

Strengthening Numeracy in Indonesia: A Policy Analysis and Integrative Review of Culturally Responsive Pedagogy

¹Rully Charitas Indra Prahmana, ²Samsul Ma'arif, ³Puri Pramudiani

¹Universitas Ahmad Dahlan, Indonesia

¹Western Michigan University, United States

^{2,3}Universitas Muhammadiyah Prof. DR. HAMKA, Indonesia

CORRESPONDING AUTHOR'S EMAIL

rully.indra@mpmat.uad.ac.id

MANUSCRIPT HISTORY

Submitted: 27/11/2025

final revision: 10/07/2026

accepted: 13/07/2026

ABSTRACT

This study examines the foundations, policy design, implementation strategies, and culturally responsive pedagogical orientation underpinning Indonesia's National Numeracy Movement. A qualitative policy analysis integrated with an integrative literature review was conducted by synthesizing government policy documents, studies, and reports published between 2020 and 2025. Data were analyzed using document, content, and thematic analyses. The findings indicate that Indonesia's numeracy reform is supported by a coherent policy framework grounded in the Deep Learning approach, which emphasizes meaningful learning, contextualized instruction, educational equity, and higher-order thinking. The evidence further suggests that culturally responsive approaches—including the GEMBIRA learning model, Ethno-Realistic Mathematics Education, adaptive cooperative learning, digital technologies, and mother tongue-based instruction—enhance learner engagement and conceptual understanding. However, the empirical evidence remains fragmented and highly context specific. The study's novelty lies in proposing an integrated conceptual framework that links policy design, implementation strategies, and culturally responsive pedagogy to explain how systemic coherence can strengthen numeracy reform. The findings underscore that sustainable improvement in numeracy requires alignment among policy, pedagogy, teacher capacity, infrastructure, and assessment systems. Policy recommendations include conducting large-scale longitudinal evaluations and sustaining investments in teacher professional development, assessment reform, and culturally responsive implementation to promote equitable and scalable numeracy outcomes.

KEYWORDS

culturally responsive pedagogy; deep learning approach; ethno-realistic mathematics education; GEMBIRA learning model; national numeracy movement

Introduction

Improving numeracy has become a global education priority because it equips individuals with the ability to interpret quantitative information, make informed decisions, and participate effectively in increasingly complex societies (Sakurai & Goos, 2023). Beyond supporting mathematical achievement, numeracy is widely recognized as a foundational competency for lifelong learning, workforce readiness, civic participation, and sustainable development (Grotlüschen et al., 2020). Nevertheless, learning outcomes remain a global concern. Approximately 70% of children in low- and middle-income countries experience learning poverty, meaning they do not attain minimum proficiency in reading and numeracy by the age of ten (Laksana et al., 2025). The COVID-19 pandemic further exacerbated these challenges by widening educational inequalities and

slowing progress toward Sustainable Development Goal 4 (Marfuah et al., 2022). Consistent with this trend, the Programme for International Student Assessment (PISA) 2022 reported substantial declines in mathematics performance across many education systems, underscoring the need for coherent, evidence-informed, and contextually responsive educational reforms rather than isolated curriculum improvements (OECD, 2023).

Indonesia provides an important context for examining contemporary numeracy reform because it faces the dual challenge of improving mathematics achievement while addressing extensive cultural, linguistic, and geographical diversity. Indonesian students have consistently performed below the OECD average in international assessments, prompting the government to prioritize numeracy as part of broader educational transformation initiatives (OECD, 2023). Recent reforms, including the National Numeracy Movement (*Gerakan Numerasi Nasional* [GNN]) and the Deep Learning approach formalized through Ministerial Regulation No. 13/2025, emphasize meaningful, contextualized, and student-centered learning that connects mathematical concepts with students' everyday experiences (Salman, 2025; Feriyanto & Anjariyah, 2024; Pusat Kurikulum dan Pembelajaran, 2025). These reforms also recognize Indonesia's cultural diversity as a pedagogical asset by promoting culturally responsive teaching (Musslifah et al., 2025), digital innovation (Isnaeni et al., 2025), formative assessment, and collaborative professional learning to support equitable numeracy development across diverse educational settings (Nafi'ah & Faruq, 2025).

Despite the growing body of research on numeracy education, important conceptual gaps remain in understanding how national numeracy reform can be translated into coherent educational practice. Previous studies have examined numeracy interventions (Graven & Jorgensen, 2024), curriculum reform (Badmus et al., 2026), culturally responsive pedagogy (Gay, 2018), ethnomathematics (D'Ambrosio, 1985), and culturally grounded mathematics learning (Prahmana, 2022). However, these strands of research have largely evolved independently, offering limited insight into how policy design, implementation strategies, and culturally responsive pedagogy interact within a comprehensive reform agenda. This limitation is particularly evident in multilingual and multicultural contexts such as Indonesia, where successful implementation depends not only on curriculum reform but also on teachers' capacity to contextualize learning through students' cultural identities and lived experiences. Consequently, an integrative perspective is needed to explain how policy aspirations, pedagogical principles, and implementation strategies can collectively support sustainable numeracy reform.

To address this gap, the Indonesian government introduced the GNN, which adopts the GEMBIRA learning model as an operational framework for translating policy into classroom practice through culturally responsive pedagogy (Widdiharto et al., 2025). Building on this policy context, the present study employs an integrated policy analysis and integrative literature review to examine the conceptual foundations, implementation strategies, and pedagogical orientation of Indonesia's numeracy reform. By synthesizing government policy documents, empirical evidence, and relevant theoretical perspectives, the study develops an integrated conceptual framework explaining how policy design, implementation strategies, and culturally responsive pedagogy collectively strengthen numeracy learning. The findings are expected to contribute to the international discourse on numeracy reform while providing evidence-informed recommendations for policymakers and educators in Indonesia and other culturally diverse education systems.

Literature Review

This literature review synthesizes the theoretical perspectives underpinning GNN, focusing on numeracy, culturally responsive pedagogy, ethnomathematics, Ethno-Realistic Mathematics Education (Ethno-RME), and GEMBIRA learning model. Collectively, these perspectives provide the conceptual foundation for examining how policy design, implementation strategies, and culturally responsive pedagogical practices can strengthen equitable and sustainable numeracy reform.

Numeracy as a Foundation for Educational Reform

Numeracy has evolved beyond the ability to perform arithmetic into a multidimensional competence encompassing mathematical reasoning, problem-solving, data interpretation, and evidence-based decision-making in everyday life. Contemporary perspectives recognize numeracy as an essential capability for lifelong learning, active citizenship, and participation in an increasingly complex society, rather than merely a component of school mathematics (Geiger et al., 2015; Geiger & Schmid, 2024). Consequently, many education systems have repositioned numeracy as a strategic policy priority linked to educational equity, workforce readiness, and sustainable development.

Within this perspective, the GNN adopts a broader conception of numeracy that aligns with the Deep Learning approach, emphasizing meaningful learning, conceptual understanding, authentic problem-solving, and the application of mathematical knowledge across diverse contexts (Pusat Standar dan Kebijakan Pendidikan, 2025; Salman, 2025; Pusat Kurikulum dan Pembelajaran, 2025). This expanded conception provides the foundation for Indonesia's numeracy reform, recognizing that improvements in learning outcomes depend not only on curriculum change but also on pedagogical approaches that enable students to connect mathematical concepts with their everyday experiences and sociocultural contexts.

