Concepts and Indicators of Mathematical Literacy in Lower Primary Education: An Integrative Review

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ABSTRACT

Mathematical literacy became widely known after the OECD introduced PISA in the 2000s. In Indonesia, the importance of mathematical literacy is reflected in several education policies, including Kurikulum 2013, Kurikulum Merdeka, Asesmen Kompetensi Minimum, Gerakan Literasi Nasional, and Gerakan Numerasi Nasional. However, research on mathematical literacy remains strongly influenced by PISA-oriented frameworks designed for 15-year-old students. Existing reviews also do not systematically explain how mathematical literacy concepts and indicators are defined for lower primary students aged 7 to 9 years. Addressing this gap, this integrative review examines how international literature and Indonesian policy define mathematical literacy or numeracy for lower primary education and identifies indicators used to measure primary students' mathematical literacy. This study uses Cooper's five-stage method to analyse empirical studies and policy documents. The review shows that most definitions adopt broad PISA-based wording, particularly the capacity to formulate, employ, and interpret mathematics, without sufficient developmental adaptation for younger learners. Indonesian policies define numeracy as the use of mathematics to solve everyday problems, interpret information, and make reasoned decisions. Indonesian policies frame mathematical literacy as solving practical everyday problems using basic maths and interpreting graphs. Findings reveal that there is no validated indicator set is uniquely designed for lower primary. The discussion shows that the current definitions that are taken from older population without any clear indicator for younger children post a risk of the difficulty in making the assessment or lesson that appropriate for younger children. Accordingly, we conclude that a coherent, grade-specific framework for lower primary mathematical literacy is urgently needed.

Keywords: mathematical literacy; lower primary; numeracy; indicators; integrative review

INTRODUCTION

Mathematical literacy became widely known in 2000, when Organisation for Economic Co-operation and Development (OECD) introduced an international survey through the Programme for International Student Assessment (PISA) (Ahyan et al., 2019; OECD, 2025). PISA explicitly assesses the students' ability in using mathematical concept in real-world context. In the PISA framework, mathematical literacy is defined as an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts, including the use of concepts, procedures, facts, and tools to describe, explain, and predict phenomena and to make well-founded judgements and decisions as a constructive, engaged citizen (Purwanti et al., 2020; Stacey, 2011). This definition suggests that mathematics learning should not only limited to procedural mastery but should support students' ability to use mathematics in real-world situations.

Many researchers and educators consider mathematical literacy as an essential skill. Mathematical literacy is required for a person to process and understand data presented in society - every day and social life - (Díez-Palomar et al., 2023; Jain & Rogers, 2019) so that one can actively engage and make data-driven decisions based on the data and information provided (Hwang & Ham, 2021). Furthermore, mathematical literacy can also prepare individuals to compete in a highly-competitive job market (Mann, 2022). In addition, this skill is also important for solving real-world problems (Rizki & Priatna, 2019) and can enable a person to argue mathematically and use various mathematical concepts to solve those problems (Hwang & Ham, 2021).

In Indonesia, the government also sees that mathematical literacy as an important skill. This can be seen in the proofs in the national curriculum many numeracy policies, such as Kurikulum 2013, Kurikulum Merdeka, Asesmen Kompetensi Minimum (AKM), Gerakan Literasi Nasional (GLN) and Gerakan Numerasi Nasional (GNN). Kurikulum 2013 was developed to align better to PISA's mathematical literacy competencies (Diputra et al., 2019). Additionally, Kurikulum Merdeka places the mathematical literacy (in government term they use numeracy) as the centre of the mathematics curriculum and the 21st century skills (Kartini et al., 2025; Mulyati et al., 2024). Furthermore, AKM is designed to assess the minimum competence in reading and mathematical literacy using PISA-like content, contexts, and cognitive processes as the national survey for the education in Indonesia (Kartini et al., 2025; Muhaimin et al., 2024). Meanwhile, GLN and GLNN aim to strengthen numeracy as a life skill that includes logical thinking, data-based decision making, and problem solving in everyday context (Naskah Akademik Gerakan Numerasi Nasional, 2026; Rakhmawati & Mustadi, 2022; Yusnanto et al., 2024). These policies from Indonesia's government show that Mathematical literacy is seen as important skills to be acquired by students.

Despite this strong policy emphasis, the conceptualization of mathematical literacy for younger learners remains insufficiently developed. Research on mathematical literacy remains dominated by PISA-oriented studies targeting 15-year-olds (Stacey, 2011; Stacey & Turner, 2015). Studies at the primary level show that Indonesian students' mathematical literacy is generally low and often limited to routine procedures and they often experience difficulties in understanding, modelling, and interpreting contextual problems (Nurmasari et al., 2022; Purwanti et al., 2020). Existing reviews show an increasing research interest in elementary students' mathematical literacy (Muhaimin et al., 2024; Putri Hapsari et al., 2022; Setiawan & Razak, 2020). However, these reviews generally discuss primary education as a whole and do not systematically clarify how concepts and indicators are differentiated across primary grades, particularly in lower primary.

