HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

ENHANCING MATHEMATICAL LITERACY AMONG PRIMARY SCHOOL PUPILS THROUGH CONTEXTUAL PROBLEM SOLVING

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Doi: https://doi.org/10.5281/zenodo.21882801

Abstract: This article investigates how mathematical literacy can be developed in primary school through contextual problem solving, multiple representations, mathematical communication, and formative assessment. Mathematical literacy is defined as the capacity to formulate, employ, and interpret mathematics in situations that are meaningful to learners, rather than as the reproduction of isolated procedures. The study uses a qualitative synthesis of international assessment frameworks, research on mathematical proficiency, realistic mathematics education, learning trajectories, and classroom assessment. The analysis identifies five interdependent dimensions: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. On this basis, the article proposes a six-phase instructional model: contextual entry, problem formulation, representation, strategy construction, explanation and comparison, and transfer. The model emphasizes age-appropriate contexts, manipulatives, drawings, tables, number lines, estimation, and precise mathematical language. It also explains how teachers can differentiate tasks without lowering the central cognitive demand and how errors can be used as evidence of pupils' reasoning. A sample planning matrix illustrates the connection between teacher actions and observable indicators of progress. The article concludes that mathematical literacy grows when children repeatedly use mathematics to make decisions, justify conclusions, and connect symbolic procedures with quantities, relationships, and real situations.

Keywords: mathematical literacy, primary education, problem solving, mathematical reasoning, representation, formative assessment, productive disposition

Annotatsiya: Maqolada boshlang‘ich sinf o‘quvchilarining matematik savodxonligini hayotiy kontekstli masalalar, turli tasvirlash vositalari, matematik muloqot va shakllantiruvchi baholash orqali rivojlantirish yo‘llari o‘rganiladi. Matematik savodxonlik alohida algoritmlarni takrorlash emas, balki mazmunli vaziyatlarda matematikani ifodalash, qo‘llash va talqin qilish qobiliyati sifatida izohlanadi. Tahlil asosida konseptual tushunish, protseduraviy ravonlik, strategik kompetensiya, moslashuvchan mulohaza va ijobiy matematik pozitsiyani birlashtiruvchi olti bosqichli ta’lim modeli taklif etiladi.

Kalit so‘zlar: matematik savodxonlik, boshlang‘ich ta’lim, masala yechish, matematik mulohaza, tasvirlash, shakllantiruvchi baholash

Аннотация: В статье рассматриваются пути развития математической грамотности учащихся начальных классов посредством контекстных задач, различных способов представления, математической коммуникации и формирующего оценивания. Математическая грамотность понимается не как воспроизведение отдельных алгоритмов, а как способность формулировать, применять и интерпретировать математику в значимых ситуациях. На основе анализа предложена шестиступенчатая модель обучения, объединяющая концептуальное понимание, процедурную беглость, стратегическую компетентность, адаптивное рассуждение и продуктивное отношение к математике.

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ISSN: 2058-5519|Impact factor-15.9
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Ключевые слова: математическая грамотность, начальное образование, решение задач, математическое рассуждение, представление, формирующее оценивание

Introduction

Mathematics in primary school is often evaluated through the speed and accuracy with which pupils execute taught procedures. These abilities are important, but they are not sufficient for mathematical literacy. A mathematically literate child can recognize a quantitative or spatial problem, select useful information, represent relationships, choose a strategy, calculate reasonably, and explain whether the result makes sense. The OECD framework describes mathematical literacy through the processes of formulating, employing, and interpreting mathematics in varied contexts [1]. Although PISA assesses older learners, the underlying processes begin in the primary years. Children learn the habits of modelling, reasoning, and checking long before they encounter formal algebra.

A narrow focus on correct answers can conceal fragile understanding. A pupil may reproduce a subtraction algorithm yet be unable to decide whether subtraction is appropriate in a comparison problem. Another may know multiplication facts but fail to interpret equal groups, arrays, scale, or combinations. Such gaps become more serious as mathematics grows more symbolic. Primary teaching therefore needs to connect procedures with quantities, structures, and situations. The goal is not to remove practice but to ensure that practice develops flexible and meaningful knowledge. Mathematical literacy is strongest when pupils know what to do, why it works, when to use it, and how to communicate the reasoning.

