Jurnal Review Pendidikan Dasar:
Jurnal Kajian Pendidikan dan Hasil Penelitian
Vol 12(1), Februari 2026

e-ISSN: 2460-8475
http://journal.unesa.ac.id/index.php/PD
https://doi.org/10.26740/jrpd.v12n1.p32-58

Concrete-to-Abstract Transitions and Affective Factors in Fourth-Grade Mathematics: A Systematic Review of Pedagogical Challenges and Merdeka Curriculum

Setianingsih, State University of Malang
Fitrika Asrofatul Arofah, State University of Malang
Suyono✉, State University of Malang
Riska Pristiani, State University of Malang

✉ *suyono.fs@um.ac.id*

Abstract: Fourth grade represents a critical transition period in elementary mathematics education where students encounter increasingly abstract concepts requiring sophisticated pedagogical approaches. This systematic literature review synthesizes 32 empirical studies (2021-2025) examining concrete-representational-abstract (CRA) instructional sequences, affective dimensions, and Merdeka Curriculum implementation challenges in fourth-grade mathematics learning. Analysis reveals three primary findings: First, systematic CRA/CPA progressions significantly enhance conceptual understanding across fractions, geometry, and algebraic thinking, yet classroom implementation frequently exhibits problematic practices including premature abstraction or prolonged concrete manipulation. Second, mathematical self-efficacy, mathematics anxiety, and achievement demonstrate consistent bidirectional relationships, with fourth grade constituting a consequential period for mathematical identity formation. Third, Merdeka Curriculum's numeracy literacy emphasis confronts substantial implementation obstacles including conceptual misconceptions, inadequate professional development, resource limitations, structural constraints, and policy misalignments.

Keywords: Mathematics Learning, Pedagogical Foundations, Numeracy Literacy, Learning Problems, Elementary School.

How to Cite: Setiangingsih, Arofah, F.A., Suyono, & Pristiani, R. (2026). Template for Manuscript of Jurnal Review Pendidikan Dasar: Jurnal Kajian Hasil Penelitian. *Jurnal Review Pendidikan Dasar: Jurnal Kajian Pendidikan dan Hasil Penelitian, 12*(1), 32-58. https://doi.org/10.26740/jrpd.v11n2.p32-58

© The Author(s) 2026

Article Info:
Received: 29 December 2025; Accepted: 25 February 2026; Published Online: 28 February 2026

Published by:
Pendidikan Dasar Universitas Negeri Surabaya

INTRODUCTION

Mathematics learning in elementary schools constitutes a fundamental component in developing students' reasoning abilities, logical thinking, and problem-solving skills that will be utilized throughout their lives. The fourth grade represents a critical transition period where students begin encountering more abstract mathematical concepts, including fractions, geometry, and basic algebraic patterns, requiring stronger conceptual understanding than previous grades (Pittalis et al., 2024; Yu et al., 2024). Research by Clements, Lizcano, and Sarama (2023) indicates that fourth-grade students often experience significant cognitive challenges when transitioning from concrete to abstract mathematical representations, affecting their mathematical achievement and attitudes toward the subject. This transitional phase demands pedagogical approaches specifically designed to bridge concrete understanding with abstract symbolization. The gap between curriculum expectations and students' developmental readiness frequently results in misconceptions, reduced self-efficacy, and mathematics anxiety that can persist into higher educational levels (Du et al., 2021; Pellegrini et al., 2021; Živković et al., 2023). Understanding these pedagogical foundations and challenges becomes crucial for developing effective instructional strategies that support meaningful mathematics learning in elementary education.

The implementation of the Merdeka Curriculum in Indonesia has introduced new paradigms emphasizing numeracy literacy as a core competency that must be developed systematically across all educational levels. Numeracy literacy extends beyond computational skills to encompass the ability to reason mathematically, interpret data, and apply mathematical thinking in real-world contexts (Khomaria & Jupri, 2024). However, empirical evidence reveals substantial challenges in integrating numeracy literacy into fourth-grade mathematics instruction, particularly regarding teachers' conceptual understanding of numeracy as an integrated component rather than a separate drill activity (Hidayah et al., 2024; Ramdhani et al., 2024). Many elementary teachers demonstrate misconceptions about numeracy, viewing it as additional content rather than a quality dimension of mathematics learning that permeates all instructional activities. This misunderstanding leads to fragmented learning experiences where procedural fluency is prioritized over conceptual understanding and mathematical reasoning (Yunitasari et al., 2023). The disconnect between policy intentions and classroom

implementation highlights the urgent need for comprehensive pedagogical frameworks that operationalize numeracy literacy within fourth-grade mathematics instruction while respecting students' cognitive developmental stages.

Contemporary research on mathematics learning emphasizes the crucial role of affective factors, particularly mathematical self-efficacy and anxiety, in shaping students' learning outcomes and persistence. Mathematical self-efficacy, defined as students' beliefs about their capabilities to successfully perform mathematical tasks, significantly predicts achievement and engagement in mathematics learning (Guntur & Purnomo, 2024; Ruijia et al., 2022). Conversely, mathematics anxiety characterized by feelings of tension, apprehension, and worry when confronting mathematical situations negatively impacts cognitive processes, working memory, and problem-solving performance (Safiyah & Widyastuti, 2022). Fourth-grade students are particularly vulnerable to developing mathematics anxiety as they encounter increasingly abstract concepts and face greater performance expectations. Research demonstrates bidirectional relationships among self-efficacy, anxiety, and achievement, where low self-efficacy contributes to heightened anxiety, which subsequently impairs performance and further diminishes self-efficacy (Du et al., 2021). These affective dimensions must be explicitly addressed within pedagogical frameworks to create supportive learning environments that foster positive mathematical identities. Teachers' instructional choices, classroom climate, and assessment practices significantly influence the development of students' mathematical self-efficacy and anxiety levels (Kaskens et al., 2020).

The concrete-to-abstract transition represents a fundamental pedagogical principle in elementary mathematics education, yet its effective implementation remains problematic in many fourth-grade classrooms. Theoretical frameworks such as Bruner's stages of representation enactive, iconic, and symbolic provide foundational guidance for sequencing mathematical experiences from concrete manipulations through pictorial representations to abstract symbolization (Clements et al., 2023; Umuhoza & Hakizimana, 2024). Research consistently demonstrates that systematic progression through concrete-representational-abstract (CRA) sequences enhances conceptual understanding, particularly for challenging topics like fractions, geometry, and early algebraic thinking (Al-Salahat, 2022; Thu & Linh, 2024). However, classroom observations reveal that many fourth-grade teachers either bypass concrete experiences

entirely, rushing to symbolic procedures, or conversely maintain students at concrete levels too long, failing to facilitate abstraction (Clements et al., 2023). The pictorial/representational phase, which serves as a critical bridge between concrete and abstract thinking, is often minimized or omitted entirely. Effective implementation of CRA approaches requires not only access to appropriate manipulative materials but also pedagogical content knowledge about how to strategically sequence experiences and facilitate students' progressive internalization of mathematical relationships (Saleh et al., 2017).

