Implementing mathematical literacy across contexts: A comparative analysis of Indonesia, South Africa, and China

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Mathematical literacy has emerged globally as an educational goal, yet its implementation varies widely, shaped by differing curriculum structures, assessment regimes, and underlying cultural perceptions. This paper presents a comparative analysis of how mathematical literacy is conceptualised and enacted in three contrasting education systems: Indonesia, South Africa, and China. Drawing on a qualitative synthesis of curriculum policy documents, assessment frameworks, and research literature, the analysis focuses on three dimensions of implementation: the role of assessment in shaping classroom practice, the positioning of mathematical literacy in relation to disciplinary mathematics, and the implications for teachers' pedagogical practices and professional identity. The paper argues that mathematical literacy cannot be understood as a uniform construct; rather, it represents a family of practices shaped by local educational priorities and reform trajectories, with implications for curriculum design, teacher education, and comparative mathematics education research.

Keywords: mathematical literacy; comparative education; curriculum reform; teacher identity

Introduction

Definitions of mathematical literacy vary across contexts because they encode different assumptions about the purposes of mathematics education and the kinds of citizens, workers or learners it seeks to form. The Organisation for Economic Co-operation and Development's Programme for International Student Assessment (PISA) has provided the most influential global definition, defining mathematical literacy as an individual's capacity to reason mathematically and to formulate, apply, and interpret mathematics to solve problems in a variety of real-world contexts (OECD, 2023). Yet this definition, for all its institutional reach, does not settle the deeper question. Jablonka (2003) maps the conceptual terrain as a continuum from basic computational competence for everyday survival, through economic participation and problem-solving, to the critical interrogation of how mathematical models shape social reality. These positions are not simply different emphases; they encode different answers to the question of what mathematics education is ultimately for.

This paper takes that conceptual plurality seriously by examining how mathematical literacy has been institutionalised in three education systems that represent genuinely distinct approaches: Indonesia, where PISA's framework has been formally adopted but classroom practice remains largely procedural; South Africa, where mathematical literacy exists as a stand-alone secondary school subject shaped by post-apartheid equity commitments; and China, where mathematical literacy is embedded within a disciplinary formation tradition that has produced exceptional PISA results through means the PISA framework itself does not fully account for. Together, these three cases illuminate the trade-offs inherent in different implementation models and support a broader argument: that mathematical literacy is best understood not as a single construct but as a family of practices, each with its own logic, each serving different constituencies, and each carrying its own risks.

Analytical framework

The comparative framework used in this paper draws on two complementary theoretical orientations. The first is Jablonka's (2003) analysis of mathematical literacy as a contested concept, which makes visible the different political and educational projects that different definitions serve. The second is the distinction, developed in the Chinese curriculum literature, between mathematical literacy defined 'outward' - in terms of what a person can do with mathematics in the world, and 'inward' - in terms of what mathematics does to the person's thinking and intellectual character (Shi, 2017). This outward-inward axis proves analytically productive across all three cases because it reveals that the differences among them are not merely technical but philosophical: they reflect different conceptions of the human being that mathematics education seeks to cultivate.

Three analytical dimensions: assessment, curriculum positioning, and teacher identity, serve as the sites where these philosophical commitments become concrete. Together they capture where the differences between the three systems are sharpest: in what examinations reward, in how each system resolves the tension between applied competence and disciplinary rigour, and in how teachers are prepared (or not) to enact what their curriculum demands.

Three models of implementation

Indonesia: Policy adoption and the contextualisation gap

Indonesia's engagement with mathematical literacy is largely framed by PISA, in which it has participated since 2000. The results have been persistently discouraging: in PISA 2022, only 18% of Indonesian 15-year-olds reached Level 2 proficiency in mathematics, against an OECD average of 69% (OECD, 2023). Research consistently identifies the 'formulate' stage of the modelling cycle: the construction of a mathematical representation of a real-world situation, as the point at which Indonesian students most commonly break down (Kappassova et al., 2025; Jupri et al., cited in Oktiningrum et al., 2016), pointing to difficulty in contextualising mathematics rather than primarily computational weakness.