This issue is important because lower primary students differ developmentally from older primary and secondary students. Lower-primary mathematics should be framed developmentally because early mathematics learning progresses through levels of thinking that become increasingly sophisticated over time, consistent with the idea of learning trajectories and developmental progressions.(Clements & Sarama, 2009). Therefore, indicators derived from general or PISA-oriented mathematical literacy frameworks may not be suitable for lower primary learners without any adjustment.

Lower-primary mathematics should be framed developmentally because early mathematics learning progresses through levels of thinking that become increasingly sophisticated over time, consistent with the idea of learning trajectories and developmental progressions. 18 These early years are "years of promise" in which high-quality experience is especially important for mathematics development, and what children know when they enter kindergarten and first grade predicts their later mathematics achievement across their school career. 16 For this reason, indicators for Grades 1–3 need to reflect the kinds of foundational understandings children are still developing—such as understanding the sequential order of counting numbers and their relative magnitudes, representing numbers on a number line, and developing base-ten numeration and place-value concepts.

In this study, lower primary refers to student in grade 1 to 3. This classification follows the common classification in Indonesian primary education, where lower primary or 'kelas rendah' refers to students from grade 1 to 3 (Prastowo, 2019) or approximately age 7 to 9-year-old (Ulyawati & Hotimah, 2025). However, there is no clear definition of lower primary or upper primary provided by government document. In Kurikulum Merdeka, primary education is organized into phases, the phases related to lower primary arephase A and phase B. Phase A covers

Grades 1 and 2, while Phase B covers Grades 3 and 4(Kementerian Pendidikan Dasar dan Menengah, n.d.-a, n.d.-b). Therefore, in this study, lower primary will be defined for students grade 1-3. Grade 4 considered only when discussing curriculum content of phase B as it grouped together with grade 3 in phase B in the official curriculum structure.

Building on this gap, the present study examines how mathematical literacy and numeracy are conceptualized for primary education, with specific attention to whether existing definitions and indicators are developmentally appropriate for lower primary students. Accordingly, the study addresses: (a) How do international frameworks and research, as well as Indonesian research and policy, define mathematical literacy or numeracy for primary students, especially for lower primary? (b) What indicators are used in existing studies and policy documents to measure or describe mathematical literacy and numeracy among primary students, and how relevant are these indicators for lower primary education?

METHOD

Research Design

This paper employs integrative review method to conceptualize mathematical literacy for lower primary and the indicator for the said mathematical literacy for lower primary. An Integrative review study is an research that synthesize empirical, theoretical, or methodological literature builds understanding regarding particular phenomenon (Toronto & Remington, 2020). In this study, the method was used to integrate findings from research articles, theoretical sources, and Indonesian policy documents related to mathematical literacy and numeracy in primary education.

The review process followed five stages adapted from Cooper (1982): problem formulation, data collection, data evaluation, data analysis and interpretation, and presentation of results. PRISMA was used to report the literature search and selection process.

Data Sources and Search Strategy

Data were collected from scopus, google scholar, and official government documents. The literature search was conducted in May 2026. The initial search used broad conceptual terms, namely “mathematical literacy” OR “numeracy.” School-level terms such as “primary school,” “elementary school,” and “lower primary” were not used in the initial search. This decision was made to avoid excluding theoretical or framework-based sources that provide relevant definitions or indicators of mathematical literacy or numeracy but do not specify a primary-school level in their title, abstract, or keywords. Relevance to primary and lower primary education was then assessed during the screening and eligibility stages.

The Scopus search identified 2,476 records. For Scopus, the search was limited to final-stage publications written in English and published between 2020 and 2026. The subject areas were limited to Social Sciences and Mathematics. The Google Scholar search was limited to the first 30 pages sorted by relevance, equivalent to the first 300 sources. For Google Scholar, peer-reviewed articles were limited to publications from 2016 to 2026, while foundational theoretical sources were no older than 2000 also they were conceptually relevant to the theme. Indonesian policy documents were searched through Google Search and were included when they were published by official government institutions and directly related to mathematical literacy, numeracy, curriculum, or assessment. The search strategy and selection limits are summarized in Table 1.

Table 1:
Search Strategy and Selection Limits

Source	Search terms	Limits and filters	Initial records	Records assessed for eligibility	Included sources
Scopus	"mathematical literacy" OR "numeracy"	Final-stage publications; English language; 2020–2026; subject areas limited to Social Sciences and Mathematics	2,476	81	9
Google Scholar	"mathematical literacy" OR "numeracy"	First 30 pages sorted by relevance, equal to the first 300 sources; peer-reviewed articles mainly from 2016–2026; foundational theoretical sources from 2000 onward retained when conceptually relevant	300	108	10
Official Indonesian	"numerasi," "AKM," and "Gerakan	Documents retrieved from official	2	2	2

government documents	Numerasi Nasional”	Indonesian government websites and directly related to numeracy, curriculum, or assessment			
Total			2,778	191	21

Inclusion and Exclusion Criteria

The collected data later were evaluated using inclusion and exclusion defined beforehand. Sources were included when it met the following criteria: (1) they discussed mathematical literacy or numeracy, (2) they focused on lower primary education, especially for empirical sources, (3) they provided a definition, conceptual explanation, framework, or indicator of mathematical literacy or numeracy, (4) they were published as peer-reviewed journal articles, conference proceedings, books, encyclopedia entries, or official policy documents.