The Merdeka Curriculum's emphasis on differentiated instruction and teaching at the right level presents both opportunities and challenges for fourth-grade mathematics instruction. Diagnostic assessment results, particularly from Asesmen Kompetensi Minimum (AKM) Kelas, reveal substantial heterogeneity in students' mathematical proficiency levels within single classrooms, exacerbated by learning disruptions during the pandemic period (Nurhaswinda et al., 2025; Sephiawardani & Bektiningsih, 2023). Teachers express significant difficulties in designing and implementing differentiated mathematics activities that appropriately challenge advanced learners while providing necessary scaffolding for struggling students (Mulabbiyah et al., 2024). Challenges include inadequate preparation time, large class sizes, limited manipulative resources, and insufficient training in differentiation strategies specific to mathematics content (Rustini et al., 2023; Sutinah et al., 2024). Additionally, teachers report confusion about effectively utilizing AKM Kelas results for instructional planning and struggle to design contextual numeracy tasks aligned with curriculum competencies. These implementation challenges indicate that policy intentions regarding adaptive, student-centered mathematics instruction have not been adequately translated into practical pedagogical frameworks and support systems accessible to elementary teachers (Hidayah et al., 2024).

This literature review addresses critical gaps in understanding the pedagogical foundations and challenges specific to fourth-grade mathematics learning within the contemporary Indonesian educational context. While existing research has examined mathematics instruction broadly or focused on specific grade levels, comprehensive synthesis examining the intersection of cognitive development, affective factors, transitional pedagogies, numeracy literacy demands, and curriculum implementation challenges specifically for fourth grade remains limited. This article synthesizes recent

empirical evidence to provide a holistic understanding of what constitutes effective fourth-grade mathematics pedagogy and what systemic obstacles prevent its realization. By integrating international research on mathematical learning progressions with Indonesian studies on Merdeka Curriculum implementation, this review offers contextualized insights for improving mathematics instruction quality. The findings aim to inform teacher education programs, professional development initiatives, and educational policies by identifying evidence-based pedagogical approaches and addressing practical implementation barriers encountered in elementary mathematics classrooms.

METHODS

Research Design and Approach

This study employs a systematic literature review methodology to synthesize existing research on pedagogical foundations and challenges in fourth-grade mathematics learning. The review followed PRISMA guidelines for transparent reporting, encompassing identification, screening, eligibility assessment, and inclusion of relevant studies published between 2021 and 2025. Literature sources included peer-reviewed journal articles, conference proceedings, and research reports accessible through academic databases including Google Scholar, ERIC, Scopus, and specialized education research repositories. Search strategies utilized Boolean operators combining key terms: “mathematics learning,” “fourth grade,” “elementary school,” “pedagogical approach,” “numeracy literacy,” “concrete-abstract transition,” “Merdeka Curriculum,” “mathematics anxiety,” and “self-efficacy.” Initial searches yielded approximately 180 potentially relevant documents, which underwent systematic screening based on predefined inclusion and exclusion criteria.

Selection Criteria and Data Extraction

Inclusion criteria specified: (1) empirical research or theoretical frameworks addressing fourth-grade mathematics learning; (2) studies examining pedagogical approaches, learning challenges, or curriculum implementation; (3) research on concrete-abstract transitions, manipulative use, or representational thinking; (4) investigations of affective factors including self-efficacy and mathematics anxiety in elementary contexts; (5) studies on numeracy literacy development and assessment; and (6) publications from

2021-2025 to ensure currency. Exclusion criteria eliminated: (1) studies focusing exclusively on secondary or higher education; (2) research on mathematics content areas beyond elementary scope; (3) purely quantitative achievement studies without pedagogical analysis; and (4) non-English or non-Indonesian publications without accessible translations. After screening titles and abstracts, 65 studies underwent full-text review, resulting in 32 studies meeting all inclusion criteria. Data extraction utilized a standardized matrix capturing: research objectives, methodologies, participant characteristics, key findings, pedagogical implications, and study limitations. Quality assessment employed adapted criteria evaluating research design rigor, sample adequacy, measurement validity, and contribution to pedagogical understanding.

Data Analysis and Synthesis

Extracted data underwent thematic analysis to identify recurring patterns, convergent findings, and significant gaps across the literature corpus. The analytical framework organized findings into five primary domains: (1) cognitive-developmental foundations of fourth-grade mathematics learning; (2) concrete-representational-abstract pedagogical sequences; (3) affective factors influencing mathematics learning; (4) numeracy literacy conceptualizations and implementation challenges; and (5) Merdeka Curriculum implementation obstacles and teacher support needs. Within each domain, studies were categorized by methodology (experimental, quasi-experimental, qualitative, mixed-methods, literature reviews), geographical context (international research, Indonesian studies), and specific focus (fraction learning, geometry, algebraic thinking, assessment practices). Comparative analysis identified consistencies and contradictions across studies, revealing robust findings versus contested areas requiring further investigation. Synthesis prioritized pedagogical implications, emphasizing actionable insights for instructional improvement rather than merely cataloging research findings.

RESULTS

Pedagogical Approaches for Concrete-to-Abstract Transition in Fourth-Grade Mathematics

The synthesis of ten studies examining concrete-to-abstract transitions in mathematics learning reveals consistent evidence supporting structured pedagogical sequences that systematically guide students from physical manipulations through pictorial

representations to symbolic abstraction. Yu et al. (2024) demonstrated that collaborative-inquiry models combining small-group manipulation of concrete materials with guided questioning significantly enhanced fourth-graders' analytical thinking and mathematical reasoning compared to traditional instruction (quasi-experimental design, n=142). Thu and Linh (2024) provided theoretical frameworks for designing fraction tasks that progressively develop abstraction and generalization abilities through activities requiring pattern recognition, grouping, and rule formulation. The Indonesian Realistic Mathematics Education (PMRI) approach investigated by Saleh et al. (2017) confirmed that realistic contexts and concrete objects effectively bridge abstraction, particularly for fraction concepts, with experimental groups demonstrating superior reasoning compared to conventional instruction. These findings converge on the principle that conceptual understanding emerges through guided transition rather than direct presentation of abstract symbols.