Culturally Responsive Pedagogy for Meaningful Mathematics Learning

Meaningful numeracy learning requires pedagogical approaches that recognize students' cultural, linguistic, and experiential backgrounds as valuable resources rather than barriers to achievement. Culturally responsive pedagogy emphasizes that learning becomes more effective when mathematical concepts are connected to learners' identities, everyday experiences, and community practices, thereby promoting engagement, conceptual understanding, and educational equity (Gay, 2018; Ladson-Billings, 1995). Within mathematics education, this perspective extends beyond the use of contextual examples by recognizing students' cultural knowledge as a legitimate resource for mathematical reasoning and conceptual development.

This approach is particularly relevant in multilingual and multicultural settings, where culturally grounded instruction and mother tongue-based education have been shown to reduce cognitive barriers while strengthening students' mathematical identities and conceptual understanding (Graven & Jorgensen, 2024; Laksana et al., 2025). In Indonesia, these principles provide an important pedagogical foundation for the GNN, which positions cultural diversity as a strategic educational asset for promoting equitable numeracy learning across diverse regional and sociocultural contexts.

Ethnomathematics and Ethno-Realistic Mathematics Education

Ethnomathematics recognizes that mathematical knowledge is embedded in the cultural practices, languages, occupations, and everyday activities of communities, challenging the assumption that mathematics is culturally neutral (Bishop, 1988; D'Ambrosio, 1985). Building on this perspective, Realistic Mathematics Education (RME) emphasizes learning through meaningful contexts that enable students to progressively construct formal mathematical understanding from authentic experiences (Juandi et al., 2022; Prahmana et al., 2020). Integrating these perspectives has led to the development of Ethno-RME, which positions local cultural practices not merely as contextual illustrations but as authentic starting points for mathematical inquiry and conceptual development (Prahmana, 2022).

Within the Indonesian context, Ethno-RME provides a coherent theoretical foundation for connecting indigenous mathematical knowledge with formal school mathematics, enabling students to develop numeracy through culturally meaningful learning experiences (Nursyahidah et al., 2025; Prahmana et al., 2026; Shahidayanti et al., 2024). By positioning culture as a source of mathematical meaning rather than supplementary instructional content, Ethno-RME supports equitable, meaningful, and contextually relevant numeracy learning across Indonesia's culturally and linguistically diverse communities.

GEMBIRA as the Operational Framework for Indonesia's National Numeracy Movement

Successful implementation of the GNN requires an operational framework capable of translating policy objectives into meaningful classroom practices. In Indonesia, this role is fulfilled by the GEMBIRA learning model, which integrates the principles of the Deep Learning approach, culturally responsive pedagogy, and Ethno-RME into a coherent framework for numeracy instruction (Widdiharto et al., 2025). Rather than treating culture as supplementary instructional material, GEMBIRA positions students' cultural experiences, local knowledge, and everyday mathematical practices as the foundation for developing conceptual understanding and mathematical reasoning. This orientation reflects the premise that equitable improvement in numeracy depends not only on curriculum reform but also on pedagogical approaches that recognize learners' cultural identities and contextual realities. Consequently, GEMBIRA functions as an operational bridge between national policy objectives and classroom implementation by enabling teachers to deliver culturally meaningful, contextually relevant, and conceptually rich numeracy learning across Indonesia's diverse educational settings.

The GEMBIRA framework consists of five instructional stages: *Gali dan Eksplorasi konteks yang dekat dengan murid* (Explore contexts close to students), *Muat konten numerasi hasil eksplorasi* (Embed numeracy content from exploration), *Buat aktivitas yang bermakna* (Design meaningful learning activities), *Ikuti pemikiran murid dalam evaluasi* (Follow students' thinking in evaluation), and *Rayakan dan Akhiri pembelajaran dengan menyenangkan* (Celebrate and conclude learning joyfully) (Widdiharto et al., 2025). These stages position culturally responsive numeracy instruction within students' lived experiences and local knowledge, providing an appropriate conceptual framework for examining the policy design, implementation strategies, and pedagogical orientation of Indonesia's GNN.

Research Methods

Research Design

This study employed an integrated policy analysis and qualitative integrative literature review to examine Indonesia's GNN. Guided by Cardno's (2018) policy analysis framework, the study analyzed policy documents to examine the reform's objectives, implementation strategies, and official policy narratives. The literature review adopted a qualitative evidence synthesis informed by thematic analysis within a critical narrative review framework, emphasizing analytical depth and interpretive rigor rather than formal systematic review procedures such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) or meta-analysis (Depraetere et al., 2021). Together, these complementary approaches provide a comprehensive understanding of the GNN's conceptual foundations, implementation strategies, and the role of culturally responsive pedagogies, particularly GEMBIRA learning model and Ethno-RME, in advancing equitable numeracy outcomes (Dixon-Woods et al., 2006).

Data Sources and Collection

Three categories of data sources were systematically compiled to support the integrated policy analysis. *First*, official policy documents issued by the Ministry of Primary and Secondary Education and the Directorate General of Teachers, Education Personnel, and Teacher Education were analyzed to examine the conceptual and institutional foundations of the GNN. These documents included the national policy framework for strengthening numeracy learning, curriculum implementation guidelines, the academic paper on the Deep Learning approach, National Assessment technical reports, and key ministerial regulations, including Director General of Teachers and Education Personnel Regulation (Perdirjen GTK) No. 0340 of 2022 concerning the Framework for Teacher Literacy and Numeracy Competencies and Director General of Teachers, Education Personnel, and Teacher Education Decree (Kepdirjen GTKPG) No. 25/B/HK.03.01/2025 concerning the Technical Guidelines for Mathematics Training for Kindergarten and Primary School Teachers.

Second, peer-reviewed studies indexed in the Scopus database and published between January 2020 and October 2025 were systematically reviewed to identify empirical evidence on numeracy interventions, culturally responsive pedagogy, and education policy implementation in Indonesia.

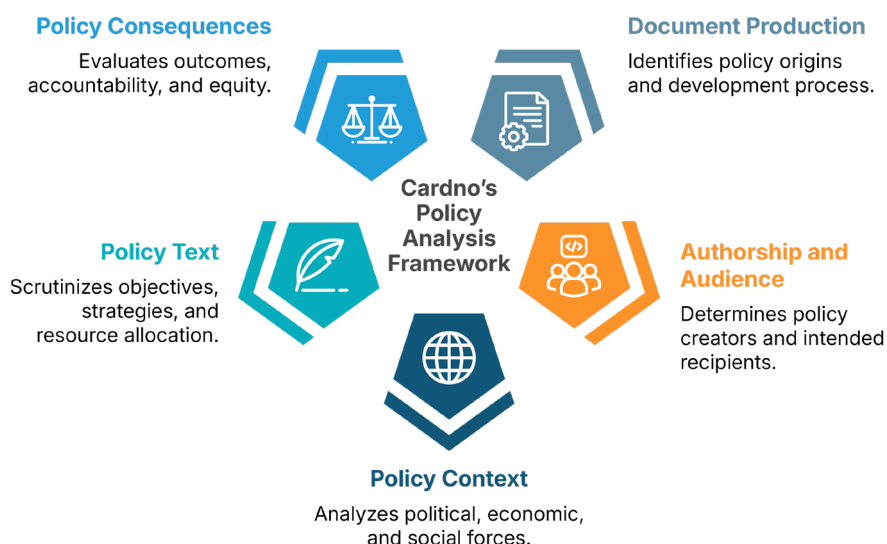
Boolean search strategies combined the keywords “numeracy learning”, “Indonesia”, “culturally responsive”, “foundational skills”, “mathematics education”, “policy implementation”, “adaptive learning”, “ethnomathematics”, and “remedial teaching”. Studies lacking empirical evidence or focusing exclusively on higher education were excluded. To situate Indonesia’s reform within an international context, OECD reports, particularly the PISA 2022 assessment and comparative education analyses, were also included.