The National Research Council describes mathematical proficiency through five intertwined strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition [2]. This framework is particularly useful because it prevents teachers from treating understanding and fluency as competitors. Conceptual understanding gives meaning to procedures; procedural fluency makes reasoning efficient; strategic competence supports problem formulation; adaptive reasoning enables justification; and productive disposition sustains effort. The present article translates these strands into an instructional model suitable for primary classrooms and aligned with contextual problem solving.

The article is a theoretical and methodological study based on qualitative synthesis. It compares the OECD mathematical literacy framework, the five-strand proficiency model, principles of effective mathematics teaching, realistic mathematics education, learning trajectories, and research on formative assessment [1–10]. The sources were coded for statements concerning task design, representation, reasoning, classroom discourse, procedural development, motivation, and assessment. Recurring principles were organized into a pedagogical sequence. No experimental outcomes are fabricated; the “results” reported below are results of the conceptual synthesis and are presented as a model for classroom application and future empirical testing.

The analysis was guided by four questions. First, what forms of knowledge allow a primary pupil to use mathematics beyond a familiar exercise? Second, what classroom actions help children move from concrete situations to diagrams and symbols? Third, how can teachers preserve cognitive demand while providing support? Fourth, what evidence reveals developing mathematical literacy? Each source was examined in relation to these questions. The final model was evaluated for developmental appropriateness, internal coherence, and practical feasibility within an ordinary lesson of thirty-five to forty-five minutes.

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The first finding is that mathematical literacy develops through purposeful contexts, but the context must illuminate rather than hide the mathematics. Realistic mathematics education argues that learners should encounter situations that can be mathematized [3]. A context may come from shopping, distance, time, classroom organization, weather, construction, games, or local environmental data. However, decorative stories do not automatically create authenticity. A task is mathematically productive when the situation creates a genuine need to compare, count, measure, organize, predict, or optimize. The teacher should be able to state which relationship pupils are expected to notice and which representation can make that relationship visible.

The second finding concerns conceptual understanding. Concepts grow when pupils connect examples, non-examples, actions, language, and representations. The number 24 can be experienced as twenty-four objects, two tens and four ones, a point on a number line, six groups of four, four groups of six, or the result of several decompositions. Each representation highlights a different structure. Manipulatives are valuable when pupils are required to explain the correspondence between the object and the mathematical idea. Merely moving blocks according to the teacher's directions may produce activity without abstraction. Questions such as "What does each block represent?" and "How would the drawing show the same relation?" create the bridge from action to symbol.

The third finding is that procedural fluency should be developed through understanding, comparison, and deliberate practice. Fluency includes accuracy, efficiency, flexibility, and appropriate choice. A child who solves $46 + 29$ as $46 + 30 - 1$ demonstrates a relation that is mathematically useful. Standard algorithms remain important because they provide reliable general methods, but they should be introduced after pupils have explored place value and composition. Practice is most effective when it mixes retrieval of essential facts with reasoning about number relationships. Short daily routines, such as number talks or estimation questions, can strengthen fluency without reducing mathematics to timed competition.

The fourth finding is the importance of strategic competence. Many pupils treat a word problem as a signal to combine visible numbers, often choosing an operation from a keyword. This habit is unreliable because the same word may occur in different mathematical structures. Strategic competence develops when pupils first describe the situation, identify the unknown, and represent relationships. They may use a bar model, table, diagram, number line, or equation. Teachers should ask, "What is happening to the quantities?" before asking, "Which operation will you use?" This small change moves attention from verbal cues to mathematical structure [4].

The fifth finding is that adaptive reasoning requires a classroom culture in which explanations are expected and compared. A correct answer does not always indicate sound reasoning, and an incorrect answer may reveal a valuable idea. Pupils should regularly complete statements such as "I know this because…," "My representation shows…," and "The two methods are similar because…." The teacher's role is to press for clarity without taking ownership of the argument. When two strategies are placed side by side, pupils can discuss efficiency, generality, and possible errors. Such comparison develops metacognition and gives mathematical language a genuine communicative purpose.