Research examining the Concrete-Representational-Abstract (CRA) instructional sequence provides robust evidence for its effectiveness across diverse student populations and mathematical content areas. Al-Salahat (2022) documented significant improvements in perimeter calculation and word problem solving among students with learning disabilities (n=8) following systematic CRA instruction, with mastery monitoring at each stage before advancing. Umuhoza and Hakizimana (2024) identified the pictorial phase as particularly critical, serving as an essential bridge where students develop critical thinking about visual representations before formalizing symbolic rules, though participation typically decreases during abstract phases. Conversely, Reyes (2024) presented alternative sequencing, demonstrating that abstract-visual-concrete (AVC) progression can enhance conceptual understanding and self-efficacy in secondary statistics, suggesting flexibility in sequencing depending on content characteristics and learner readiness. However, Clements et al. (2023) cautioned that failure frequently occurs when students remain at concrete levels through upper elementary grades, emphasizing the necessity of deliberately orchestrated progression toward abstraction. These studies collectively indicate that effective concrete-abstract transitions require explicit instructional planning, adequate time at each representational level, and strategic decisions about when and how to advance students toward symbolic thinking.

Additional studies highlight specific pedagogical strategies supporting concrete-abstract transitions in specialized mathematical domains. Alghtani and Abdulhamied (2010) established geometric representations' effectiveness in developing fourth-graders' algebraic thinking, with experimental groups demonstrating higher algebraic reasoning through visual pattern exploration (dots, tiles) bridging to variable concepts and simple formula generalization. Pittalis et al. (2024) showed that fifth-sixth grade students can handle highly abstract functional concepts when supported by embodied activities, real-world contexts, and multi-representational connections, suggesting elementary-age students' capacity for advanced thinking with appropriate scaffolding. Tran and Duong (2023) reported dramatic achievement increases (from 37.21% to 96.89% mastery) using concrete manipulatives for three-dimensional geometry nets, though noting limited analysis of subsequent abstraction steps. The consistent message across these studies emphasizes that manipulative effectiveness depends critically on intentional pedagogical mediation, where teachers strategically sequence experiences, facilitate connections between representations, and explicitly guide abstraction processes rather than assuming understanding naturally emerges from concrete experiences alone.

Table 1. Summary of Concrete-to-Abstract Pedagogical Approaches in Fourth-Grade Mathematics

Study	Pedagogical Approach	Content Focus	Key Finding	Limitation
(Yu et al., 2024)	Collaborative-Inquiry Model	General 4th grade math	Enhanced analytical thinking & reasoning	Single school context
(Thu & Linh, 2024)	Abstraction task design	Fraction operations	Rich abstraction opportunities through grouping, patterns, rules	No empirical testing
(Saleh et al., 2017)	PMRI (Realistic contexts)	Fraction reasoning	Realistic contexts bridge abstraction effectively	Limited implementation details
(Al-Salahat, 2022)	CRA sequence	Geometry perimeter	Systematic progression strengthens understanding	Small sample (n=8, LD students)
(Umuhoza & Hakizimana, 2024)	CPA approach	Secondary mathematics	Pictorial phase critical; participation declines in abstract phase	Secondary level, transfer needed
(Reyes, 2024)	AVC sequence (reversed)	Statistics	Alternative sequencing can	Secondary level, statistics focus

			enhance understanding	
(Clements et al., 2023)	Learning trajectories	Early mathematics	Failure when students remain concrete too long	Pre-K to early elementary focus
(Alghtani & Abdulhamied, 2010)	Geometric representations	Algebraic thinking	Visual patterns bridge to variables and formulas	Local curriculum context
(Pittalis et al., 2024)	Embodied & dynamic activities	Functional thinking	Elementary students can handle abstraction with support	Grades 5-6, advanced concepts
(Tran & Duong, 2023)	Concrete manipulatives	3D geometry nets	Dramatic mastery increase (37%→97%)	Limited abstraction analysis

Note: CRA = Concrete-Representational-Abstract; CPA = Concrete-Pictorial-Abstract; AVC = Abstract-Visual-Concrete; PMRI = Pendidikan Matematika Realistik Indonesia; LD = Learning Disabilities

Affective Factors: Self-Efficacy, Mathematics Anxiety, and Achievement

Analysis of ten studies examining affective dimensions reveals consistent bidirectional relationships among mathematical self-efficacy, mathematics anxiety, and achievement, with significant implications for fourth-grade instruction. Du et al. (2021) established through longitudinal analysis (n=2,789) that mathematical self-efficacy and achievement mutually influence each other, while mathematics anxiety reciprocally affects both efficacy beliefs and performance outcomes. Ruijia et al. (2022) demonstrated that self-efficacy and self-concept positively predict achievement, while anxiety negatively predicts performance, with anxiety mediating the relationship between self-efficacy and achievement among sixth-grade students. Živković et al. (2023) confirmed these patterns in fifth-grade contexts, identifying both constructs as strong predictors of mathematical performance. These longitudinal and cross-sectional findings converge on the conclusion that affective factors are not merely consequences of achievement differences but actively shape learning trajectories, suggesting that pedagogical interventions must address emotional and motivational dimensions alongside cognitive development.

Research examining relationships specific to elementary contexts provides nuanced understanding of how affective factors operate during the critical fourth-grade transition period. Safiyah and Widyastuti (2022) documented significant negative correlations (r = -0.248) between academic self-efficacy and mathematics anxiety among upper elementary Indonesian students, indicating that confidence and anxiety inversely

relate even at young ages. Guntur and Purnomo (2024) revealed that self-regulation and metacognition mediate relationships between high self-efficacy and lower anxiety (n=480), contributing to superior learning outcomes. Kaskens et al. (2020) found that self-concept positively predicted arithmetic fluency, though mathematics anxiety showed weaker predictive power, while teacher pedagogical knowledge significantly influenced problem-solving development (multi-level analysis, 610 students, 31 teachers). Mahmudah et al. (2024) demonstrated that self-efficacy explained 63.7% of achievement variance during online learning, with low-efficacy students exhibiting avoidance and reduced persistence. These studies emphasize that self-efficacy development begins early, anxiety prevention must commence in elementary grades, and teacher competencies significantly shape students' affective profiles.

Intervention studies provide evidence regarding effective approaches for enhancing self-efficacy and reducing mathematics anxiety in elementary settings. Hung, Huang, and Hwang (2014) demonstrated that game-based learning improved achievement, self-efficacy, and motivation, though differences in anxiety across conditions were non-significant (n=69, three groups), suggesting that while engagement-focused interventions strengthen positive affect, anxiety reduction may require more targeted strategies. Katz (2015) documented that classroom interventions combining goal-setting, strategy training, and reflection substantially increased self-efficacy, achievement, and reduced accompanying anxiety (action research, 8 sixth-graders), illustrating that even small-scale, teacher-led initiatives can meaningfully impact affective dimensions. Tarkar et al. (2022) found that mathematics anxiety relates to avoidance of challenging problems and lower success rates, while emotional self-efficacy enhances willingness to attempt difficult tasks, suggesting that scaffolding emotional regulation alongside mathematical problem-solving supports healthier engagement patterns. Collectively, these intervention studies indicate that affective dimensions respond to deliberate instructional attention, with most effective approaches combining: incremental success experiences, explicit strategy instruction, metacognitive reflection, supportive classroom climates, and differentiated challenge levels that maintain optimal difficulty without overwhelming anxiety.