Sources were excluded when they focused only on secondary education, adults, preschool children without any connection to primary education, financial literacy reading literacy, or other unrelated literacy domain. Sources were also excluded when they did not provide definitions or indicators relevant to mathematical literacy or numeracy. Indonesian journal articles were included only when they were published in journals indexed at least SINTA 2. Official policy documents were included when they were retrieved from Indonesian government websites and directly related to mathematical literacy or numeracy.

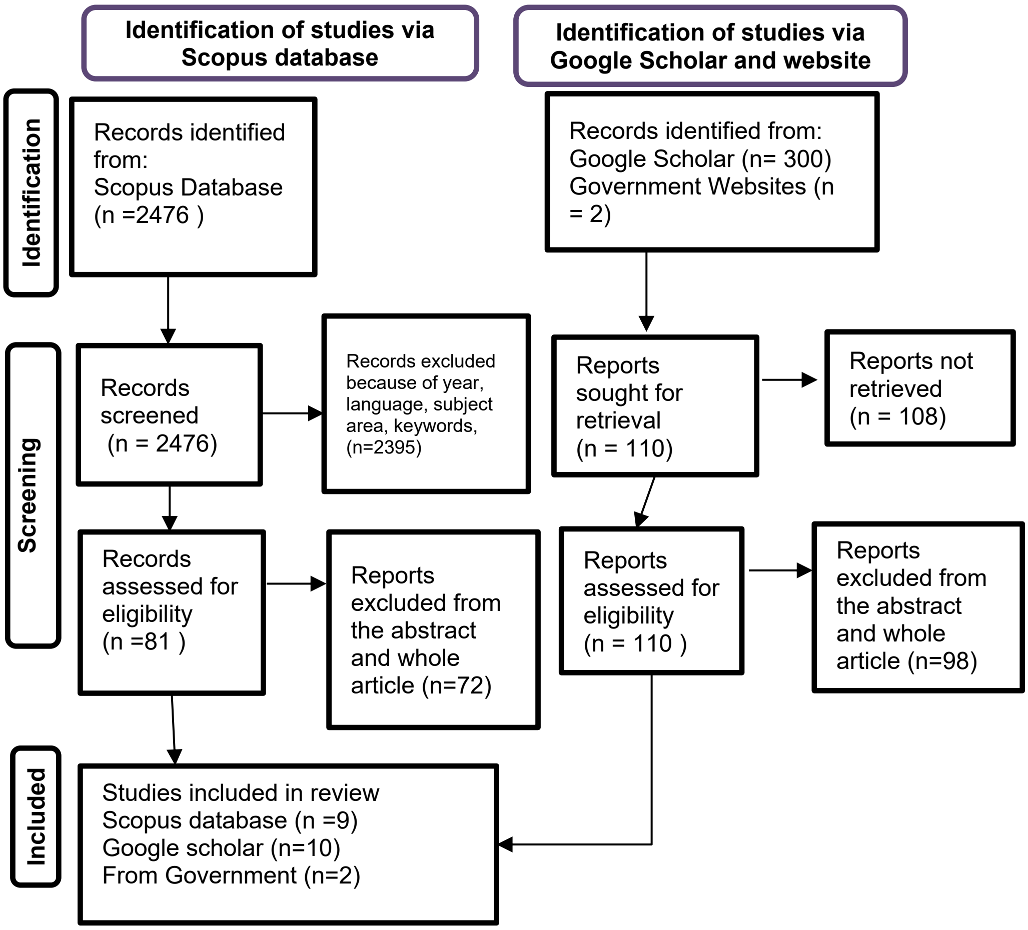
Screening and Selection Process

The screening process was conducted in stages. First, titles and abstracts were screened to remove irrelevant records. Second, full texts were reviewed to identify sources that met the inclusion criteria. Third, the remaining sources were evaluated based on their relevance to the review questions. Review papers were used to support the background and research gap, but they were not included in the final synthesis sources.

Picture 1 presents the PRISMA flow diagram used to report the literature search and selection process. The Scopus search identified 2,476 records. After applying restrictions based on publication year, language, subject area, and keywords, 81 records were assessed for eligibility. Of these, 72 reports were excluded after title, abstract, and full-text screening, leaving 9 Scopus-indexed sources for inclusion. The Google Scholar search identified 300 records initially and 108 records were recorded for eligibity, and 2 policy documents were retrieved from official government websites. All 110 reports were available for retrieval and assessed for eligibility. After title, abstract, and full-text screening, 98 reports were excluded, leaving 10

Google Scholar sources and 2 government documents. The final corpus therefore consisted of 21 sources: 9 from Scopus, 10 from Google Scholar, and 2 from government documents.

Picture 1:
PRISMA flow diagram for literature search and selection process



Data Extraction

Data from the 21 included sources were extracted into a review matrix. The matrix consisted of author, year, source type, country or context, term used, definition, indicators, education level, and relevance to lower primary education. This matrix was used to organize the data and to compare how mathematical literacy and numeracy were conceptualized across different sources.