Policy Document Analysis Framework

Following Cardno’s (2018) framework (Figure 1), policy documents were analyzed across five dimensions: (1) document production and location; (2) authorship and intended audience; (3) policy context; (4) policy text; and (5) policy consequences. These dimensions were used to examine policy origins, institutional context, policy actors, intended beneficiaries, reform objectives, theoretical foundations, implementation strategies, resource allocation, accountability mechanisms, equity considerations, and intended policy outcomes. This framework enabled a comprehensive analysis of how the GNN conceptualizes numeracy improvement, incorporates culturally responsive pedagogy, and supports implementation across Indonesia’s diverse educational contexts.

Figure 1

Cardno’s Framework for Policy Document Analysis



Source: Adapted from Cardno, 2018

Literature Review Protocol

The literature review followed established procedures for qualitative evidence synthesis. Inclusion criteria comprised empirical studies examining numeracy interventions in Indonesian educational settings, culturally responsive mathematics pedagogy applicable to multicultural contexts, policy implementation related to foundational skills reforms in developing countries, peer-reviewed journal articles or reputable institutional reports, and publications in English or Indonesian. Exclusion criteria included theoretical papers lacking empirical evidence, studies focusing exclusively on higher education, and publications issued before 2020 unless they provided essential theoretical foundations.

Data Analysis

Policy documents were analyzed using content analysis to identify core policy principles, implementation strategies, theoretical foundations, and accountability mechanisms. The academic literature was synthesized through thematic analysis, with studies categorized according to intervention strategies, including adaptive cooperative learning, cultural integration, digital technologies, differentiated remedial instruction, and mother tongue-based instruction. Findings

were triangulated across government documents, empirical studies, and implementation reports to identify areas of convergence, divergence, and evidence gaps between policy intentions and documented implementation. Particular attention was given to the ways in which culturally responsive pedagogy, operationalized through the GEMBIRA learning model and Ethno-RME, is reflected in both policy design and educational practice.

Limitations

This study relied primarily on official policy documents and published academic literature. Consequently, unpublished implementation experiences and classroom-level practices may not be fully represented. In addition, language limitations restricted the inclusion of some provincial reports published only in Indonesian. The timeframe (2020–2025) captures early stages of implementation, whereas longer-term sustainability and scaling outcomes require future investigation. Despite these limitations, the triangulation across multiple data sources and systematic analytical procedures strengthens the credibility and transferability of the findings to other developing countries pursuing culturally grounded numeracy reforms.

Research Findings

The study synthesizes evidence from government policy documents, peer-reviewed empirical studies, and implementation reports to examine Indonesia's efforts to strengthen numeracy. The findings reveal a theoretically coherent policy framework and evidence-informed implementation strategies alongside persistent implementation challenges. The results are organized into five thematic areas: (1) policy framework conceptualization within the Deep Learning approach; (2) evidence-based pedagogical strategies; (3) culturally responsive pedagogy through GEMBIRA and Ethno-RME; (4) implementation challenges, and (5) an integrative synthesis. Collectively, these themes illustrate how national policy is translated into educational practice by triangulating evidence from multiple data sources.

Policy Framework Conceptualization: GNN within Education Reform

GNN, introduced in August 2025, represents a strategic education policy initiative within Indonesia's broader education reform (OECD, 2024; Pusat Standar dan Kebijakan Pendidikan, 2025; Pusat Kurikulum dan Pembelajaran, 2025). Government policy documents identify numeracy as a key driver of educational quality and emphasize the development of critical thinking, problem-solving, and twenty-first-century competencies (Pusat Kurikulum dan Pembelajaran, 2025). The policy framework is organized around three interconnected pillars that integrate learning outcomes, pedagogical approaches, and implementation mechanisms (Cardno, 2018).

First, the policy establishes ambitious national targets aligned with the 2025–2029 National Medium-Term Development Plan, including improving Indonesia's PISA mathematics performance and increasing the proportion of students achieving minimum competency from 18% to at least 50% (OECD, 2023; Pusat Standar dan Kebijakan Pendidikan, 2025). *Second*, the GNN operationalizes the Deep Learning approach by promoting authentic learning, higher-order thinking skills (HOTS), collaborative learning, and digital innovation (Hoogland, 2023; Pusat Kurikulum dan Pembelajaran, 2025). *Third*, the policy incorporates principles of implementation science by encouraging contextualized, multilevel implementation rather than uniform national standardization (OECD, 2024; Zein, 2020). Supporting strategies include professional learning communities (Admiraal et al., 2021), school leadership development (He et al., 2024), community numeracy initiatives (Zhou, 2025), and job-embedded teacher professional development (Özyildirim et al., 2025). Family engagement initiatives further promote positive mathematical dispositions among learners (Balala et al., 2021).

Analysis of PISA 2022 results, which showed that only 18% of Indonesian students attained minimum mathematics proficiency, prompted a policy shift toward equity and capacity building. Comparative evidence from Singapore, Finland, Vietnam, and Indonesia highlights the importance of coherent curricula, high-quality teacher preparation, and contextually appropriate assessment reform (Hosseinpour et al., 2018; Khodabin & Arsalani, 2025; OECD, 2023; Ro, 2021). Consequently, Indonesia's numeracy policy adopts a broader conception of numeracy

encompassing mathematical reasoning, spatial thinking, and data interpretation, thereby moving beyond the procedural emphasis of previous reforms (Geiger et al., 2015; Kurniawati et al., 2018).

Overall, the policy framework is consistent with evidence indicating that sustainable education reform requires coordinated action across classroom, institutional, community, and system levels (Balala et al., 2021; OECD, 2024). By embedding teacher capacity building and professional learning within institutional structures, the GNN provides a sustainable and equity-oriented model for strengthening foundational learning across diverse educational contexts.

Ethnomathematics as a Culturally Responsive Foundation for Numeracy

The reviewed evidence indicates that ethnomathematics provides a strong foundation for culturally responsive numeracy by connecting formal mathematics with students' cultural and linguistic experiences. Payadnya et al. (2025) demonstrated that students effectively used the Balinese base-six counting system (*Wa Pat Nem Tus Dasa*) in marketplace transactions but experienced difficulty transitioning to the base-ten arithmetic used in formal schooling. Similarly, Hendriana et al. (2025) found that the use of Javanese mathematical language facilitated intuitive understanding, although this advantage diminished when instruction relied exclusively on Indonesian. Additional studies indicate that integrating traditional games, indigenous measurement systems, textile patterns, agricultural practices, and marketplace mathematics into instruction enhances student engagement and conceptual understanding (Shahidayanti et al., 2024; Sunzuma & Umbara, 2025).

Studies on Ethno-RME further demonstrate that culturally and contextually grounded instructional modules improve students' critical thinking and conceptual understanding, while digital ethnomathematics resources increase learner engagement (Nurhusain et al., 2025; Shahidayanti et al., 2024). Collectively, these findings highlight an important gap: despite Indonesia's rich mathematical heritage across more than 718 local languages and 1,340 ethnic communities, indigenous mathematical knowledge remains largely absent from standardized curricula. The evidence therefore suggests that culture should be positioned not merely as supplementary instructional content but as a pedagogical foundation for strengthening numeracy, cultural identity, and educational equity.

Evidence-Based Pedagogical Strategies for Numeracy Improvement

Evidence published between 2020 and 2025 indicates that Indonesia's numeracy reform is most effective when implemented through complementary pedagogical strategies that address diverse learner characteristics and educational contexts. Five instructional approaches consistently emerge across the literature: adaptive cooperative learning, culturally integrated instruction, digital technology integration, differentiated remedial instruction, and mother tongue-based multilingual education (Makur et al., 2019; Susilawati et al., 2024). Collectively, these approaches operationalize the objectives of the GNN by promoting equitable participation, conceptual understanding, and contextualized learning. Among these approaches, adaptive cooperative learning demonstrates consistently positive effects on number sense, computation, and mathematical problem-solving by combining collaborative learning with continuous formative assessment tailored to students' readiness levels (Hammadi et al., 2023; Mufidah et al., 2023).