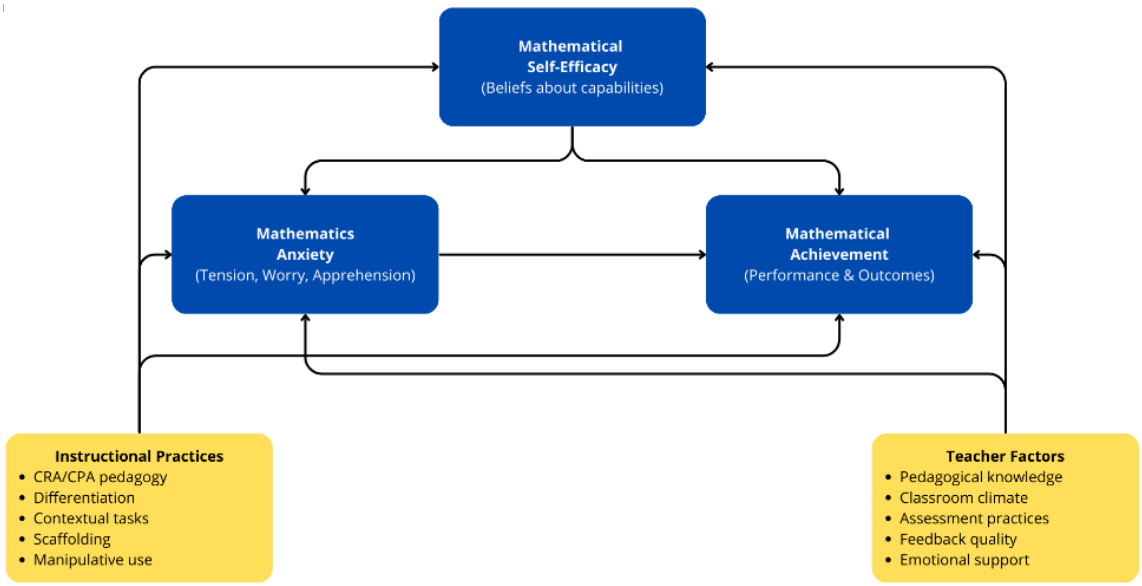


Figure 1. Conceptual Model of Relationships Among Self-Efficacy, Mathematics Anxiety, and Achievement in Elementary Mathematics Learning

Challenges in Implementing Numeracy Literacy within the Merdeka Curriculum

Analysis of twelve studies examining Merdeka Curriculum implementation reveals substantial challenges preventing effective integration of numeracy literacy into fourth-grade mathematics instruction (Ramdhani et al., 2024). Khomaria and Jupri (2024) identified critical misconceptions among elementary teachers who separate "numeracy drills" from mathematics learning, fail to understand AKM Kelas diagnostic functions, and focus on assessment preparation rather than improving instructional quality. Hidayah et al. (2024) confirmed that despite generally positive perceptions, mathematics teachers struggle integrating numeracy into curriculum objectives and programs (AKM, PSP), particularly regarding contextual problem design and numeracy assessment construction. These conceptual confusions fundamentally undermine numeracy literacy goals, as teachers cannot effectively foster mathematical reasoning, data interpretation, and real-world application when viewing numeracy as supplementary content rather than core instructional quality dimensions. The disconnect between policy rhetoric emphasizing integrated numeracy competencies and teachers' operational understandings represents a primary implementation obstacle requiring urgent attention through targeted professional development.

Studies examining general Merdeka Curriculum implementation challenges reveal systemic obstacles affecting mathematics instruction quality (Hasriani et al., 2024). Yunitasari et al. (2023) synthesized findings from 47 studies, identifying primary barriers including: inadequate teacher understanding of Merdeka Curriculum concepts, difficulties adapting to new practices, and insufficient readiness, consequently hampering differentiated instruction and contextual numeracy-literacy integration. Rustini et al. (2023) documented challenges including limited training, inadequate learning resources and facilities, and excessive administrative burdens consuming planning time needed for contextual numeracy activity design. Sutinah et al. (2024) revealed disconnects between teachers' subjective readiness perceptions and substantive understanding, with particular difficulties implementing project-based learning and assessment practices essential for contextual numeracy. Mulabbiyah et al. (2024) detailed structural constraints including: insufficient mastery of instructional material development, excessive module preparation time, inadequate infrastructure, large class sizes in limited space preventing effective differentiation, and challenges conducting diagnostic and formative numeracy assessments. These converging findings indicate that implementation challenges span conceptual, pedagogical, structural, and resource dimensions, requiring multifaceted intervention strategies rather than isolated professional development sessions.

Additional studies examining specific grade levels and school contexts provide granular understanding of implementation realities. Asmahasanah, Chairunnissa, and Hakim (2023) documented first-grade teachers' difficulties understanding new terminology (CP, TP, modul ajar, P5), overwhelming preparation demands, and students' unreadiness for project-based integration, limiting time for meaningful numeracy activity design. Basuki, Ahmad, and Zulaikha (2023) found that despite positive reception, hasty implementation, minimal socialization and training, and absent clear guidance prevented teachers from developing learning materials and books aligned with student development, including numeracy competencies. Sephiawardani and Bektiningsih (2023) revealed that while teachers demonstrated adequate planning readiness, post-pandemic achievement gaps created difficulties adjusting to diverse student levels, hampering differentiated numeracy task implementation. Nurhaswinda et al. (2025) observed that despite generally successful literacy-numeracy implementation in fourth grade, challenges persisted regarding classroom spatial arrangements, limited facilities, and large group sizes

preventing effective targeted numeracy activities. These contextual studies demonstrate that implementation obstacles vary across school types, grade levels, and regional contexts, necessitating differentiated support responsive to specific local challenges rather than uniform national interventions.

Figure 2 illustrates five interrelated categories of challenges in implementing numeracy literacy within the Merdeka Curriculum: conceptual understanding, pedagogical design, resource limitations, training and support, and structural constraints. These challenges are reflected in teachers' misconceptions about numeracy literacy, difficulties designing contextual and differentiated learning activities, inadequate instructional resources, insufficient professional development, and classroom conditions that restrict effective implementation. The figure synthesizes the recurring challenges identified across the reviewed studies and highlights the need for coordinated interventions addressing teachers' pedagogical competencies and the structural conditions of mathematics instruction.