Data Analysis

Data analysis was conducted through extraction, coding, comparison, and synthesis. The extracted data were coded according to the two research questions. The first coding focus was the definition of mathematical literacy or numeracy, including key elements emphasized in each source, such as mathematical content, cognitive processes, real-world contexts, reasoning, communication, and problem solving. The second coding focus was the indicators used to measure or describe mathematical literacy or numeracy, including process competencies and mathematical content domains.

After coding, the data were compared across sources using a constant comparison approach. Similar definitions and indicators were grouped into categories, while differences across international frameworks, empirical studies, and Indonesian policy documents were identified. Data display as tables were used to organize the findings and support interpretation.

The final synthesis was used to answer the research questions and to identify the extent to which existing concepts and indicators are appropriate for lower primary education. The findings were organized into two main parts. The first part presents how mathematical literacy and numeracy are defined in international literature, Indonesian research, and Indonesian policy. The second part presents the indicators used to measure or describe mathematical literacy and numeracy, with particular attention to their relevance for lower primary education.

FINDINGS AND DISCUSSION

1. Definition of mathematical literacy or numeracy for lower primary

To answer the first research question, all the included sources were analysed and grouped according to the conceptual emphasis used to define mathematical literacy or numeracy. The grouping was based on whether each source emphasized the official PISA construct, broader mathematical literacy, practical numeracy, foundational mathematical competence, or early number-related skills. There are five main group identified: PISA framework definition, other mathematical literacy definitions, numeracy, basic mathematical literacy, early numeracy. The first group refers to sources that directly use or explain the official PISA framework definition. The second group includes mathematical literacy definitions that may be influenced by PISA but are not limited to the official PISA wording. The remaining three groups represent related constructs that emphasize practical mathematical application, foundational mathematical competence, or early number-related skills. Table 2 presents the comparison of the terms used, sources, key elements of the definitions, and target age or education level.

Table 2:
Terminology and Definitions of Mathematical Literacy and Numeracy in the Reviewed Sources

Conceptual Group	Term used	Sources	Key elements of definition	Target level/ age
PISA framework definition	Mathematical literacy	(Burkhardt, 2008; De Lange, 2005; Geiger & Schmid, 2024; Goos, 2021; Seçgin et al., 2024; Wang et al., 2021)	Capacity to apply mathematical concepts, procedures, facts, tools, processes, and reasoning to formulate, employ, and interpret mathematics in real-world problems	General (Burkhardt, 2008; De Lange, 2005; Geiger & Schmid, 2024; Goos, 2021) Primary(Seçgin et al., 2024; Wang et al., 2021)
Other mathematical literacy definitions	Mathematical literacy	(Haara, 2018)	Higher-order thinking that enables understanding and using mathematics in everyday, authentic situations.	General
Other mathematical literacy definitions	Mathematical literacy	(Kliziene et al., 2021)	Integration of mathematical knowledge, understanding, applied skills, problem solving, logical thinking, modelling, and communication	General definition; empirical context was Grade 4 primary students
Other mathematical literacy definitions	Mathematical literacy	(Niss, 2015)	Functional and empowering use of mathematics in extra-mathematical or real-world contexts	General
Numeracy	Numeracy	(De Lange, 2005; Sakurai & Goos, 2023)	Application of number and data skills in authentic everyday contexts, including estimation, mental processing, and the use of mathematical or digital tools	General
Numeracy	Numeracy	(Lindström-Sandahl et al., 2024)	Foundational number sense and procedural fluency in arithmetic as a basis for arithmetic and problem solving	Second-grade students (around 7–8 years old)

Numeracy	Numeracy/ Numerical literacy	(Aini et al., 2024; Rohmah et al., 2022)	Reasoning and symbol use to understand number-rich information, think critically, and solve daily-life problems	primary students,
Numeracy	Numeracy	(Prodyanatasari, 2024)	Use of mathematical facts, procedures, and tools to solve contextual everyday problems and explain the role of mathematics in life	Grade 1-2
Numeracy	Numeracy (Mathematics literacy–numeracy)	(FRAMEWORK ASESMEN KOMPETENSI MINIMUM, 2023)	Use of mathematical knowledge to explain events, solve problems, and make responsible decisions in real-world settings	School-age students in general;
Numeracy	Numeracy	(Naskah Akademik Gerakan Numerasi Nasional, 2026)	Application of mathematics in daily life through logical, critical, analytical, and creative thinking, including data-based decision making	All citizens / life-span perspective
Basic Mathematical Literacy	Basic mathematical literacy	(Federiakin et al., 2021)	Competence for solving daily-life problems involving arithmetic, graphs, spatial thinking, practical procedures, and data analysis	Primary Students
Early numeracy	Early numeracy (EN)	(Džumhur et al., 2022)	Foundational skills before formal schooling, including counting, number symbols, quantity comparison, and simple object manipulation	Preschool children, before starting school
Early numeracy	Early numeracy (EN)	(Dierkx et al., 2025)	Ability to use the number-word sequence and make relational statements in numerical contexts.	Kindergarten and Grade 1 children

Table 2 shows that there are several terms used when dealing with mathematical literacy or numeracy. Those are mathematical literacy, basic mathematical literacy, numeracy, and early numeracy. Additionally, some authors note that there are three terms related to mathematical literacy, mathematical literacy, numeracy, and quantitative literacy, that are used interchangeably in the literature (De Lange, 2005; Goos, 2021; Niss, 2015; Wang et al., 2021). However, the relationship among these terms is not always interpreted the same way. Niss (2015) and De Lange (2005) state that the terms have broadly similar meaning and still differences among the terms. In contrast, Goos (2021) state that these three definitions are the same, the difference is in the particular country's choice of the term. This variation shows that mathematical literacy and numeracy are closely related, but the meanings depend on how each source frames the role of mathematical knowledge, context, and application.