Technology-supported instruction also contributes positively when implemented within sound pedagogical frameworks. WordWall gamification enhances student motivation and mathematical problem-solving (Suhartuti et al., 2025), while Adaptive Digital Books strengthen numeracy literacy through multimedia interaction (Yerizon et al., 2025). Computer-based Minimum Competency Assessments likewise demonstrate effective implementation (Mufidah et al., 2023). However, disparities in digital infrastructure and teachers' Technological Pedagogical Content Knowledge continue to limit equitable implementation. These findings underscore the importance of integrating technology within culturally responsive and realistic mathematics learning contexts (Latip et al., 2023; Nurman et al., 2025; Nursyahidah et al., 2025).

Theoretical Foundations of Culturally Responsive Numeracy

Culturally responsive numeracy within the GNN is theoretically grounded in the complementary traditions of RME, ethnomathematics, and Ethno-RME. Originally developed by Freudenthal,

RME conceptualizes mathematics as a human activity in which learners progressively construct formal mathematical understanding through meaningful, experience-based problems and guided reinvention (Juandi et al., 2022). In Indonesia, RME has consistently improved conceptual understanding while reducing reliance on procedural memorization, particularly in primary mathematics education (Prahmana et al., 2020). Complementing this perspective, ethnomathematics, introduced by D'Ambrosio (1985) and Bishop (1988), recognizes that mathematical thinking is embedded in culturally situated practices, including indigenous counting systems, measurement traditions, commerce, games, and artistic expressions. Rather than viewing cultural diversity as a challenge, ethnomathematics positions it as a valuable pedagogical resource for promoting meaningful and inclusive mathematics learning.

Ethno-RME integrates these two traditions by embedding indigenous mathematical knowledge within the context-based learning trajectory of RME, thereby extending realistic learning contexts to culturally authentic experiences while operationalizing sociocultural learning principles (Prahmana, 2022). Through local practices such as agricultural measurement, marketplace arithmetic, textile patterns, and traditional games, Ethno-RME provides meaningful entry points for developing numeracy, mathematical reasoning, and higher-order thinking. Collectively, these complementary perspectives provide the conceptual foundation of the GNN by positioning culturally meaningful learning as a central mechanism for strengthening equitable, contextualized, and transferable numeracy competencies across Indonesia's culturally and linguistically diverse educational system.

Operationalizing Culturally Responsive Numeracy through GEMBIRA and Ethno-RME

The theoretical principles underpinning the GNN are operationalized through GEMBIRA and Ethno-RME, which together translate culturally responsive pedagogy into classroom practice and teacher professional learning. Developed through collaboration between the Ministry of Primary and Secondary Education and mathematics education researchers, GEMBIRA integrates the principles of RME and ethnomathematics by positioning students' cultural experiences as the starting point for mathematical learning while guiding progressive conceptual abstraction through structured learning pathways (Widdiharto et al., 2025). Its seven interconnected dimensions draw upon established learning theories related to scaffolding, intrinsic motivation, authentic learning, holistic development, creative problem-solving, formative assessment, and differentiated instruction (Gay, 2018; Ladson-Billings, 1995; Potgieter & van der Walt, 2022; Zhan et al., 2024). Importantly, GEMBIRA serves two complementary functions: as a Sustainable Professional Development framework for teachers and as an instructional framework for implementing culturally responsive numeracy.

Complementing GEMBIRA, research on Ethno-RME demonstrates that culturally contextualized instructional modules meet established criteria for validity, practicality, and effectiveness while improving students' critical thinking and learning engagement (Shahidayanti et al., 2024). Recent studies further indicate that integrating digital cultural media strengthens ethnomathematics-based instruction and increases student participation (Nurhusain et al., 2025; Nursyahidah et al., 2025). Nevertheless, significant challenges remain. Although Indonesia's remarkable cultural diversity—represented by more than 718 local languages and 1,340 ethnic communities—offers exceptional opportunities for inclusive mathematics education (Safitri et al., 2024), many instructional practices continue to treat culture primarily as contextual enrichment rather than as an epistemological foundation for mathematical reasoning (Payadnya et al., 2025; Hendriana et al., 2025).

Toward Sustainable and Equitable Implementation of the GNN

Despite its coherent policy design and evidence-informed pedagogical orientation, the implementation of the GNN continues to face systemic challenges that constrain the translation of policy into classroom practice. Triangulated evidence from policy documents and empirical studies consistently identifies teacher capacity as the principal implementation challenge (OECD, 2024; Pusat Standar dan Kebijakan Pendidikan, 2025). Although the curriculum promotes HOTS, classroom instruction and assessment remain predominantly procedural, reflecting teachers'

limited capacity to design authentic numeracy tasks and distinguish between mathematics as a school subject and numeracy as a contextual life competency (Forgasz & Hall, 2019; Zana et al., 2024). These limitations are compounded by insufficient pre-service preparation, fragmented professional development, and teacher competency levels that remain below national expectations (Marfuah et al., 2022; Zana et al., 2024). While online professional development has expanded access to teacher learning, technological constraints and limited classroom application continue to reduce its effectiveness. Persistent disparities in digital infrastructure further limit equitable implementation, particularly in rural and remote areas.

Nevertheless, Indonesia possesses a strong foundation for sustainable numeracy reform. National policy integrates the Deep Learning approach, culturally responsive pedagogy, and implementation science within a coherent framework (Pusat Standar dan Kebijakan Pendidikan, 2025; Widdiharto et al., 2025). Empirical evidence consistently supports adaptive cooperative learning, ethnomathematics-based cultural integration, digital learning innovations, differentiated remedial instruction, and mother tongue-based multilingual education as effective approaches for improving numeracy (Fan et al., 2021; Hendriana et al., 2025; Laksana et al., 2025; Makur et al., 2019; Nickow et al., 2024; Payadnya et al., 2025; Shahidayanti et al., 2024; Suhartuti et al., 2025; Susilawati et al., 2024; Yerizon et al., 2025). Collectively, these approaches—including GEMBIRA and Ethno-RME—position Indonesia's cultural and linguistic diversity as a valuable pedagogical resource for strengthening equitable numeracy outcomes.

Achieving these policy objectives requires stronger alignment between policy aspirations and implementation capacity. Sustained, job-embedded professional development should strengthen teachers' expertise in culturally responsive numeracy, ethnomathematical integration, and HOTS-oriented assessment, while collaborative professional learning communities should support continuous instructional improvement. Strategic investment in digital infrastructure, culturally contextualized learning resources, and equitable assessment systems that value mathematical reasoning, contextual problem-solving, and culturally grounded thinking is equally essential. Addressing these priorities will strengthen implementation fidelity, reduce educational inequities, and enhance the long-term sustainability of Indonesia's National Numeracy Movement.

Discussion

Strengthening Numeracy Through a Systematic Policy Approach

The GNN seeks to strengthen students' numeracy by fostering collaboration among four educational pillars: family, school, community, and media (Pusat Standar dan Kebijakan Pendidikan, 2025; Prahmana et al., 2026). Within this policy framework, numeracy is conceptualized as a foundational competency that enables individuals to solve everyday problems and make informed, logical, and systematic decisions, thereby promoting a culture of numeracy in both educational settings and society (Geiger et al., 2015; Geiger & Schmid, 2024). This orientation reflects the broader evolution of mathematics education, which increasingly recognizes numeracy as essential for participation in contemporary societies characterized by complex quantitative information and evidence-based decision-making.