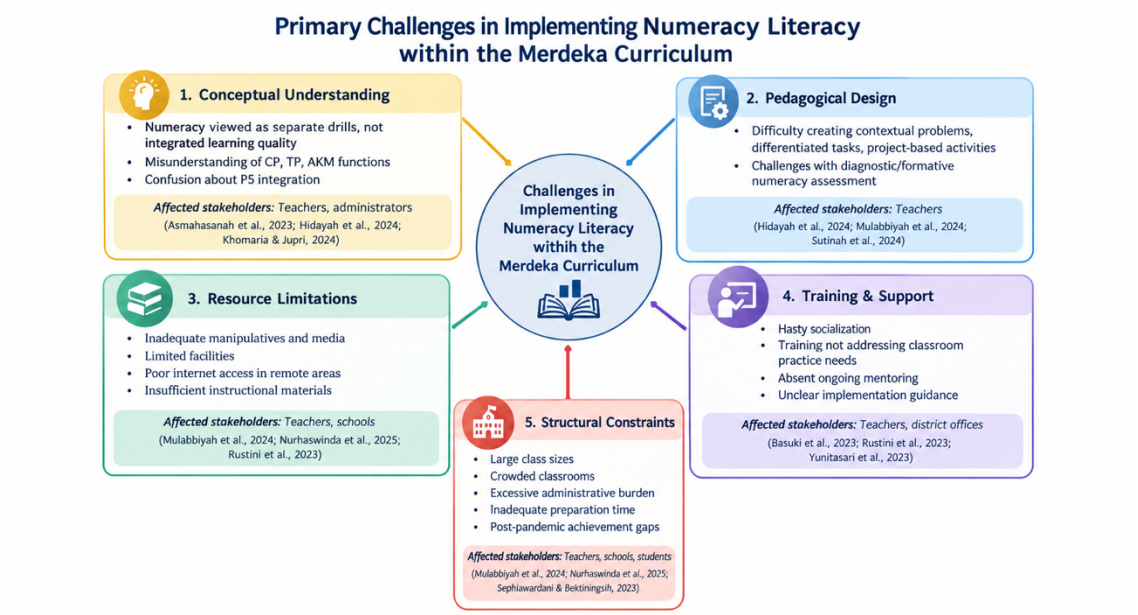


Figure 2. Primary Challenges in Implementing Numeracy Literacy within the Merdeka Curriculum

To provide a more detailed account of these challenges, Table 2 presents the five categories of implementation challenges, their specific manifestations, the stakeholders affected, and the supporting references identified in the reviewed literature.

Table 2. Primary Challenges in Implementing Numeracy Literacy within Merdeka Curriculum

Challenge Category	Specific Manifestations	Affected Stakeholders	Supporting Studies
Conceptual Understanding	Numeracy viewed as separate drills, not integrated learning quality; misunderstanding of CP, TP, AKM functions; confusion about P5 integration	Teachers, administrators	(Asmahasanah et al., 2023; Hidayah et al., 2024; Khomaria & Jupri, 2024)
Pedagogical Design	Difficulty creating contextual problems, differentiated tasks, project-based activities; challenges with diagnostic/formative numeracy assessment	Teachers	(Hidayah et al., 2024; Mulabbiyah et al., 2024; Sutinah et al., 2024)
Resource Limitations	Inadequate manipulatives and media, limited facilities, poor internet access in remote areas, insufficient instructional materials	Teachers, schools	(Mulabbiyah et al., 2024; Nurhaswinda et al., 2025; Rustini et al., 2023)
Training & Support	Hasty socialization, training not addressing classroom practice needs, absent ongoing mentoring, unclear implementation guidance	Teachers, district offices	(Basuki et al., 2023; Rustini et al., 2023; Yunitasari et al., 2023)
Structural Constraints	Large class sizes, crowded classrooms, excessive administrative burden, inadequate preparation time, post-pandemic achievement gaps	Teachers, schools, students	(Mulabbiyah et al., 2024; Nurhaswinda et al., 2025; Sephiawardani & Bektiningsih, 2023)

Note: CP = Capaian Pembelajaran (Learning Outcomes); TP = Tujuan Pembelajaran (Learning Objectives); P5 = Projek Penguatan Profil Pelajar Pancasila (Profile Strengthening Projects)

DISCUSSION

Cognitive-Developmental Foundations and Pedagogical Implications

Fourth-grade mathematics learning occurs during a critical developmental transition when students shift from predominantly concrete operational thinking toward early formal operational reasoning, as conceptualized within Piagetian frameworks. Research evidence demonstrates that this transitional period requires pedagogical approaches explicitly designed to bridge concrete experiences with increasingly abstract mathematical representations and symbolic manipulations (Clements et al., 2023; Yu et al., 2024). The cognitive demands of fourth-grade content particularly fractions, multi-digit operations, geometric reasoning, and algebraic pattern recognition exceed what purely concrete or purely abstract instruction can effectively address. Students require

systematic progression through enactive (hands-on), iconic (pictorial), and symbolic (abstract) representational modes, with sufficient instructional time and scaffolding at each level before advancement (Al-Salahat, 2022; Umuhoza & Hakizimana, 2024). However, classroom observations consistently reveal problematic practices including premature rush to symbolic procedures without adequate concrete foundation, or conversely, prolonged concrete manipulation without facilitating abstraction, both resulting in superficial procedural knowledge lacking conceptual depth. Effective fourth-grade pedagogy must operationalize developmental principles through deliberate instructional design that honors students' cognitive readiness while strategically advancing toward abstraction through carefully sequenced representational experiences.

The Indonesian Realistic Mathematics Education (PMRI) approach offers particularly promising frameworks for fourth-grade instruction by emphasizing contextual problems that are "experientially real" to students, regardless of whether situations are physically encountered or imaginable. Saleh et al. (2017) demonstrated PMRI's effectiveness in enhancing mathematical reasoning through realistic contexts and concrete objects that facilitate abstraction, particularly for conceptually challenging fraction content. This approach aligns with international research on contextual learning while incorporating Indonesian cultural contexts through ethnomathematics integration. The RME principle of "horizontal mathematization" where students organize real-world phenomena using mathematical tools followed by "vertical mathematization" where mathematical ideas themselves become objects of analysis provides pedagogical roadmap for concrete-abstract transitions (Saleh et al., 2017). However, successful PMRI implementation requires substantial pedagogical content knowledge regarding how to select appropriate contexts, facilitate mathematical model emergence from realistic situations, and guide progressive formalization toward conventional mathematical notation and procedures. Current challenges include teachers' limited access to contextually rich task repositories, insufficient training in RME facilitation techniques, and pressure to cover extensive content rapidly, leaving inadequate time for exploratory, context-based learning experiences that PMRI methodology demands.

