

Integrating Real-Life Contexts into Mathematics Education to Support Critical Thinking

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Received: 25 February 2026; **Accepted:** 22 March 2026; **Published:** 13 April 2026

Abstract: This article examines the pedagogical potential of integrating real-life contexts into mathematics education in order to support students' critical thinking. The relevance of the topic is determined by current educational demands that require learners not only to reproduce procedures but also to interpret situations, evaluate information, justify conclusions, and make reasoned decisions in everyday, academic, and civic settings. In contemporary mathematics education, real-life contexts are no longer viewed as decorative additions to abstract content. They are increasingly interpreted as meaningful environments in which mathematical reasoning, modelling, and reflection can be developed together. The purpose of the article is to substantiate a methodological approach to integrating real-life contexts into mathematics teaching so that contextualized learning contributes directly to the formation of critical thinking. The study is theoretical and methodological in nature and is based on the analysis, comparison, and synthesis of research in mathematical literacy, mathematical modelling, authentic tasks, and critical mathematical thinking. The article argues that critical thinking in mathematics is strengthened when learners work with authentic and socially meaningful situations, formulate mathematical models, interpret results in relation to the original context, and evaluate the adequacy, limitations, and consequences of their solutions. A pedagogical model is proposed in which contextual tasks are organized through gradual movement from situation analysis to mathematization, solution, interpretation, discussion, and reflective evaluation. The practical significance of the study lies in its applicability to school mathematics, teacher education, and curriculum design aimed at increasing the relevance, depth, and intellectual productivity of mathematics learning.

Keywords: Mathematics education, real-life contexts, critical thinking, mathematical literacy, mathematical modelling, contextual learning, authentic tasks, mathematical reasoning, reflective judgment, teacher practice.

Introduction: The contemporary understanding of mathematics education has moved far beyond the transmission of formulas, algorithms, and routine procedures. International curriculum and assessment frameworks increasingly define successful mathematics learning as the ability to reason mathematically, formulate and interpret problems, and use mathematics to make well-founded judgments in life-related situations. The OECD PISA 2022 framework explicitly treats mathematical literacy as active engagement with mathematics in real-world contexts and links it to constructive, engaged, and reflective citizenship. This position is important because it shifts

the focus of mathematics teaching from formal manipulation alone to purposeful application, interpretation, and decision-making. When mathematics is taught only as a closed symbolic system, students may learn to execute procedures without understanding when, why, or whether those procedures are appropriate. By contrast, contextualized mathematics invites learners to compare assumptions, evaluate evidence, interpret quantitative information, and connect solutions to reality, all of which are central features of critical thinking [1].

This shift also corresponds to current research on critical mathematical thinking. Recent scholarship notes

that critical thinking in mathematics has long been encouraged in policy discourse, yet it has often remained under-theorized in classroom practice. Monteleone, Miller, and Warren argue that the blending of mathematical thinking and critical thinking requires a more explicit conceptual framework, one that helps teachers recognize such processes as explaining, evaluating, reasoning, and interpreting within mathematical activity. Their work is especially important because it shows that critical mathematical thinking is not an external addition to mathematics but an intrinsic mode of engaging with mathematical ideas. In the school setting, this means that students should not merely reach answers but also explain their reasoning, examine alternatives, question assumptions, and consider the validity of conclusions in relation to a given situation [2].

Real-life contexts are especially productive for this purpose because they naturally generate uncertainty, relevance, and the need for judgment. Unlike decontextualized exercises, meaningful contexts require students to decide what information matters, how quantities are related, what assumptions are reasonable, and how a mathematical result should be interpreted. However, the value of context depends on its pedagogical use. Research on authentic and realistic tasks shows that contextual problems are effective not when they merely imitate reality superficially, but when they motivate mathematical inquiry and reveal how mathematics helps make sense of the world. Clarke and Roche show that contextualized tasks have strong potential to challenge and engage students, yet they also emphasize that teachers must maintain a clear mathematical focus and deliberately consolidate learning at the end of the lesson. Sawatzki likewise demonstrates that real-life contexts offer considerable strengths for numeracy-oriented learning while also presenting difficulties and complexities that require careful task design and teacher mediation [3; 4].

For this reason, the integration of real-life contexts into mathematics education should not be treated as a motivational technique alone. It should be viewed as a methodological strategy for cultivating mathematical literacy, reflective reasoning, and critical judgment. The purpose of this article is therefore to substantiate a pedagogical approach to integrating real-life contexts into mathematics education to support critical thinking.

The article addresses the following problem in a unified way: how to design and use contextual tasks so that students do not simply solve applied problems, but engage in deeper critical analysis through mathematization, interpretation, and evaluation [1; 5].