From a systemic perspective, the GNN is structured around the interaction of four educational pillars that collectively shape learners' cognitive, social, and cultural development (Widdiharto et al., 2025). Rather than operating independently, these pillars form an interconnected ecosystem in which numeracy practices are developed and reinforced across formal and informal learning environments (Prahmana et al., 2026). This multisectoral approach acknowledges that improving numeracy extends beyond classroom instruction and requires coordinated support from multiple stakeholders (Graven & Jorgensen, 2024; Badmus et al., 2026). Such alignment is essential for fostering a sustainable numeracy culture in which mathematical thinking becomes embedded in everyday life.

Operationalizing the GNN Through GEMBIRA

At the implementation level, the GNN is operationalized through coordinated initiatives, most notably the GEMBIRA Mathematics Training introduced in 2025 by the Directorate General of

Teachers, Education Personnel, and Teacher Education as part of its Sustainable Professional Development programs. The training is designed to promote contextualized and meaningful mathematics instruction that develops critical thinking and the practical application of mathematical knowledge. Its pedagogical sequence guides teachers from exploring students' lived experiences to reflecting on their mathematical thinking, thereby strengthening connections between mathematical concepts and authentic learning experiences (Widdiharto et al., 2025; Prahmana et al., 2026). This approach is consistent with the Deep Learning approach, which emphasizes conceptual understanding, active engagement, and the application of knowledge in meaningful contexts.

Training modules are differentiated according to educational level. For kindergarten teachers, the modules include "Me and Numbers: Playmates", "Fun with Patterns and Objects", "Exploring Shapes, Space, and Position", "Measuring Adventures", and "Joyful Data Exploration". For primary school teacher, the curriculum includes "Joyful Numbers", "Playing with Symbols and Patterns", "Exploring Shapes Around Us", "Measuring Fun: Play and Learn", and "Adventures with Data" (Kepdirjen GTKPG No. 25/B/HK.03.01/2025).

Implementation follows a cascading Training of Trainers (ToT) model coordinated by GTKPG. National facilitators are prepared centrally, while regional facilitators receive training through workshops conducted across Indonesia's 38 provinces by technical implementation units, including *Balai Besar Guru dan Tenaga Kependidikan* (BBGTK), *Balai Guru dan Tenaga Kependidikan* (BGTK), and *Kantor Guru dan Tenaga Kependidikan* (KGTK). These facilitators subsequently disseminate effective mathematics teaching practices across educational levels, reflecting the policy view that numeracy is a cross-curricular competency rather than the sole responsibility of mathematics teachers.

Culturally Responsive Pedagogy as an Integrative Framework

The findings indicate that GEMBIRA should not be viewed as a stand-alone solution for improving numeracy. Rather, it represents one component of a broader repertoire of evidence-based instructional approaches identified in this review, including adaptive cooperative learning (Susilawati et al., 2024), culturally integrated instruction (Hendriana et al., 2025; Payadnya et al., 2025; Shahidayanti et al., 2024), digital learning innovations (Suhartuti et al., 2025; Yerizon et al., 2025), differentiated remedial instruction (Fan et al., 2021; Nickow et al., 2024), and mother tongue-based multilingual education (Makur et al., 2019; Laksana et al., 2025). Collectively, these approaches are consistent with the principles of culturally responsive pedagogy (Ladson-Billings, 1995; Gay, 2018), which emphasizes meaningful learning by connecting instruction to students' cultural, linguistic, and experiential backgrounds.

Within this framework, culturally responsive pedagogy—operationalized through approaches such as Ethno-RME—serves as a bridge between policy objectives and classroom implementation. By recognizing local knowledge, linguistic diversity, and community-based mathematical practices, these approaches reposition cultural diversity as an educational asset rather than a barrier to learning (Wong et al., 2025). This perspective aligns with sociocultural theories of learning (Bishop, 1988), which emphasize the importance of social interaction and cultural context in knowledge construction, while extending the RME principles through culturally authentic learning experiences (Juandi et al., 2022; Prahmana et al., 2020).

Implementation Challenges and Systemic Tensions

Despite the strong policy foundation, important challenges remain in translating policy into classroom practice. Although national policy emphasizes the Deep Learning approach and culturally responsive pedagogy, implementation remains uneven across schools and regions (Pusat Kurikulum dan Pembelajaran, 2025). Limited teacher capacity to design higher-order, contextually meaningful learning activities continues to constrain the effective implementation of these pedagogical principles (Zohar, 2006). In addition, disparities in infrastructure and unequal access to professional learning opportunities contribute to variation in implementation quality (Shirrell et al., 2019). Assessment practices that continue to prioritize procedural knowledge further limit the adoption of more authentic and contextually grounded approaches to numeracy (Geiger & Schmid, 2024).

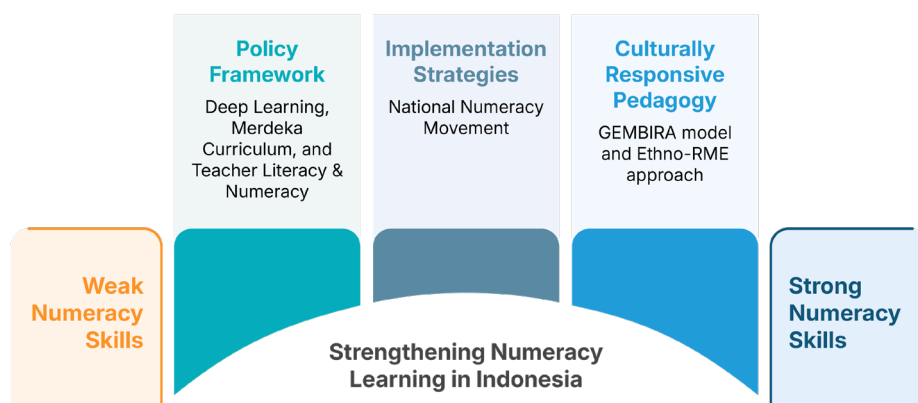
These findings suggest that sustainable numeracy reform depends not only on innovative instructional models but also on strong alignment among policy design, teacher capacity, assessment systems, and institutional support. Without such alignment, culturally responsive pedagogies may be implemented only superficially, reducing their potential to address persistent inequities in student learning outcomes (Gay, 2018). Conversely, coherent policy, sustained professional development, and supportive assessment systems provide favorable conditions for implementing culturally responsive numeracy instruction at scale.

An Integrated Conceptual Framework for Numeracy Reform

Figure 2 presents an integrated conceptual framework that synthesizes the findings of this study by illustrating the interdependence of three dimensions that collectively support the development of stronger numeracy competencies: Policy Framework, Implementation Strategies, and Culturally Responsive Pedagogy. The policy framework establishes the institutional foundation through the Deep Learning approach and alignment with the national curriculum. Implementation Strategies encompass coordinated initiatives such as the GNN, professional learning communities, and system-level capacity-building efforts. Culturally Responsive Pedagogy constitutes the instructional core by grounding mathematics learning in students' lived experiences and cultural contexts (Gay, 2018) through approaches such as GEMBIRA (Widdiharto et al., 2025) and Ethno-RME (Prahmana, 2022).

Figure 2

Strengthening Numeracy Learning in Indonesia



Source: Synthesized from Geiger et al., 2015; Gay, 2018; Prahmana, 2022; and Widdiharto et al., 2025

The framework demonstrates that sustainable improvement in numeracy outcomes requires simultaneous attention to these three interrelated dimensions rather than isolated interventions. The Policy Framework provides the institutional foundation through the Deep Learning approach, curriculum alignment, and development of teacher literacy and numeracy competencies. Implementation Strategies translate policy into practice through coordinated stakeholder engagement, professional learning, and system-level support. Culturally Responsive Pedagogy, operationalized through GEMBIRA and Ethno-RME, strengthens instructional quality by connecting mathematics learning with students' cultural identities and lived experiences, thereby promoting conceptual understanding, learner engagement, and equitable learning opportunities.