Based on Table 2, some sources still use the PISA framework to define mathematical literacy even for primary students or lower primary students. There are no separate definitions for each level of students such as lower primary, upper primary, secondary. In PISA, mathematical literacy is defined as a person's ability to reason mathematically and to formulate, employ, and interpret mathematics in solving problems across various real-world contexts and includes the use of mathematical concepts, procedures, facts, and tools to describe, explain and predict phenomena to help individuals understand the role of mathematics in the world and make well-founded judgements and decisions (OECD, 2025). Therefore, the PISA framework basically covers three important aspects of mathematical literacy namely content (mathematical concepts), mathematical process (formulate, employ, and interpret mathematics), and context. These dimensions are useful for understanding mathematical literacy as more than procedural competence. However, because PISA was developed for 15-year-old students, the framework does not specify how these dimensions should be operationalized for lower primary students.

Other definitions of mathematical literacy show a similar structure, even if they are not based on the PISA framework. Haara (2018) states that mathematical literacy is a person's ability to engage in higher-order thinking skills specific to mathematics that allows the understanding and application of mathematics in real-life, everyday situations. Kliziene et al. (2021) describe mathematical literacy not only includes understanding and applying mathematical skills and knowledge to solve specific problems but also logical thinking and mathematical communication (argumentation, interpretation) used in the processes. These two definitions are in line with Niss (2015) that states mathematical literacy's purpose should be making mathematics functional in real-world contexts. These definitions show that mathematical literacy is generally built on three related aspects: mathematical content, cognitive processes, and context. However, these definitions remain broad and do not clearly explain how mathematical literacy should be adapted for lower primary students.

The numeracy definitions in table 2 show several similarities. Most sources define numeracy as the use of mathematics in real-life contexts (Aini et al., 2024; De Lange, 2005; Prodyanatasari, 2024; Rohmah et al., 2022; Sakurai & Goos, 2023). This application of mathematics refers to the ability to understand information, apply mathematical ideas, think critically (Aini et al., 2024), reason mathematically and use mathematical symbols (Rohmah et al., 2022). Additionally, numeracy also involves the use of mathematics tools (Sakurai & Goos, 2023), the ability to handle numbers and data, and the ability to evaluate statements regarding problems and situations that require mental processing and estimation (De Lange, 2005). These definitions show that numeracy definitions have a very similar nuance as mathematical literacy, because both combine three important aspects, namely mathematical concepts, process, and real-life context in its definition.

Different from the broader definition of numeracy discussed above, Lindström-Sandahl et al. (2024) defined numeracy as focusing on foundational understanding of numbers, mathematical concepts, and procedural fluency with arithmetic that form the basis for basic arithmetic and problem solving. This definition is similar to the definition of early numeracy by Džumhur et al. (2022) and Dierkx et al. (2025), which emphasize in the foundational set of skills that students need in problem solving. These definitions do not always require an explicit real-life context. Furthermore, the key similarity of these three sources is their target age group, since they focused on grade 1-2 or even younger student. Therefore, these definitions would be the most tailored to the lower primary or even younger students. However, their relevance is stronger for early lower primary students and may not fully cover the whole lower-primary range, especially Grade 3.

Another term found in the reviewed sources is basic mathematical literacy. Federiakin et al. (2021) define basic mathematical literacy as a competency needed to handle everyday situations such as grocery shopping, cooking, and paying bills. It includes multiple components, such as computational skills, understanding fundamental concepts, spatial thinking, real-world problem solving, implementing complex algorithms, and analysing data from graphs. This definition is relevant to primary education because Federiakin et al. focus specifically on primary students. However, the definition does not clearly distinguish between lower and upper primary students. Similar to early numeracy, basic mathematical literacy gives stronger attention to foundational mathematical concepts compare with the general mathematics literacy definition. Even so, it still needs further adaptation before it can be used as a lower-primary-specific definition.

In addition to the definition above, this review also examines the definition of numeracy based on the Indonesian Ministry of Education. In Indonesian policy documents, numeracy is closely related to mathematical literacy. The first formal definition of numeracy or mathematical literacy appears in framework of Minimum Competence Assessment (AKM) in 2022. According to Framework Asesmen Kompetensi Minimum (AKM) (2023) numeracy refers to a person's ability to use their mathematical knowledge to explain events, solve problems, or make decisions in everyday life. This helps individuals recognize the role of mathematics in real life so they can make the necessary judgments and decisions and become responsible human beings who are capable of logical reasoning. A similar definition appears in Gerakan Numerasi Nasional (National Numeracy Movement) launched by the ministry. In this document, numeracy is defined as the ability to use mathematics in everyday life, and it includes the logical, critical, analytical and critical thinking, also using data to make decision in real-life context.