The critical role of the representational/pictorial phase in concrete-abstract transitions deserves particular emphasis, as this intermediate stage is frequently minimized or omitted in fourth-grade instruction despite its pedagogical significance

(Hussein et al., 2022). Umuhoza and Hakizimana (2024) identified the pictorial phase as essential bridging space where students develop critical thinking about visual representations, manipulate images mentally, and begin formalizing relationships before encountering purely symbolic abstraction. During this phase, students translate concrete actions into drawings, diagrams, number lines, and other visual models, gradually internalizing mathematical relationships while maintaining perceptual supports. Research indicates that premature movement from concrete manipulatives directly to symbolic notation often results in students mechanically mimicking procedures without understanding underlying concepts (Clements et al., 2023). The representational phase allows students to experiment with mathematical ideas in semi-concrete form, test hypotheses visually, and develop visual-symbolic connections that facilitate subsequent abstract thinking. Fourth-grade teachers require professional development specifically addressing how to leverage representational thinking including strategic use of visual models, student-generated diagrams, and technology-based dynamic representations as powerful mediators between concrete experiences and formal mathematical symbolism.

Affective Dimensions and Mathematical Identity Development

The consistent evidence regarding bidirectional relationships among self-efficacy, mathematics anxiety, and achievement carries profound implications for fourth-grade instructional practice, suggesting that affective dimensions cannot be treated as peripheral concerns but must be central to pedagogical design. Du et al. (2021) established that mathematical self-efficacy and achievement mutually reinforce or undermine each other longitudinally, while mathematics anxiety reciprocally influences both constructs, creating either virtuous or vicious cycles affecting students' mathematical trajectories. Fourth grade represents a particularly consequential period for affective development, as students encounter increasingly challenging content, face heightened performance expectations, and begin forming stable beliefs about their mathematical abilities that persist into adolescence (Ruijia et al., 2022; Živković et al., 2023). Teachers' instructional choices including task difficulty calibration, feedback specificity, public performance requirements, competitive versus cooperative structures, and pace pressures significantly shape whether students develop confident, resilient mathematical identities or anxious, avoidant orientations. Pedagogical approaches that emphasize mastery goals over performance goals, provide differentiated challenge levels maintaining optimal difficulty,

celebrate effort and strategy use rather than speed or innate ability, and normalize struggle as essential to mathematical learning create classroom environments supporting positive self-efficacy development while preventing mathematics anxiety emergence.

The mediating role of self-regulation and metacognition in relationships between self-efficacy and anxiety documented by Guntur and Purnomo (2024) highlights the importance of explicitly teaching students regulatory strategies alongside mathematical content. Students with strong self-regulatory skills including goal-setting, strategy selection, progress monitoring, and adaptive response to difficulties experience less mathematics anxiety even when encountering challenging content because they possess tools for managing cognitive and emotional demands effectively. Fourth-grade instruction should deliberately incorporate metacognitive scaffolding, prompting students to articulate their thinking processes, evaluate strategy effectiveness, identify error sources, and reflect on learning progress. Such practices not only enhance mathematical understanding but simultaneously develop self-regulation competencies that buffer against anxiety and support self-efficacy maintenance during difficulty (Guntur & Purnomo, 2024). However, typical fourth-grade mathematics instruction focuses predominantly on content coverage and correct answer production, with minimal attention to process reflection or strategy instruction. Reorienting instruction toward balanced emphasis on content mastery and self-regulated learning processes requires significant pedagogical shifts, including reduced content density to allow time for reflection, assessment practices evaluating thinking processes alongside correctness, and classroom discourse norms valuing explanation and justification over rapid response production.

Intervention research demonstrating self-efficacy and anxiety responsiveness to instructional practices offers hope that deliberate pedagogical attention can positively influence affective trajectories even within existing classroom constraints. Katz (2015) documented meaningful improvements in self-efficacy, achievement, and anxiety reduction through classroom-based interventions combining goal-setting, strategy instruction, and reflection, implemented by regular teachers without extensive external resources. These findings suggest that affective interventions need not require specialized programs or extensive additional time but rather involve reframing existing instructional practices through affective-sensitive lenses. Key principles include: structuring learning

experiences to ensure frequent, incremental success; providing specific, process-focused feedback emphasizing controllable factors; teaching problem-solving strategies explicitly rather than assuming students intuit effective approaches; creating classroom cultures where errors are learning opportunities rather than failures; and differentiating task difficulty so all students experience appropriate challenge maintaining engagement without overwhelming anxiety (Katz, 2015; Tarkar et al., 2022). Fourth-grade teachers require support recognizing how seemingly neutral instructional decisions pacing, grouping, questioning patterns, wait time, public performance requirements carry affective consequences, along with practical strategies for designing learning environments that simultaneously advance mathematical understanding and foster positive mathematical identities.

Numeracy Literacy: Reconceptualizing Fourth-Grade Mathematics Goals

The Merdeka Curriculum's emphasis on numeracy literacy represents important shift from narrow computational skill focus toward broader mathematical competencies encompassing reasoning, problem-solving, data interpretation, and real-world application, yet substantial conceptual confusion persists regarding what numeracy literacy means operationally in fourth-grade contexts (Ramdhani et al., 2024). Khomaria and Jupri (2024) documented teachers viewing numeracy as supplementary activities separate from core mathematics instruction, fundamentally misunderstanding numeracy as quality dimension permeating all mathematical learning rather than additional content to cover. This misconception leads to fragmented learning experiences where procedural fluency is prioritized during regular mathematics lessons while isolated “numeracy tasks” are sporadically inserted, failing to develop integrated competencies that numeracy literacy entails. Genuine numeracy literacy requires that all mathematical instruction emphasize sense-making, connection to contexts, multiple solution strategies, reasoning communication, and critical evaluation of results not occasional application problems appended to procedural practice (Hidayah et al., 2024). Reconceptualizing numeracy literacy as instructional quality rather than content addition requires fundamental shifts in teachers' pedagogical thinking, curriculum interpretation, and assessment practices transformations demanding sustained professional development far exceeding current brief workshop-based training models.

The disconnect between curriculum policy intentions and classroom implementation realities reflects deeper tensions regarding what elementary mathematics education should accomplish and how achievement should be assessed. Asesmen Kompetensi Minimum (AKM) emphasizes contextual problem-solving, reasoning, and application competencies, yet many teachers perceive AKM primarily as external accountability measures requiring test preparation rather than diagnostic tools informing instructional adaptation (Khomaria & Jupri, 2024). This assessment-driven mentality undermines numeracy literacy goals by narrowing instruction toward anticipated test formats rather than broadening mathematical experiences to develop flexible, adaptive competence across diverse problem contexts. Additionally, teachers express legitimate concerns that comprehensive numeracy literacy development requiring time for exploration, discussion, multiple representations, and contextual connection conflicts with extensive content coverage expectations and standardized assessment pressures (Hidayah et al., 2024; Sutinah et al., 2024). These systemic tensions cannot be resolved through teacher training alone but require coherent policy alignment ensuring curriculum scope, instructional time allocations, assessment practices, and accountability mechanisms collectively support rather than undermine numeracy literacy goals. Fourth-grade teachers need explicit guidance regarding content prioritization, permission to reduce breadth for depth, exemplary task models demonstrating contextual numeracy integration across content domains, and assessment tools evaluating reasoning processes alongside computational correctness.