The study is theoretical and methodological in character. Its main methods are analysis, comparison, synthesis, and pedagogical modelling. Scientific publications on mathematical literacy, contextual learning, mathematical modelling, authentic tasks, and critical mathematical thinking were examined in order to identify the conceptual foundations of a context-based approach to mathematics teaching. Particular attention was given to studies that illuminate the relationship between real-world problem situations and the development of reasoning, evaluation, and reflective judgment. In addition, methodological positions from mathematics education organizations and international assessment frameworks were used to clarify the role of context in modern mathematics teaching [1; 5].

The logic of the analysis proceeded from three assumptions. First, critical thinking in mathematics develops most effectively when students must work with situations that are not fully pre-structured for them and therefore require interpretation. Second, real-life contexts contribute to learning only when the context is mathematically productive and not merely decorative. Third, the educational value of contextual tasks depends on the teacher's ability to organize a complete learning cycle that includes problem formulation, mathematical representation, solution, interpretation, discussion, and evaluation. On this basis, a pedagogical model was constructed that connects authentic contexts with the development of critical thinking through mathematically focused classroom activity [3; 4; 6].

The analysis makes it possible to argue that the integration of real-life contexts into mathematics education supports critical thinking through several interrelated mechanisms. The first mechanism is the activation of meaningful problem interpretation. In ordinary textbook exercises, the structure of the problem is often already determined, and students mainly identify the correct operation or formula. In contrast, real-life tasks require students to determine what the problem actually is. They must distinguish

relevant from irrelevant information, clarify the conditions of the situation, and identify the mathematical relationships embedded in it. This interpretive stage already involves critical work because students must examine the situation rather than simply apply a memorized procedure. The OECD framework is especially clear that the choice of mathematical strategies and representations is dependent on context and that real-world tasks require the use of contextual knowledge in building mathematical models. It also notes that real-world contexts frequently involve substantial textual information, making comprehension and interpretation fundamental prerequisites for success in mathematical literacy [1].

The second mechanism is mathematization. When students transform a concrete situation into a mathematical structure, they engage in one of the most intellectually demanding phases of mathematical activity. This phase requires abstraction without losing contact with meaning. Research on modelling competencies shows that mathematical modelling has become a central construct in mathematics education and that a wide variety of sub-competencies are involved in fostering it, including interpreting situations, selecting representations, and coordinating solution strategies. The literature review by Cevikbas, Kaiser, and Schukajlow demonstrates both the richness of approaches to modelling and the importance of structured training strategies for developing modelling competencies across educational levels. From the standpoint of critical thinking, mathematization is crucial because it requires students to justify why a given variable, representation, or assumption is appropriate and to understand that alternative models may also be possible [5].

The third mechanism is evaluative interpretation of results. In many school settings, once a numerical answer is obtained, the task is considered complete. Yet context-based mathematics changes the meaning of completion. A solution must be interpreted back into the situation, checked for plausibility, and evaluated in relation to its assumptions and consequences. It is at this stage that critical thinking becomes most visible. Students ask whether the answer is realistic, whether important factors were omitted, whether the model oversimplified reality, and whether a different conclusion might emerge under changed conditions.

Hattori and colleagues, writing about critical thinking in mathematics through socially open-ended problems, emphasize that critical mathematical work in real-world settings involves not only analysis but also effective and ethical decision-making. Their study shows that students' critical thinking can be fostered through tasks in which mathematical reasoning is tied to discussion of fairness, acceptability, and the viewpoints of others. This broadens the meaning of mathematical competence from technical success to responsible judgment [6].

The fourth mechanism is dialogic justification. Real-life contexts tend to generate multiple approaches, which creates productive space for comparison, argumentation, and critique. In such environments, students are more likely to explain why they chose a representation, defend the validity of their assumptions, and compare the strengths and limitations of different solution paths. NCTM's teaching guidance stresses that effective mathematics instruction should engage students in tasks that promote reasoning and problem solving and that allow multiple entry points and representations. This principle is especially important when working with contextual tasks because classroom discussion becomes the means through which students convert experience into generalizable mathematical understanding. Context alone does not guarantee criticality; the teacher must use purposeful questioning and mathematical discourse to ensure that learners reflect on evidence, structure arguments, and connect their ideas to core concepts [7].

