such familiarity may also reduce cognitive load, because students do not need to invest as much mental effort to imagine the situation or interpret the narrative; instead, more cognitive resources can be allocated to selecting strategies, coordinating representations, and reasoning through the solution. Globally, this study extends the discourse on how international numeracy standards, such as OECD indicators, can be operationalized and interpreted within diverse socio-cultural contexts, demonstrating that framework adoption requires contextual mediation rather than direct transplantation.

Accordingly, the findings not only reaffirm the persistent challenge of low numeracy literacy in Indonesia, but also suggest a strategic direction for improvement through mathematics instruction that is more contextualized and adaptive. Specifically, cultural contexts should be used as cognitive and representational scaffolds that help students enter the problem, build models, and interpret results, while instruction deliberately targets the weaker OECD indicators, particularly reasoning, strategy selection, and tool use, so that contextualization leads to comprehensive numeracy literacy development rather than improvements limited to communication. More broadly, the study positions Indonesia as a critical case for understanding how emerging economies can adapt international frameworks to local sociocultural realities, thereby contributing to the global discourse on equity and relevance in numeracy education.

4. CONCLUSION

This study confirms that the numeracy literacy profile of ninth-grade students in junior high schools across Karawang, Purwakarta, and Subang remains predominantly in the low category, with 85.71% of students demonstrating limited proficiency in most OECD (2012) indicators. The results show that students' relative strength lies in the communication indicator, as many students were able to identify given information, restate what was asked, and write solution steps in a descriptive or procedural form. This indicates that students have begun to develop basic mathematical communication habits, particularly in organizing problem information and presenting written work. However, the major weaknesses were found in mathematization, reasoning and argumentation, representation, strategy selection, and the use of formal symbols and mathematical tools, suggesting that students' competence remains more procedural than conceptual and that they experience persistent difficulty transferring mathematical knowledge to contextual problem solving. The absence of students in the high category further reflects a substantial gap between current classroom practices and the integrated numeracy competencies required in the twenty-first century. Consistent with this pattern, classroom observations and interviews with both students and teachers confirmed that contextual problems are perceived as challenging, largely because students are unfamiliar with modeling real-life situations and coordinating representations, strategies, and justification within a single meaningful task. This underscores the urgent need for more contextualized and meaningful approaches in mathematics education at the junior high school level.

Overall, this study highlights the urgency of reforming mathematics instruction to address students' fundamental weaknesses while capitalizing on their existing strengths. The integration of local cultural contexts-such as the Candi Jiwa heritage site in Karawang-together with e-learning modules designed under the principles of Cognitive Load Theory, presents a promising pathway to enhancing students' numeracy literacy. By adapting international standards to local realities, this study provides not only empirical evidence but also a theoretical contribution to the discourse on improving numeracy literacy in developing countries.

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Declarations

Author Contribution : ASA: Conceptualization, Funding acquisition, and Writing - original draft; YY: Formal analysis, Methodology, and Writing - review & editing; AGP: Formal analysis, Supervision, and Validation; CZ: Data curation, Investigation, Project administration, and Software; MAA: Resources, and Visualization; MNA: Visualization, and Writing - review & editing.

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