Effective numeracy literacy development in fourth grade requires integrating mathematical content with real-world contexts meaningful and accessible to 9-10 year-old students while maintaining appropriate cognitive challenge and mathematical rigor. Research on contextual problem design indicates that effective tasks possess several key characteristics: situations are genuinely problematic rather than thin story wrappings around computational exercises; contexts are experientially real to students through personal experience or vivid imagination; multiple solution strategies are viable, promoting reasoning diversity; mathematical relationships are embedded within contexts rather than explicitly stated, requiring students to mathematize situations; and tasks afford extension and generalization, connecting specific instances to broader mathematical principles (Saleh et al., 2017; Thu & Linh, 2024). However, many commercially available

and teacher-designed "contextual problems" fail these criteria, presenting artificial scenarios disconnected from students' lives, containing all necessary information explicitly, affording single solution paths, and requiring simple computational retrieval rather than genuine mathematical reasoning. Developing high-quality contextual numeracy tasks demands substantial pedagogical content knowledge regarding: age-appropriate contexts spanning students' diverse backgrounds; mathematical potential within everyday situations; scaffolding strategies supporting diverse learners; and facilitation techniques promoting mathematical discourse around contextual explorations (Hidayah et al., 2024). Fourth-grade teachers require access to curated, high-quality task repositories aligned with curriculum competencies, along with protocols for adapting existing materials and creating original contextual problems responsive to local community contexts through ethnomathematics integration.

Structural and Systemic Implementation Challenges

Analysis of Merdeka Curriculum implementation challenges reveals that pedagogical transformation aspirations confront substantial structural obstacles including inadequate resources, insufficient preparation time, large class sizes, and teacher professional development systems not designed for the ambitious instructional shifts curriculum demands (Hasriani et al., 2024). Mulabbiyah et al. (2024) documented that large class sizes (often 30-40 students) in limited physical space make differentiated mathematics instruction practically infeasible, as teachers cannot circulate supporting small groups, monitor individual progress, or provide targeted interventions while maintaining classroom management. These structural constraints are particularly problematic for mathematics learning requiring manipulative use, collaborative problem-solving, and individualized scaffolding all central to effective fourth-grade pedagogy but logistically challenging in crowded classrooms with insufficient materials (Nurhaswinda et al., 2025). Additionally, excessive administrative documentation requirements consume planning time teachers need for developing contextual tasks, creating differentiated materials, and reflecting on student learning patterns. These structural realities indicate that improving fourth-grade mathematics learning quality requires not only teacher capacity building but also systemic reforms addressing workload, class size policies, resource allocation, and administrative expectations creating conditions where ambitious pedagogy becomes

feasible rather than aspirational rhetoric overwhelming already-burdened teachers (Rustini et al., 2023; Yunitasari et al., 2023).

The inadequacy of current professional development models for supporting Merdeka Curriculum implementation represents critical systemic weakness requiring urgent attention. Multiple studies document that teachers receive brief, one-time workshops providing general curriculum orientation but insufficient practical guidance regarding specific pedagogical strategies for mathematics instruction (Basuki et al., 2023; Sutinah et al., 2024). Effective professional development for complex pedagogical transformation requires sustained engagement over extended periods, including: initial conceptual grounding in curriculum principles and learning progressions; concrete modeling of instructional strategies through demonstration lessons; supported implementation in teachers' own classrooms with coaching and feedback; collaborative reflection analyzing student work and refining practices; and ongoing collegial learning communities providing continuous support (Rustini et al., 2023). Current workshop-based models provide none of these essential elements, leaving teachers to independently interpret curriculum documents, develop implementation strategies through trial-and-error, and manage challenges without expert guidance. Fourth-grade mathematics instruction would benefit from differentiated professional development responsive to teachers' existing knowledge and skill levels, focused on specific content domains (fractions, geometry, measurement) where pedagogical content knowledge gaps are most consequential, and incorporating sustained classroom-embedded coaching supporting iterative practice refinement rather than expecting transformation from isolated training events.

The particular challenges facing teachers in remote, under-resourced schools deserve explicit attention, as numeracy literacy goals emphasizing contextual, exploratory, manipulative-rich instruction require material and technological resources many Indonesian elementary schools lack. Rural schools often have inadequate supplies of basic manipulatives (fraction pieces, geometric solids, base-ten blocks), minimal technology access preventing use of digital learning tools, and limited professional learning opportunities due to geographical isolation (Rustini et al., 2023). These resource disparities create inequitable implementation where well-resourced urban schools can actualize curriculum intentions while under-resourced rural schools maintain traditional

procedural instruction, exacerbating existing achievement gaps. Addressing these inequities requires targeted interventions including: development of low-cost, locally-sourced manipulative alternatives using community materials; creation of offline-accessible digital resources; mobile professional development bringing expert support to remote locations; and peer learning networks connecting geographically dispersed teachers facing similar challenges. Additionally, curriculum implementation expectations must acknowledge contextual realities, providing differentiated guidance for resource-constrained settings rather than assuming uniform capacity across all schools to implement idealized pedagogical approaches requiring substantial material and technological infrastructure currently unavailable in many Indonesian elementary schools.

Toward Integrated Pedagogical Frameworks for Fourth-Grade Mathematics

Synthesizing findings across cognitive-developmental foundations, affective dimensions, concrete-abstract transitions, and numeracy literacy conceptualizations suggests the need for integrated pedagogical frameworks specifically designed for fourth-grade mathematics instruction that addresses these multiple dimensions simultaneously rather than treating them as separate concerns. Effective fourth-grade mathematics pedagogy must: (1) honor students' concrete operational thinking while strategically advancing toward abstraction through systematic CRA/CPA progressions; (2) explicitly address self-efficacy development and anxiety prevention through mastery-oriented goal structures, differentiated challenge, and metacognitive scaffolding; (3) embed mathematical learning within contextually rich, meaningful problems requiring reasoning and sense-making; (4) provide substantial time for exploratory, collaborative investigation rather than rapid coverage of fragmented skills; (5) utilize diverse representational modes including manipulatives, visual models, technology-based simulations, and symbolic notation with explicit connection-making across representations; and (6) assess understanding through performance tasks evaluating reasoning processes, problem-solving strategies, and communication competence alongside computational accuracy. These principles align with contemporary learning sciences research while respecting fourth-graders' developmental characteristics, yet substantial gaps persist between research evidence and typical classroom practices,

indicating the need for more effective translation mechanisms bridging research and practice communities.