Overall, the proposed framework is consistent with contemporary scholarship in mathematics education, which emphasizes that sustainable numeracy development requires coherent policy, coordinated implementation, and culturally responsive instructional practices that value students' cultural knowledge and lived experiences (Geiger et al., 2015; Geiger & Schmid, 2024). In this regard, Indonesia's National Numeracy Movement provides valuable insights into how culturally responsive pedagogy can be integrated into large-scale education reform while also highlighting the institutional and pedagogical conditions necessary for successful implementation across diverse educational contexts.

Conclusion and Policy Recommendations

This study examined Indonesia's GNN through an integrated policy analysis and an integrative literature review to investigate its conceptual foundations, implementation strategies, and culturally responsive pedagogical orientation. The findings demonstrate that the GNN is conceptually grounded in the Deep Learning approach, which reconceptualizes numeracy as a contextual, transferable, and meaningful competency rather than merely procedural mathematical proficiency. Within this policy framework, culturally responsive pedagogy, operationalized through GEMBIRA and Ethno-RME, serves as the principal mechanism for translating national policy into classroom practice by positioning students' cultural identities, local knowledge, and lived experiences as legitimate resources for numeracy learning.

The review identified five complementary implementation strategies—adaptive cooperative learning, culturally integrated instruction, digital technology integration, differentiated remedial instruction, and mother tongue-based multilingual education—that collectively support the translation of policy into educational practice. Across diverse educational contexts, these approaches consistently contribute to greater student engagement, stronger conceptual understanding, and more equitable learning opportunities. However, the available evidence remains fragmented and is derived primarily from localized or short-term studies, limiting conclusions regarding scalability, long-term sustainability, and system-wide effectiveness. Overall, the findings indicate that the principal challenge facing Indonesia's numeracy reform is not the absence of an appropriate policy framework but the persistent gap between policy aspirations and implementation capacity. Sustainable improvement therefore depends on coherent alignment among policy design, teacher professional learning, culturally responsive pedagogy, assessment reform, and continuous implementation support. By integrating these dimensions into a single conceptual framework, this study contributes to the international literature on how culturally responsive pedagogy can facilitate the implementation of national education policy within culturally and linguistically diverse education systems.

Based on these findings, several policy priorities should be considered by the Ministry of Primary and Secondary Education (*Kemendikdasmen*) to strengthen implementation of the GNN.

First, strengthening teacher capacity should become the central policy priority through sustained, job-embedded professional learning that develops competencies in culturally responsive pedagogy, contextual numeracy task design, higher-order mathematical reasoning, and formative assessment. Integrating GEMBIRA into the national Continuing Professional Development (*Pengembangan Keprofesian Berkelanjutan* [PKB]) system, coordinated through BBGTK, BGTK, and KGTK, would provide a coherent institutional mechanism for improving implementation fidelity across provinces.

Second, national assessment policies should be aligned more closely with the objectives of the Deep Learning approach and the GNN by strengthening the Minimum Competency Assessment (*Asesmen Kompetensi Minimum* [AKM]) and school-based assessments to evaluate mathematical reasoning, contextual problem-solving, data interpretation, and culturally meaningful applications of numeracy rather than procedural performance alone. Such alignment would reinforce coherence among curriculum, pedagogy, assessment, and accountability systems while encouraging classroom practices consistent with the intended policy objectives.

Third, implementation policies should prioritize educational equity by directing strategic investment toward disadvantaged, rural, remote, and linguistically diverse communities. Priority investments should include digital infrastructure, culturally contextualized learning resources, mother tongue-based multilingual instruction during the foundational years, and stronger partnerships with local communities to integrate indigenous mathematical knowledge into classroom learning. These initiatives would enable Indonesia's cultural diversity to function as a strategic educational asset rather than a source of educational inequality.

Finally, to support long-term policy effectiveness, *Kemendikdasmen* should establish a comprehensive national monitoring and evaluation system capable of continuously assessing implementation quality, teacher capacity, student numeracy outcomes, and regional equity. Integrating quantitative performance indicators with evidence from classroom implementation would provide policymakers with timely feedback for evidence-informed policy refinement.

Within the broader framework of the National Medium-Term Development Plan and Sustainable Development Goal 4 (SDG 4), such a system would strengthen accountability while supporting the scalability, sustainability, and long-term impact of Indonesia's culturally responsive numeracy reform.

Acknowledgment

The authors gratefully acknowledge the support provided by the *Pusat Standar dan Kebijakan Pendidikan, Badan Standar, Kurikulum, dan Asesmen Pendidikan*, Ministry of Primary and Secondary Education (*Kemendikdasmen*), Universitas Ahmad Dahlan, Western Michigan University, and Universitas Muhammadiyah Prof. DR. HAMKA for supporting this research.

References

- Admiraal, W., Schenke, W., De Jong, L., Emmelot, Y., & Sligte, H. (2021). Schools as professional learning communities: What can schools do to support professional development of their teachers?. *Professional Development in Education*, 47(4), 684–698. <https://doi.org/10.1080/19415257.2019.1665573>
- Akbar, A., Riyanti, V., & Christi, S. R. N. (2025). *Desain pembelajaran mendalam [Deep learning design]*. Penerbit Haura Utama
- Badmus, O. T., Adeniji, S., Getenet, S., & Jita, L. C. (2026). A comparative analysis of Foundation and early primary years mathematics curricula: Insights from Australia and South Africa. *Journal of Curriculum Studies*, 58(1), 27–52. <https://doi.org/10.1080/00220272.2025.2544583>
- Balala, M. M. A., Aarepattamannil, S., & Cairns, D. (2021). Investigating the associations of early numeracy activities and skills with mathematics dispositions, engagement, and achievement among fourth graders in the United Arab Emirates. *Large-Scale Assessments in Education*, 9(1), 13. <https://doi.org/10.1186/s40536-021-00106-4>
- Bishop, A. J. (1988). Mathematics education in its cultural context. *Educational Studies in Mathematics*, 19(2), 179–191. <https://doi.org/10.1007/BF00751231>
- Cardno, C. (2018). Policy Document Analysis: A practical educational leadership tool and a qualitative research method. *Educational Administration: Theory & Practice*, 24(4), 623–640. <https://eric.ed.gov/?id=EJ1305631>
- D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of Mathematics. *For the Learning of Mathematics*, 5(1), 44–48. <https://www.jstor.org/stable/40247876>
- Depraetere, J., Vandeviver, C., Keygnaert, I., & Beken, T. V. (2021). The critical interpretive synthesis: An assessment of reporting practices. *International Journal of Social Research Methodology*, 24(6), 669–689. <https://doi.org/10.1080/13645579.2020.1799637>
- Dixon-Woods, M., Cavers, D., Agarwal, S., Annandale, E., Arthur, A., Harvey, J., ... & Sutton, A. J. (2006). Conducting a critical interpretive synthesis of the literature on access to healthcare by vulnerable groups. *BMC Medical Research Methodology*, 6(1), 35. <https://doi.org/10.1186/1471-2288-6-35>
- Fan, T., Song, J., & Guan, Z. (2021). Integrating diagnostic assessment into curriculum: A theoretical framework and teaching practices. *Language Testing in Asia*, 11(1), 2. <https://doi.org/10.1186/s40468-020-00117-y>
- Feriyanto, F., & Anjariyah, D. (2024). Deep learning approach through meaningful, mindful, and joyful learning: A library research. *Electronic Journal of Education, Social Economics and Technology*, 5(2), 208–212. <https://doi.org/10.33122/ejeset.v5i2.321>
- Forgasz, H. J., & Hall, J. (2019). Learning about numeracy: The impact of a compulsory unit on pre-service teachers' understandings and beliefs. *Australian Journal of Teacher Education*, 44(2), 15–33. https://researchmgt.monash.edu/ws/portalfiles/portal/262862003/262861939_oa.pdf
- Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. Teachers College Press.
- Geiger, V., & Schmid, M. (2024). A critical turn in numeracy education and practice. *Frontiers in Education*, 9, 1363566. <https://doi.org/10.3389/feduc.2024.1363566>
- Geiger, V., Goos, M., & Forgasz, H. (2015). A rich interpretation of numeracy for the 21st century: A survey of the state of the field. *ZDM Mathematics Education*, 47(4), 531–548. <https://doi.org/10.1007/s11858-015-0708-1>