The numeracy definition based on Indonesia government is general and similar to PISA-based definition of mathematical literacy because they combine mathematical content, cognitive processes, and real-life context. However, the AKM Framework also states that the mathematical concepts used in numeracy should be adjusted to the complexity of concepts learned at each grade level and aligned with students' development (Framework Asesmen Kompetensi Minimum (AKM), 2023). It becomes a significant point where there is a need in the emphasis on the grade-level and development appropriateness. This principle is highly relevant for lower primary education because it recognizes that numeracy tasks should not simply be transferred from frameworks designed for older students. However, the policy documents do not yet provide a specific definition of mathematical literacy or numeracy for Grades 1–3.

The reviewed definitions show that mathematical literacy or numeracy are generally built on three shared dimensions: mathematical content, cognitive processes, and real-life context. Additionally, for lower primary education, these dimensions need to be interpreted developmentally. In contrast, early numeracy definitions are developmentally relevant but too narrow to represent the broader construct of mathematical literacy. Therefore, lower-primary mathematical literacy should be positioned as a bridging construct between early numeracy and broader mathematical literacy. In this review, lower-primary mathematical literacy refers to students' ability to use developmentally appropriate mathematical content, basic cognitive processes, and meaningful everyday contexts to interpret and solve simple problems. For Grades 1–3, this includes foundational number understanding, arithmetic fluency, measurement, geometry and spatial sense, patterns, and simple data handling, together with simple reasoning, representation, communication, and problem solving in familiar everyday situations.

2. Indicator of mathematical literacy/ Numeracy for lower Primary

Among the included sources, seven sources explicitly provided indicators, dimensions, or operational components of mathematical literacy, numeracy, basic mathematical literacy, or early numeracy. Table 3 shows all the indicator based on the term use in the paper.

Table 3:
Operational Indicators of Mathematical Literacy/ Numeracy

Source	Term use	Indicator
(De Lange, 2005)	Mathematical literacy	1. Mathematical thinking and reasoning 2. Mathematical argumentation 3. Mathematical communication 4. Modelling 5. Problem posing and solving 6. Representation 7. Symbols 8. Tools and technology
(Seçgin et al., 2024)	Mathematical literacy	Turner, Blum & Niss framework, as cited by Secgin et al.: 1. logical thinking, 2. communication, 3. creating models, 4. problem-solving, 5. representing information, 6. using symbolic/technical language and tools; each scored at four levels
(Goos, 2021)	Numeracy	Element of numeracy models 1. Mathematical knowledge 2. Dispositions 3. Tools 4. Contexts 5. Critical orientation
(Rohmah et al., 2022)	Numeracy	Rizki & Priatna framework, as cited by Rohmah et al.: 1. think critically and pose mathematical questions, 2. distinguish proofs from other reasoning and create ideas, 3. mathematical communication (express ideas verbally/visually), 4. translate reality into mathematics and validate, 5. willingness to ask and solve problems in various ways,

		6. represent and understand relations between representations, 7. use mathematical symbols well, 8. use various mathematical tools
(Federiakin et al., 2021)	Basic Literacy Mathematics	Content area 1. Spatial concepts 2. Measuring 3. Patterns and sequences 4. Modelling 5. Data handling Cognitive domains 1. Knowing 2. Applying 3. Reasoning
(Dierkx et al., 2025)	Early numeracy	two theoretical components, 1. concepts of comparison 2. counting skills
(FRAMEWORK ASESMEN KOMPETENSI MINIMUM, 2023)	Numeracy	Cognitive Process Indicators (Problem-Solving) 1. Formulate 2. Employ 3. Interpret Content-Domain Indicators 1. Numbers 2. Geometry and Measurement, 3. Algebra, 4. Data and Uncertainty

From table 3, we can grouped the type of indicator used in the sources into three types of indicator. The first is the indicator that shows the process competency lists only (De Lange, 2005; Goos, 2021; Rohmah et al., 2022; Seçgin et al., 2024). The second is the indicator that shows the process and content domain lists (Federiakin et al., 2021; FRAMEWORK ASESMEN KOMPETENSI MINIMUM, 2023). Last one shows Foundational early-numeracy indicators (Dierkx et al., 2025). In this paper, the indicators that are discussed here will be split into two big ideas, that is process and content domain.

a. Process competency indicators

There are recurrent core processes competencies that can be seen from table two. Those are reasoning/ logical thinking/ critical thinking, problem posing and problem solving, mathematical communication (verbal, visual, and symbolic), Representation and Modelling context, the use of symbols and formal mathematics language and terminology, and the use of tools including digital technology.

The reasoning/ logical thinking/ critical thinking can be refer to the use of the information to make decision and justify the judgement or challenge he arguments (Goos, 2021). Additionally, this indicator also refer to the ability to understand about proofs and differentiate it to other forms of reasoning, not just the ability to construct and evaluate arguments (De Lange, 2005). Therefore, it can be said that the first indicator covers practical and structural aspect of reasoning and thinking. The practical related to how one use information to make decision justify judgements, and challenge arguments, while the structural is more abstract such as understanding proof, and distinguishing them from other reasoning, not just merely construct and evaluate an argument.