The sixth finding is the central role of productive disposition. Children need to see mathematics as sensible, useful, and learnable through effort. Repeated public comparison of speed can create the belief that mathematical ability is a fixed talent. In contrast, tasks with multiple entry points allow pupils to contribute different representations and strategies. Productive struggle should be

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distinguished from unproductive confusion. A challenging task is beneficial when the goal is understandable, prior knowledge is available, and support can be offered without removing the reasoning. The teacher communicates that difficulty is expected and that revision is part of mathematical work.

Phase one is contextual entry. The teacher presents a concise situation, object, picture, or question that contains a quantitative relationship. For example, pupils may plan how to arrange twenty-four seedlings in equal rows. The teacher checks that the situation is understood and invites pupils to estimate possible arrangements. No operation is announced. The purpose of this phase is to create an intellectual need for mathematics and activate relevant knowledge. A successful entry is brief; it does not overload pupils with unnecessary reading or irrelevant details.

Phase two is problem formulation. Pupils identify what is known, what is unknown, and what conditions must be respected. They restate the problem in their own words and may generate a mathematical question. This phase is crucial because formulation is itself part of literacy [1]. In the seedling task, pupils recognize that every seedling must be used and every row must contain the same number. The teacher records pupil language and gradually introduces precise terms such as factor, array, equal group, or remainder when they are developmentally appropriate.

Phase three is representation. Pupils use objects, sketches, tables, bar models, number lines, or symbols to make the relationship visible. The teacher encourages more than one representation and asks how they correspond. For younger pupils, physical actions may come first; for older primary pupils, a quick diagram may be more efficient. Representation should reduce cognitive load and expose structure. A table of rows and seedlings per row can reveal factor pairs more clearly than repeated guessing. Pupils learn that choosing a representation is a strategic decision, not an artistic decoration.

Phase four is strategy construction and calculation. Pupils select a method, carry it out, and monitor intermediate results. The teacher provides prompts rather than steps: “Could you decompose the number?”, “Would a table help?”, or “What pattern do you notice?” Support may include a partially completed representation, smaller numbers, or a worked analogous example. The central reasoning remains with the pupil. Calculation accuracy is checked, but the teacher also asks whether the magnitude is plausible. Estimation becomes a normal part of solution rather than an optional final exercise.

Phase five is explanation and comparison. Selected pupils present contrasting strategies. The class identifies what is mathematically valid, where methods connect, and which method may be more efficient in a particular case. The teacher intentionally chooses examples that reveal a useful relation or common misconception. Discussion is not a parade of answers; it is a structured investigation of ideas. Pupils may revise their own work after hearing another strategy. Revision demonstrates learning and should not be treated as evidence of failure.

Phase six is transfer. Pupils apply the underlying idea to a changed situation, new numbers, or a different representation. If the first task involved equal rows, the transfer task may ask which totals cannot be arranged in a specified number of equal rows and why. Transfer reveals whether pupils learned a procedure tied to one surface story or recognized a general structure. A brief exit task can provide formative evidence for the next lesson. The teacher records which pupils can formulate, represent, reason, and interpret independently.

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Phase	Core pupil action	Teacher prompt	Observable evidence
1. Contextual entry	Notice a quantitative or spatial problem.	What do you notice? What might need to be found?	Relevant observations and reasonable estimates.
2. Formulation	Identify knowns, unknowns, and conditions.	What is changing? What must remain true?	A clear mathematical question or restatement.
3. Representation	Model the relation with objects, drawings, tables, or symbols.	How does this picture match the situation?	A representation that preserves the quantities and relation.
4. Strategy	Choose and execute a method.	Why is this method useful here?	Accurate work, monitoring, and plausible results.
5. Explanation	Justify and compare methods.	Where do these strategies connect?	Evidence-based mathematical language and revision.
6. Transfer	Use the idea in a changed situation.	What remains the same in this new problem?	Recognition and application of the general structure.

Formative assessment should examine the process as well as the answer. A simple rubric can include four indicators: interpretation of the situation, quality of representation, coherence of strategy, and justification of the result. These indicators allow teachers to distinguish different needs. A pupil may understand the situation but calculate inaccurately; another may calculate correctly after choosing an inappropriate model by chance. The instructional response should differ. Black and Wiliam show that assessment becomes formative when evidence is used to adapt teaching and when learners understand the goal [9]. Consequently, a score without diagnostic feedback has limited value for literacy development.