- Graven, M., & Jorgensen, R. (2024). Early numeracy opportunities through number stories with marginalised families. *ZDM–Mathematics Education*, 56(3), 319–333. <https://doi.org/10.1007/s11858-023-01537-9>
- Grotlüschen, A., Desjardins, R., & Liu, H. (2020). Literacy and numeracy: Global and comparative perspectives. *International Review of Education*, 66(2), 127–137. <https://doi.org/10.1007/s11159-020-09854-x>
- Hammadi, S. S., Majeed, B. H., & Hassan, A. K. (2023). Impact of deep learning strategy in mathematics achievement and practical intelligence among high school students. *International Journal of Emerging Technologies in Learning*, 18(6), 42–52. <https://doi.org/10.3991/ijet.v18i06.38615>
- He, P., Guo, F., & Abazie, G. A. (2024). School principals' instructional leadership as a predictor of teacher's professional development. *Asian-Pacific Journal of Second and Foreign Language Education*, 9(1), 63. <https://doi.org/10.1186/s40862-024-00290-0>
- Hendriana, H., Ristiana, N., Kusaka, S., Peni, N. R. N., & Prahmana, R. C. I. (2025). Integrating indigenous number systems and indefinite units into mathematics learning: A study on Javanese language and culture. *Infinity Journal*, 14(3), 797–816. <https://doi.org/10.22460/infinity.v14i3.p797-816>
- Hoogland, K. (2023). The changing nature of basic skills in numeracy. *Frontiers in Education*, 8, 1293754. <https://doi.org/10.3389/feduc.2023.1293754>
- Hosseinpoor, A. R., Nambiar, D., Tawilah, J., Schlottheuber, A., Briot, B., Bateman, M., ... & Floranita, R. (2018). Capacity building for health inequality monitoring in Indonesia: Enhancing the equity orientation of country health information systems. *Global Health Action*, 11(sup1), 7–12. <https://doi.org/10.1080/16549716.2017.1419739>
- Isnaeni, F., Budiman, S. A., Nurjaya, N., & Mukhlisin, M. (2025). Analysis of the readiness for implementing deep learning curriculum in madrasah from the perspective of educators. *Attadrib: Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, 8(1), 15–30. <https://doi.org/10.54069/attadrib.v8i1.841>
- Juandi, D., Kusumah, Y. S., & Tamur, M. (2022). A meta-analysis of the last two decades of realistic mathematics education approaches. *International Journal of Instruction*, 15(1), 381–400. <https://e-iji.net/ats/index.php/pub/article/view/452>
- Khodabin, M., & Arsalani, A. (2025). Artificial intelligence literacy as national strategy: A systematic review of policy, equity, and capacity building across the global south. *Journal of World Sociopolitical Studies*, 9(4), 777–814. <https://doi.org/10.22059/wsps.2025.396472.1530>
- Kurniawati, S., Suryadarma, D., Bima, L., & Yusrina, A. (2018). Education in Indonesia: A white elephant?. *Journal of Southeast Asian Economies*, 35(2), 185–199. <http://dx.doi.org/10.1355/ae35-2e>
- Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32(3), 465–491. <https://doi.org/10.3102/00028312032003465>
- Laksana, D. N. L., Qondias, D., Veliz, L., Chiu, C., Utami, K. H. D., & Listyana, I. G. A. A. P. (2025). Adapting mother tongue-based instructional models to address gender disparities in literacy and numeracy skills. *International Journal of Language Education*, 9(2), 377–391. <https://hdl.handle.net/1959.11/71314>
- Latip, A., Robandi, B., Amaliah, Khakim, R. R., & Fatonah, N. (2023). Technological Pedagogical Content Knowledge (TPACK) framework for science teachers' competencies in facing global challenges and issues: A narrative literature review. *International Journal of Pedagogy and Teacher Education*, 7(1), 45–57. <https://doi.org/10.20961/ijpte.v0i0.74699>
- Makur, A. P., Prahmana, R. C. I., & Gunur, B. (2019). How mathematics attitude of mothers in rural area affects their children's achievement. *Journal of Physics: Conference Series*, 1188(1), 012009. <http://dx.doi.org/10.1088/1742-6596/1188/1/012009>
- Marfuah, Suryadi, D., Turmudi, & Isnawan, M. G. (2022). Providing online learning situations for in-service mathematics teachers' external transposition knowledge during COVID-19 pandemic: Case of Indonesia. *Electronic Journal of E-Learning*, 20(1), 69–84. <http://dx.doi.org/10.34190/ejel.20.1.2388>
- Meland, E. A., & Brion-Meisels, G. (2024). An integrative model for culturally sustaining SEL in the classroom. *Social and Emotional Learning: Research, Practice, and Policy*, 3, 100042. <https://doi.org/10.1016/j.sel.2024.100042>