The second indicator about problem posing and problem solving is related to the first indicator that is critical thinking. Rizki and priatna (as cited in Rohmah et al., 2022) state that students can think critically by asking mathematical questions and understanding the limitations of mathematical concepts. Additionally, De Lange (2005) explain further that student not only able to pose mathematical questions but also recognize what kind of answers it may result. It means it also draws on student's ability related to mathematical concepts and skills and problem-solving strategies (Goos, 2021). Furthermore, it is also related the ability to see the different types of mathematical statements, not only understand the limit of mathematical concepts. Thus, the problem-posing and problem-solving indicator does not stand alone. It is a practical expression of critical thinking. It involves not only asking mathematical questions and understanding the limits of mathematical concepts, but also anticipating the kinds of answers mathematics can offer and distinguishing among different types of mathematical statements.

The next indicator would be mathematical communication. This indicator refers to the ability to express the ideas in variety of ways such as verbal, written work, or other visual form (De Lange, 2005; Rohmah et al., 2022). Furthermore, it also relate to the ability to understand other's work (De Lange, 2005). So, it can be said this indicator related to the ability to communicate actively not just understand others' work but also able to convey the idea to others.

The next indicator would be representation and modelling of context. This indicator refers to the individual ability to translate many range of context, it can be real world context or within school (different curriculum context) (Goos, 2021; Rohmah et al., 2022). This indicator is not only related to the ability of translating other context in mathematical structures, but also students need to be able to interpret the model back into context (De Lange, 2005). Additionally, De Lange (2005) also state that it relate to the ability to validate the model and critically reflect not only the model, but also the solutions, and the modelling process itself. To sum up, the representation and modelling indicator demands two competences, that is to translate various contexts whether it is real world or within curriculum into mathematical structures, and interpreting the model back into the context. It also requires the ability to validate, critique, and reflect on the model, the process, and the solution made.

The next indicator is the use of symbols and formal mathematics language and terminologies. This indicator means that this is the ability in using symbolic, formal, and technical language and operations (De Lange, 2005; Rohmah et al., 2022). This indicator related to the mathematical communication and modelling where one need to use symbols and formal mathematics language and terminologies to convey their idea.

The last indicator related to the competence is the ability to use tools including digital technology. De Lange (2005) stated that this related to the ability of using aids and tools, including technology, when appropriate. In addition, Goos (2021) not only refer tools that are things such as models or measuring instruments and digital technology such as computers, software, calculators, and internet, but also include representational such as symbol systems, graphs, maps, diagrams, drawings, and tables, to mediate and shape the thinking process. This means the tools is not refers to things and technology, but also representations that can help the process of thinking

Among these process indicators unfortunately there are no indicator that specify for students in primary or lower primary. Similar to the discussion in the definition of mathematical literacy/ numeracy. It is important to pay attention that the indicator need to be adjusted to the complexity of the concept learnt in each class, and it should be parallel to students' development (Framework Asesmen Kompetensi Minimum (AKM), 2023). Thus, it will need further study to see the level of students' development that is appropriate to the indicator of mathematical process mentioned here related to many theory that related to the students' development. For lower primary education, each process competency needs to be reformulated in simpler and more observable terms that match students' mathematical content knowledge, language development, and everyday experiences.

b. Content-domain indicators

In addition to process competencies, the reviewed sources also identify mathematical content domains as indicators of mathematical literacy or numeracy. The content domains that appear across the reviewed sources include number and operations, geometry and spatial sense, measurement, patterns and early algebra, and data handling. Similar to the indicator of mathematical process, the indicator of mathematical content, need to be adjusted so that it is relate to the content that the students have learnt. the most suitable one would be using federiakin et.al. since this study specified in primary school. However, the place for the study is outside of Indonesia. It means it needs to be analysed using the curriculum to compare the content.

Compared with process indicators, content-domain indicators are more straightforward to adapt for lower primary education because they can be aligned with the mathematical content specified in the curriculum. In the

Indonesian context, the Merdeka Curriculum provides relevant content benchmarks for primary mathematics. Although this study defines lower primary as Grades 1–3, the Merdeka Curriculum organizes primary education by phases. Phase A covers Grades 1–2, while Phase B covers Grades 3–4. Therefore, Phase A is used to represent Grades 1–2, while Phase B is consulted only to identify Grade 3 content because Grade 3 is grouped with Grade 4 in the official curriculum structure. Table 4 presents the mathematical content relevant to lower primary education based on Phase A and Phase B of the Merdeka Curriculum.

Table 4:
Comparison of the mathematical content covering in Merdeka Curriculum

Domain	Phase A (Grades 1-2) (Kementerian Pendidikan Dasar dan Menengah, n.d.-a)	Phase B (Grades 3-4) (Kementerian Pendidikan Dasar dan Menengah, n.d.-b)
Number & Operations	Concrete numbers up to 100; basic addition/subtraction. Fractions as physical pieces.	Abstract place value to 10,000; all four operations. Decimals and percentage introduction.
Geometry & Spatial	Identifying basic 2D/3D shapes; directional vocabulary (left/right).	Analyzing properties (angles, lines); composing and decomposing shapes.
Measurement	Non-standard units; direct physical comparisons.	Standard metric units; calculating area and volume.
Pattern & Early Algebra	Noticing regularities: Copying and creating repeating visual/sound patterns. Equivalence: Understanding the equals sign (=) as "balance" or "the same as" using physical objects, rather than just "the answer is."	Generalizing rules: Identifying and continuing numerical patterns. Relational thinking: Finding unknown values in simple open sentences (e.g., 12 + ... = 20) using logic and inverse operations rather than formal algebraic steps.
Data Handling	Sorting physical objects; tally marks and basic pictograms.	Interpreting structured tables and bar charts with unit scales.