Indonesia's national curriculum formally recognises mathematical literacy goals that align with PISA's framework, including contextual problem-solving, reasoning, and communication. However, classroom practice has remained dominated by procedural teaching in which real-world contexts, when they appear at all, function as decorative framing rather than genuine sites of mathematical reasoning (Widjaja, 2011). The Pendidikan Matematika Realistik Indonesia (PMRI) movement, drawing on Realistic Mathematics Education principles developed in the Netherlands, sought to address this gap by repositioning real-world contexts, particularly those drawn from Indonesian cultural and natural heritage, as the starting point of mathematical learning rather than its optional application (Widjaja, Dolk, & Fauzan, 2010). However, PMRI has remained a reform movement rather than a system-wide transformation.

The deeper structural problem is that Indonesia's high-stakes national examinations do not consistently reward contextual reasoning, creating a familiar but particularly acute policy-practice gap: the official curriculum endorses literacy goals that the assessment system does not reliably operationalise, leaving teachers without clear pedagogical guidance and students without sustained opportunity to develop the capacities that PISA measures.

South Africa: structural separation and the limits of equity reform

South Africa's approach to mathematical literacy is structurally distinct from those of Indonesia and China: since 2006, Mathematical Literacy has been a distinct, compulsory school subject for students in Grades 10–12 who do not take Mathematics. The rationale was explicitly political: during the apartheid era and into the early post-apartheid period, between 2000 and 2005, as many as 40% of students took no mathematics at all (Goos & O'Sullivan, 2023). The Curriculum and Assessment Policy Statement for Mathematical Literacy (Department of Basic Education, 2011) defined the subject in terms consistent with PISA's, aiming to develop critical citizenship through engagement with authentic real-life problems.

The structural separation of Mathematical Literacy from Mathematics has produced a persistent tension between these equity goals and the subject's curriculum status. Because Mathematical Literacy cannot be used to access university programmes requiring mathematics, it is widely perceived by students, parents, and even teachers as a weaker alternative: mathematics for those who could not manage the real subject. A subject designed to provide democratic access to mathematical engagement has, in practice, often functioned as a ceiling rather than a floor, confirming rather than disrupting patterns of educational stratification.

The assessment structure compounds this problem. Bali, Julie, and Mbekwa (2020) analysed five consecutive nationally set examinations in Mathematical Literacy and found that 86.25% of marks were awarded to mathematical calculations, with zero marks allocated to problem formulation or model validation across all five papers. The modelling competencies most central to the subject's stated rationale, constructing a mathematical representation of a messy real-world situation and evaluating whether a model is adequate, did not appear in the marking schemes at all. For Bali et al. (2020), this directly contradicts the intended curriculum's goal of developing critical citizenship.

For teachers, this creates a profound professional identity problem. Teachers of Mathematical Literacy are often former mathematics teachers whose professional training and self-understanding were built around disciplinary content mastery. The subject demands a different orientation: facilitating contextual reasoning, drawing on knowledge from finance, measurement, data, and social affairs, and supporting students in making connections across domains rather than mastering a defined syllabus. Pillay and Bansilal (2025) found considerable variation in how South African Mathematical Literacy teachers navigated these demands in practice, with some developing rich contextual pedagogies and others defaulting to procedural approaches that undermined the subject's stated purposes. The absence of sustained professional development specifically oriented towards contextual pedagogy means that whether students receive the subject as intended depends largely on the individual teacher.

China: inward formation and the PISA paradox

China's position in comparative mathematical literacy debates is complicated by a fundamental paradox: its education system is organised around a conception of mathematical literacy that is philosophically distinct from PISA's, yet Chinese students consistently rank among the highest-performing PISA students in mathematics.