- Mufidah, I., Kusairi, S., & Arifin, S. (2023). Development of AKM numeracy instruments on numbers, geometry & measurement materials for grade IV elementary school students. *PrimaryEdu: Journal of Primary Education*, 7(1), 45–60. <https://doi.org/10.22460/pej.v7i1.3567>
- Musslifah, A. R., Deporos, S. R. C., & Purnomosidi, F. (2025). Implementation of deep learning based on local wisdom 'Bhineka Tunggal Ika, Tan Hana Dharma Mangrwa' in MI Central Java: An ethnographic study of education. *Attadrib: Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, 8(2), 340–352. <https://doi.org/10.54069/attadrib.v8i2.915>
- Nafi'ah, J., & Faruq, D. J. (2025). Conceptualizing deep learning approach in primary education: Integrating mindful, meaningful, and joyful. *Journal of Educational Research and Practice*, 3(2), 225–237. <https://doi.org/10.70376/jerp.v3i2.384>
- Nickow, A., Oreopoulos, P., & Quan, V. (2024). The promise of tutoring for PreK–12 learning: A systematic review and meta-analysis of the experimental evidence. *American Educational Research Journal*, 61(1), 74–107. <https://doi.org/10.3102/00028312231208687>
- Nurhusain, M., Upu, H., & Djadir. (2025). Ethnomathematics-based learning & the Merdeka curriculum in the society 5.0 era: Indonesian educational innovation. *International Journal of Integrative Sciences*, 4(4), 743–766. <https://doi.org/10.55927/ijis.v4i4.203>
- Nurman, Utomo, S., Gesmi, I., Othman, Z., & Zainal. (2025). Public services amid infrastructure inequities: A case study of Indonesia's outer islands. *International Journal of Sustainable Development & Planning*, 20(5), 2213–2223. <http://dx.doi.org/10.18280/ijstdp.200536>
- Nursyahidah, F., Wardono, W., Mariani, S., & Wijayanti, K. (2025). Integrating technology, ethnomathematics, and realistic mathematics education in learning statistics: A learning trajectory. *Infinity Journal*, 14(3), 633–654. <https://doi.org/10.22460/infinity.v14i3.p633-654>
- OECD. (2023). *PISA 2022 results (Volume I and II): Country notes – Indonesia*. OECD Publishing. https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/11/pisa-2022-results-volume-i-and-ii-country-notes_2fca04b9/indonesia_0e09c072/c2e1ae0e-en.pdf
- OECD. (2024). *Transforming education in Indonesia: Examining the landscape of education policy and programmes*. OECD Publishing. <https://doi.org/10.1787/9ff8d407-en>
- Özyildirim, G., Kayikci, K., Ömeroglu, M., & Yalcinkaya, S. (2025). Reconceptualizing professional development through job-embedded approach: Early childhood teachers' views on benefits and challenges. *European Early Childhood Education Research Journal*, 1–17. <https://doi.org/10.1080/1350293X.2025.2576749>
- Payadnya, I. P. A. A., Atmaja, I. M. D., Noviyanti, P. L., Wibawa, K. A., & Jayantika, I. G. A. N. T. (2025). Exploring “Wa Pat Nem Tus Dasa”: The potential of a Balinese traditional mod 2 counting system in culturally based Mathematics learning. *Journal for Multicultural Education*, 19(2), 1–12. <https://doi.org/10.1108/JME-02-2025-0050>
- Potgieter, E., & van der Walt, M. (2022). Metacognitive awareness and the zone of proximal intermediate phase Mathematics teachers' professional development. *EURASIA Journal of Mathematics, Science and Technology Education*, 18(8), em2134. <https://doi.org/10.29333/ejmste/12206>
- Prahmana, R. C. I. (2022). Ethno-realistic Mathematics education: The promising learning approach in the city of culture. *SN Social Sciences*, 2(12), 257. <https://doi.org/10.1007/s43545-022-00571-w>
- Prahmana, R. C. I., Ma'arif, S., & Pramudiani, P. (2026). Indigenous knowledge as educational asset: Culturally responsive mathematics education and equity pursuit in Indonesia's multilingual contexts. *Mosharafa: Jurnal Pendidikan Matematika*, 15(1), 37–59. <https://doi.org/10.31980/mosharafa.v15i1.3532>
- Prahmana, R. C. I., Sagita, L., Hidayat, W., & Utami, N. W. (2020). Two decades of realistic Mathematics education research in Indonesia: A survey. *Infinity Journal*, 9(2), 223–246. <https://doi.org/10.22460/infinity.v9i2.p223-246>
- Pusat Kurikulum dan Pembelajaran. (2025). *Naskah akademik pembelajaran mendalam menuju pendidikan bermutu untuk semua*. Badan Standar, Kurikulum, dan Asesmen Pendidikan, Kementerian Pendidikan Dasar dan Menengah Republik Indonesia. <https://kurikulum.kemendikdasmen.go.id/rujukan/kajian-naskah-akademik>

- Pusat Standar dan Kebijakan Pendidikan. (2025). *Kebijakan penguatan pembelajaran keterampilan fondasional [Policy on strengthening foundational skills learning]*. Kementerian Pendidikan Dasar dan Menengah
- Ro, J. (2021). On the matter of teacher quality: Lessons from Singapore. *Journal of Curriculum Studies*, 53(4), 500–515. <https://doi.org/10.1080/00220272.2020.1808903>
- Safitri, W. S., Sahmin, Isnawan, M. G., & Indrawati. (2024). The Influence of regional languages on presenting and solving local Mathematics problems: A systematic literature review. *Polyhedron International Journal in Mathematics Education*, 2(1), 30–37. <https://doi.org/10.59965/pijme.v2i1.88>
- Sakurai, J., & Goos, M. (2023). Revisiting tools in numeracy learning: The role of authentic digital tools. *Frontiers in Education*, 8, 1291407. <https://doi.org/10.3389/educ.2023.1291407>
- Salman, A. (2025). Deep learning based educational transformation as a roadmap to Indonesia emas 2045. *At Turots: Jurnal Pendidikan Islam*, 7(1), 639–648. <https://doi.org/10.51468/jpi.v7i1.1171>
- Shahidayanti, T., Prahmana, R. C. I., & Fran, F. A. (2024). Integrating Ethno-Realistic Mathematics education in developing three-dimensional instructional module. *Journal of Honai Math*, 7(3), 379–400. <https://doi.org/10.30862/jhm.v7i3.698>
- Shirrell, M., Hopkins, M., & Spillane, J. P. (2019). Educational infrastructure, professional learning, and changes in teachers' instructional practices and beliefs. *Professional Development in Education*, 45(4), 599–613. <https://doi.org/10.1080/19415257.2018.1452784>
- Suhartuti, L. I., Rahaju, E. B., Mariana, N., & Purwoko, B. (2025). Wordwall educational games and elementary students' Mathematics learning: A systematic review of interest and critical thinking development. *Journal of Innovation and Research in Primary Education*, 4(4), 2972–2980. <https://doi.org/10.56916/jirpe.v4i4.1870>
- Sunzuma, G., & Umbara, U. (2025). Ethnomathematics-based technology in Indonesia: A systematic review. *Asian Journal for Mathematics Education*, 4(1), 129–153. <https://doi.org/10.1177/27527263241305812>
- Susilawati, E., Muslim, S., & Khaerudin. (2024). Analysis of needs for developing adaptive-cooperative learning models to improve numeracy competence at the middle school level. *Third International Conference on Humanity Education and Society (ICHES)*, 3(1), 1–13. <https://proceedingsiches.com/index.php/ojs/article/view/218>
- Widdiharto, R., Prahmana, R. C. I., Isaeni, N., Widodo, S. A., Mayangwuri, S., & Pramudiani, P. (2025). The theoretical framework of GEMBIRA learning model: An impactful insight for Indonesian numeracy movement. *Union: Jurnal Ilmiah Pendidikan Matematika*, 13(3), 721–733. <https://doi.org/10.30738/union.v13i3.20353>
- Wong, J. W., Athanases, S. Z., & Houk, J. (2025). From deficit to asset-based perspectives on multilingual learners: A critical inquiry in teacher education. *The Teacher Educator*, 60(2), 225–246. <https://doi.org/10.1080/08878730.2024.2377778>
- Yerizon, Arnellis, A., Suherman, Arnawa, I. M., Sa'dijah, C., & Anwar, L. (2025). Developing adaptive digital book (ADB) in enhancing students' numeracy literacy ability. *Infinity Journal*, 14(3), 571–586. <https://doi.org/10.22460/infinity.v14i3.p571-586>
- Zana, F. M., Sa'dijah, C., Susiswo, Anwar, L., & Zulnaidi, H. (2024). Curriculum and teacher assessment practices in Mathematics learning: Alignment with higher order thinking skills in Indonesian secondary schools. *Journal on Mathematics Education*, 15(4), 1311–1334. <https://doi.org/10.22342/jme.v15i4.pp1311-1334>
- Zein, S. (2020). *Language policy in superdiverse Indonesia*. Routledge. <https://doi.org/10.4324/9780429019739>
- Zhan, Z., He, L., & Zhong, X. (2024). How does problem-solving pedagogy affect creativity? A meta-analysis of empirical studies. *Frontiers in Psychology*, 15, 1287082. <https://doi.org/10.3389/fpsyg.2024.1287082>
- Zhou, L. (2025). Transforming preservice teachers in teaching Mathematics through family math night: Community-based learning in an urban context. *Journal of Urban Mathematics Education*, 18(1), 12–33. <https://files.eric.ed.gov/fulltext/EJ1484300.pdf>
- Zohar, A. (2006). The nature and development of teachers' metastrategic knowledge in the context of teaching higher order thinking. *The Journal of the Learning Sciences*, 15(3), 331–377. https://doi.org/10.1207/s15327809jls1503_2