Table 4 shows that lower-primary mathematical content can be organized into five main domains: number and operations, geometry and spatial sense, measurement, patterns and early algebra, and data handling. In Phase A, the content remains concrete and strongly connected to direct experience, such as using numbers up to 100, performing basic addition and subtraction, identifying simple two-dimensional and three-dimensional shapes, comparing objects using non-standard measurement, recognizing repeating patterns, and sorting or representing simple data. In Phase B, the content becomes more abstract and systematic, including place value up to 10,000, four arithmetic operations, standard units of measurement, properties of shapes, numerical patterns, open number sentences, tables, and bar charts.

Overall, the reviewed sources and curriculum comparison suggest that content indicators for lower-primary mathematical literacy can be derived from five curriculum-aligned domains: number and operations, measurement, geometry and spatial sense, patterns and early algebra, and data handling. These domains provide the mathematical content through which lower-primary students can demonstrate reasoning, communication, representation, and problem solving in meaningful everyday contexts.

CONCLUSION

Defining Mathematical Literacy and Numeracy for Primary Students, Especially Lower Primary

There are two views of definition of mathematical lliteracy/ numeracy whether it is in Indonesia or outside of Indonesia. For the general definitions, including some studies that are the subjects are primary students, many still opt to use the general definitions. The definition of mathematical literacy/ numeracy is rest on three pillars: mathematical content, cognitive processes (reasoning, applying, communicating), and real-world context.

The PISA framework, though built for 15-year-olds students, is regularly applied not only for secondary school but also to primary students especially to upper primary. Indonesian policy follows the same stance: both AKM and the National Numeracy Movement, where the government define numeracy as using mathematics to solve everyday problems, think logically, and make responsible decisions. Additionally, to this definition, the government write that the content should be adjusted to each grade level.

For lower primary especially grade 1-2 or younger, many international studies use early numeracy as the term. The mathematical competence that is discuss here would be more about fundamental skills such as understanding numbers, procedure and fluency in arithmetic, and basic problem solving. It can be said that the early numeracy is the set of pre-formal skills that come before the numeracy. However, the line is not clear where should one move from early numeracy to numeracy in lower primary.

As mention before, Indonesia's policy does not have the exact definition for mathematical literacy/ numeracy for lower primary. The Indonesian government's guidance confirms this: numeracy tasks should match the concept complexity taught at each level and be developmentally appropriate. Yet, this guidance remains limited and unclear. Further study is needed to analyse and adjust the definition so that it is genuinely suitable for lower primary.

Mathematical literacy for lower primary refers to students' ability to use developmentally appropriate mathematical content, cognitive processes, and real-life contexts to solve everyday problems. It includes fundamental number understanding, procedural fluency in arithmetic, simple reasoning, communication, representation, and problem solving. simple reasoning, communication, representation, and problem solving.

Indicators Used to Measure Primary Students' Mathematical Literacy

The existing studies operationalize mathematical literacy through two broad types of indicators: process competencies and content domains. Process competencies—reasoning, problem posing and solving, mathematical communication, representation and modelling, the use of symbols and formal language, and the use of tools including digital technology—are the most frequently cited and form a recurrent core across frameworks. Content domains appear in only a few sources and cover standard primary curriculum strands: numbers, geometry and measurement, algebra, data and uncertainty, and in one case, modelling as a content area.

However, none of these process indicators are specifically designed for primary or lower primary students. They are adapted from general or PISA-oriented frameworks by simplifying tasks, not by redefining the indicator itself. At the early primary level, the only indicators available are those of early numeracy—concepts of comparison and counting skills which capture foundational number skills but exclude the richer processes of reasoning, modelling, and communication. Thus, existing measurement frameworks either offer a full set of generic indicators that lack developmental specificity, or a minimal set of early numeracy indicators that do not yet constitute mathematical literacy. The AKM guidance rightly states that indicators should match the complexity of the concept taught and the student's developmental stage, but what this means operationally for each primary grade remains unclear. Further study is needed to define developmentally appropriate indicators that bridge early numeracy and the full mathematical literacy competency set for primary students.

The content indicators—number and operations, geometry and spatial sense, measurement, patterns and algebra, and data handling—appear in fewer sources but offer a clearer path for adaptation. For lower primary, defining content indicators proves easier than defining process indicators. The Merdeka Curriculum already specifies concrete, developmentally appropriate content for Phase A (Grades 1–2): numbers up to 100, basic shapes, non-standard measurement, repeating patterns, and simple data handling. These are explicitly stated, accessible, and ready to be used as content benchmarks. Thus, while process indicators still require developmental analysis, content indicators can already be drawn directly from the curriculum

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