The 2017 General Senior Secondary Mathematics Curriculum Standards codify six core mathematical competencies: mathematical abstraction, logical reasoning, mathematical modelling, intuitive imagination, mathematical operations, and data analysis, organised under the Three Mathematical Abilities framework (三会, sān huì): seeing the real world through a mathematical lens (数学眼光), thinking about it with mathematical reasoning (数学思维), and expressing it in mathematical language (数学语言) (Ministry of Education, 2017; Shi, 2017). These competencies define mathematical literacy inwardly: what mathematics does to the mind and intellectual character of the person, cultivated progressively through well-designed problems and reflective engagement, rather than through direct instruction or primarily through contextual immersion.

The paradox arises because China's disciplinary formation approach produces exceptional PISA results despite not being designed around PISA's outward-facing model. Xu et al. (2021) argue that this performance is partly explicable through the deep internalisation of the Four Basics, which builds mathematical formation that transfers into contextual reasoning without that contextual reasoning being directly taught. Leung (2021) sharpens the point: the Chinese term 核心素养 does not translate straightforwardly as 'competencies' or 'literacy' in the PISA sense, because PISA literacy implies adequacy for a purpose, while 素养 implies internal cultivation of something desirable beyond the merely functional. These are not different routes to the same destination; they are different conceptions of what mathematics education is ultimately building in a person.

Yet China's system is not without its own structural tensions. The university entrance examination exerts enormous pressure on classroom practice, and research suggests that this pressure selectively suppresses the reflective, creative, and critical dimensions of mathematical literacy even within a system that produces exceptional aggregate results. Huang (2021) found that mathematics anxiety among Chinese students is negatively associated with mathematical modelling performance, and that this relationship is stronger for complex and open tasks than for routine computation. These are precisely the tasks closest to genuine mathematical literacy. Lü and Wu (2017) place mathematical spirit (数学精神), including rigour, truth seeking and intellectual creativity, at the highest level of their four-level competency hierarchy. Without this dimension, the framework risks becoming a form of sophisticated skills training, detached from the values that give mathematics its formative power. Whether classroom practice reaches this level is a different question from whether the curriculum aspires to it.

Comparative discussion

Placing these three cases alongside each other makes visible a cross-cutting pattern: all three systems demonstrate, in different ways, the tendency for examination regimes to narrow richer literacy goals toward what can be reliably scored. In South Africa, the process is most visible, with the examination framework explicitly contradicting the curriculum's stated modelling goals. In Indonesia, it operates through misalignment, as an assessment system that does not reward contextual reasoning, ensuring that the adopted PISA framework has no traction in classrooms. In China, it is most subtle, selectively suppressing the critical and creative dimensions of the competency framework that are hardest to assess and least reliably rewarded. On curriculum positioning, the three systems represent genuinely different resolutions of the tension between literacy and disciplinary mathematics: structural separation in South Africa, integration without transformation in Indonesia, and disciplinary formation as the generative condition for contextual performance in China, each carrying its own risks of status, coherence, and aspirational gap.

For teachers, the implications differ across contexts but converge on a common problem: implementing mathematical literacy, as each system defines it, requires different professional capacities from those required for teaching disciplinary mathematics, and none of the three systems has yet developed teacher education at the scale and specificity this difference demands. What all three share is a gap between the professional formation that pre-service training currently provides and the demands of genuine mathematical literacy pedagogy.

Conclusions

Mathematical literacy is not a uniform educational construct but a family of practices shaped by distinct political histories, philosophical commitments, and institutional structures. Comparative research that treats national models as more or less successful approximations of a single ideal will always misread what it is looking at. The three cases examined here illustrate this irreducible plurality: South Africa's model encodes a commitment to democratic access and critical citizenship that its assessment system has not yet learned to honour; Indonesia's model encodes a commitment to PISA alignment that its classroom practice has not yet learned to enact; China's model encodes a commitment to deep disciplinary formation whose critical and creative dimensions remain vulnerable to examination pressure. A comparative framework adequate to these differences must orient improvement towards each system's own internal logic: for South Africa, aligning what examinations reward with what the curriculum demands; for Indonesia, developing contextual pedagogies rooted in local cultural experience; for China, protecting the reflective dimensions of the competency framework from narrowing. All three systems also face a shared imperative to invest in teacher education specifically oriented to the pedagogical demands of mathematical literacy, as each context defines them.

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