Errors are particularly informative. If a pupil adds all numbers in a problem, the error may reveal a keyword strategy rather than carelessness. If a child writes 3/8 as larger than 1/2 because eight is larger than two, the work reveals whole-number reasoning applied to fractions. Teachers can anonymously display selected errors and ask the class to identify the idea, test it, and repair it. This practice must be psychologically safe; the purpose is to investigate reasoning, not identify a weak pupil. Over time, children learn to regard error analysis as a normal mathematical activity.

Assessment tasks should vary in representation and context. If pupils only solve vertical calculations, teachers cannot know whether they can interpret the same operations in a situation. A balanced set may include a short contextual problem, a diagram to complete, a calculation to explain, and a claim to evaluate. Oral explanation is valuable for pupils whose written language is still

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developing. Teachers should also observe whether pupils estimate, check, ask clarifying questions, and persist. These behaviours are part of mathematical literacy even when they are not visible in the final numeral.

The proposed model supports the five strands of mathematical proficiency as a unified system [2]. Contextual entry and formulation strengthen strategic competence; representations deepen conceptual understanding; calculation develops procedural fluency; explanation supports adaptive reasoning; and repeated successful engagement contributes to productive disposition. No phase is completely isolated. For example, a number line can simultaneously support understanding, strategy, and explanation. The model is therefore not a rigid script but a planning lens. Teachers may combine phases in a short lesson or extend one problem across several sessions.

Differentiation within the model should preserve the mathematical goal. Teachers can reduce reading load, offer manipulatives, provide a representation template, allow partner rehearsal, or change the size of numbers. They should avoid replacing a reasoning task with a page of simpler calculations for pupils who need support. Such replacement reduces access to the very competencies that define literacy. High-attaining pupils can be challenged through generalization, proof, alternative constraints, or creation of a related problem rather than merely receiving more of the same calculations.

Mathematical language deserves explicit attention. Words such as difference, product, equal, approximately, at least, and per carry relations that may not be familiar in everyday speech. Teachers should model complete explanations and display useful sentence structures without turning discourse into memorization. Multilingual pupils may first discuss an idea with a partner using their strongest language and then formulate it in the instructional language. Visual and symbolic representations provide additional bridges. Precision grows through meaningful use, not through copying definitions alone.

Digital tools can support mathematical literacy when they allow dynamic representation, immediate testing of conjectures, or collection of real data. Virtual manipulatives, spreadsheets, geometry environments, and simple coding tasks can make relationships visible. However, technology should not decide every step or reward only speed. Pupils need opportunities to predict before using a tool, explain what changed, and connect the screen representation to symbols and real quantities. The teacher should ask whether the digital resource increases reasoning or merely automates it.

A practical starting point is to redesign one routine exercise per lesson as a literacy task. Instead of asking pupils to calculate 6×8, the teacher may present several possible arrangements of forty-eight objects and ask which are valid and how they know. Instead of ten isolated conversions, pupils may plan the length of ribbon needed for several packages and justify an estimate. Small changes in questioning can produce large changes in reasoning. The teacher should plan the anticipated representations, likely misconceptions, and the final transfer question before the lesson.

Weekly planning should include a balance of number, measurement, geometry, data, and pattern, together with recurring opportunities to formulate and interpret. Classroom displays can feature strategy examples and mathematical vocabulary rather than only rules. Pupils should keep selected work that shows revision and explanation. Family tasks should use accessible situations such as comparing prices, measuring ingredients, reading timetables, or estimating distance; they should not require parents to teach unfamiliar methods. The emphasis is on conversation about quantities and decisions.

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Mathematical literacy in primary school is the ability to use mathematical ideas with understanding, flexibility, and judgment. It cannot be secured by procedural rehearsal alone, nor can it develop through unguided discovery without systematic teaching. The six-phase model proposed in this article coordinates context, formulation, representation, strategy, explanation, and transfer. It preserves the importance of fluent calculation while placing calculation inside a broader process of sense making. When pupils repeatedly interpret situations, model relationships, compare strategies, analyze errors, and justify conclusions, they begin to experience mathematics as a coherent way of thinking. This foundation prepares them not only for later assessments but also for responsible decision-making in everyday and academic life.

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