Based on the sources examined, a pedagogical model can be proposed for integrating real-life contexts into mathematics education to support critical thinking. The model begins with the selection of a context that is authentic enough to be meaningful yet focused enough to illuminate a target mathematical idea. Examples may include budgeting, transport costs, energy consumption, mobile data plans, environmental measurements, local business data, or media graphs. The next stage is problem framing, during which students discuss the situation, identify the question, and clarify what needs to be known. Then follows mathematization, when students introduce variables, create tables, diagrams, equations, or graphs, and choose tools appropriate to the context. After solving

the mathematical problem, students return to the original situation and interpret the meaning of the result. Finally, they evaluate their own reasoning, compare it with alternative approaches, and discuss the adequacy and limitations of their conclusions. This final evaluative loop is essential because it transforms contextual problem solving into critical mathematical thinking rather than routine application [2; 5; 6].

The results of the theoretical synthesis also show that contextual learning supports critical thinking only under several pedagogical conditions. The first is conceptual clarity. Teachers must know exactly what mathematical idea a contextual task is intended to reveal. Clarke and Roche warn that rich tasks can lose their educational value when the lesson is not brought together around a clear mathematical focus. The second condition is contextual relevance. If students do not perceive the situation as meaningful, the task becomes another artificial word problem. The third condition is openness combined with structure. Tasks must allow inquiry, but they also need boundaries that keep the mathematical investigation coherent. The fourth condition is reflective closure. Students need time to discuss what assumptions they made, why their method worked, and where the model may fail. Without this reflective phase, context may increase engagement but not necessarily critical thought [3; 4].

The findings of this theoretical study suggest that real-life contexts can serve as a powerful medium for developing critical thinking in mathematics, but only when they are treated as epistemic environments rather than motivational wrappers. This distinction is fundamental. In weak versions of contextual teaching, a practical story is added to a conventional exercise without changing the cognitive demand of the task. Students still perform a predetermined procedure, and the context plays no real role in reasoning. In stronger versions, by contrast, the context changes what students must do intellectually: they interpret, select, justify, evaluate, and revise. Such tasks align with broader understandings of mathematical literacy, where mathematics is used to describe, explain, and predict phenomena and to support judgment in the world [1; 8].

This interpretation is strengthened by research on mathematical literacy and contextual problem solving. Manfreda Kolar and Hodnik argue that mathematical

literacy is inseparable from the competent response of an individual to the world and that contextual problems may support the interplay between mathematical knowledge and mathematical literacy. Their discussion is particularly useful because it shows that contextual tasks are not simply applications after “real learning” has occurred. They are one of the spaces in which new mathematical knowledge can itself be constructed. In the same way, studies of real-life financial dilemmas and practical classroom tasks indicate that authentic contexts can deepen engagement and reveal new forms of understanding, but only when the teacher deliberately supports transitions between context, representation, and abstraction [4; 8].

An additional argument for contextualized mathematics comes from research linking mathematical thinking and critical thinking. Er’s 2024 study found a significant moderate relationship between students’ mathematical thinking and critical thinking and concluded that increases in critical thinking are associated with increases in mathematical thinking. Although this does not prove that contextual tasks alone cause such improvement, it does support the broader claim that mathematics education should cultivate more than procedural fluency. If mathematical thinking and critical thinking are related, then classroom designs that require evidence-based reasoning, interpretation, and evaluation are likely to contribute to both. Real-life contexts are especially suitable for this because they oblige learners to move back and forth between mathematical structure and lived reality [9].

At the same time, the study reveals important limitations and cautions. Contextual tasks can fail when the reading load becomes excessive, when the social situation is unfamiliar, or when teachers do not help students distinguish mathematically essential features from distracting details. The OECD framework itself notes that text comprehension is a prerequisite for success in mathematical literacy tasks, which means that contextual teaching must be sensitive to language demands. Moreover, not every real-life situation is equally educative. Some are interesting but mathematically weak; others are mathematically rich but socially remote. Therefore, the integration of real-life contexts into mathematics teaching should be systematic, selective, and pedagogically justified. Its aim is not to replace formal mathematics, but to create

reciprocal movement between formalization and reality so that students learn to think mathematically and critically at the same time [1; 3].

Integrating real-life contexts into mathematics education is a productive strategy for supporting critical thinking because it places students in situations that require interpretation, mathematization, justification, and evaluation. Context-rich mathematics helps learners understand that mathematical knowledge is not isolated from life, but is a means of making sense of evidence, relationships, and decisions in the world around them. The theoretical analysis conducted in this article shows that the educational effect of context depends on thoughtful task design, clear mathematical goals, purposeful teacher guidance, and reflective discussion after solution. When these conditions are met, real-life contexts strengthen mathematical literacy and provide a natural setting for critical mathematical thinking. For this reason, context-based mathematics teaching should be treated not as an optional supplement, but as an essential direction for improving the intellectual and civic quality of mathematics education.

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