Implementation of such integrated frameworks requires reconceptualizing teacher preparation and professional development to develop sophisticated pedagogical content knowledge specific to elementary mathematics. Fourth-grade teachers need deep understanding of: mathematical learning progressions across elementary years; cognitive development principles and their instructional implications; affective factors influencing mathematics learning and classroom practices shaping self-efficacy and anxiety; concrete-abstract transition strategies including manipulative selection and representational sequencing; numeracy literacy competencies and contextual task design; formative assessment techniques informing instructional adaptation; differentiation strategies accommodating diverse readiness levels; and culturally responsive pedagogy incorporating students' diverse backgrounds and community contexts. Current teacher preparation programs typically provide general pedagogy and content knowledge separately without adequate integration, while in-service professional development focuses on isolated strategies rather than comprehensive pedagogical frameworks. Developing fourth-grade mathematics teaching expertise requires extended, practice-embedded learning opportunities where teachers: study student thinking through work analysis and clinical interviews; practice instructional strategies in supported contexts with expert feedback; collaborate analyzing teaching challenges and co-developing solutions; and engage in sustained inquiry cycles investigating their own practice effectiveness. Such intensive professional learning models require substantial investment but represent necessary prerequisites for actualizing research-based pedagogical transformations at scale.

Finally, achieving widespread improvement in fourth-grade mathematics learning quality requires policy coherence across curriculum standards, assessment systems, instructional time allocations, resource provisions, and accountability structures. Current misalignments where curriculum emphasizes reasoning and problem-solving while assessments prioritize computational speed, or policy mandates differentiated instruction while structural conditions prevent its implementation create untenable situations for teachers attempting to navigate contradictory demands. Policymakers must ensure that: curriculum scope is realistic given available instructional time, allowing depth over

breadth; assessment practices evaluate competencies curriculum prioritizes, including reasoning and application alongside computation; professional development receives sustained funding supporting ongoing teacher learning rather than sporadic workshops; schools have adequate materials, technology, and physical infrastructure enabling recommended pedagogical approaches; class sizes and teacher workloads permit individualized attention and thoughtful lesson preparation; and accountability systems recognize improvement processes and contextual challenges rather than punishing schools serving disadvantaged populations for achievement gaps rooted in structural inequities. Creating conditions where excellent fourth-grade mathematics teaching becomes normative rather than exceptional requires systemic transformation addressing these multiple policy domains coherently, guided by research evidence regarding effective elementary mathematics pedagogy and realistic understanding of implementation requirements.

CONCLUSION

This comprehensive literature review reveals that effective fourth-grade mathematics learning requires carefully orchestrated pedagogical approaches bridging concrete experiences with increasingly abstract mathematical thinking while simultaneously addressing students' affective development and contextual meaning-making. Research consistently demonstrates that systematic progression through concrete-representational-abstract sequences, when implemented with adequate time and strategic scaffolding at each level, significantly enhances conceptual understanding across diverse mathematical content domains. However, classroom observations indicate substantial implementation gaps, with instruction often rushing to symbolic procedures without sufficient concrete foundation or conversely maintaining students at manipulative levels without facilitating abstraction. The critical representational phase, serving as essential bridge between concrete and abstract thinking, receives inadequate attention despite its pedagogical significance for supporting students' progressive internalization of mathematical relationships and preparing for formal symbolic reasoning.

Affective dimensions particularly mathematical self-efficacy and anxiety prove equally consequential for learning outcomes, exhibiting bidirectional relationships with achievement that create either virtuous or vicious cycles affecting students' long-term

mathematical trajectories. Fourth grade represents critical period for mathematical identity formation, when instructional practices significantly shape whether students develop confident, resilient orientations or anxious, avoidant stances persisting into higher education levels. Merdeka Curriculum aspirations regarding numeracy literacy and differentiated instruction, while pedagogically sound, confront substantial implementation challenges including conceptual misconceptions, inadequate teacher preparation, resource limitations, structural constraints, and policy misalignments undermining transformation intentions. Addressing these challenges requires systemic interventions spanning teacher professional development, resource allocation, policy coherence, and structural reforms creating conditions where research-based pedagogical approaches become feasible for all fourth-grade teachers rather than exceptional practices possible only in well-resourced contexts.

AI Use Statement

The authors used AI tools, if applicable, for language editing and proofreading. The authors take full responsibility for the manuscript's content.

Author Contributions

S: contributed to conceptualization, literature screening, and manuscript drafting. FAA: contributed to data extraction and synthesis. S: contributed to supervision and critical manuscript review. RP: contributed to literature analysis and manuscript revision. All authors approved the final manuscript.

Funding Statement

This research received no specific funding from public, commercial, or nonprofit funding agencies.

Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

Al-Salahat, M. M. S. (2022). The Effect of Using Concrete-Representational-Abstract Sequence in Teaching the Perimeter of Geometric Shapes for Students with Learning Disabilities. *International Journal of Education in Mathematics, Science and Technology*. https://doi.org/10.46328/ijemst.2403

Alghtani, O., & Abdulhamied, N. A. (2010). The Effectiveness of Geometric Representative Approach in Developing Algebraic Thinking of Fourth Grade Students. *Procedia - Social and Behavioral Sciences*, *8*, 256–263. https://doi.org/10.1016/j.sbspro.2010.12.035

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: teacher challenges and strategies. *Journal of Integrated Elementary Education*. https://doi.org/10.21580/jieed.v3i2.17592

Basuki, G., Ahmad, M., & Zulaikha, S. (2023). Implementation Of Merdeka Curriculum In Public School In Menteng Central Jakarta. *International Conference On Digital Advance Tourism, Management And Technology*. https://doi.org/10.56910/ictmt.v1i2.120

Clements, D., Lizcano, R., & Sarama, J. (2023). Research and Pedagogies for Early Math. *Education Sciences*. https://doi.org/10.3390/educsci13080839

Du, C., Qin, K., Wang, Y., & Xin, T. (2021). Mathematics interest, anxiety, self-efficacy and achievement: Examining reciprocal relations. *Learning and Individual Differences*. https://doi.org/10.1016/j.lindif.2021.102060

Guntur, M., & Purnomo, Y. (2024). Unravelling the interplay of self-efficacy, self-regulation, metacognition in alleviating math anxiety among primary school student: a conditional process analysis. *Education 3-13*. https://doi.org/10.1080/03004279.2024.2396096

Hasriani, H., Yanto, Y., Mayaputri, V., & Mahendra, O. (2024). A study on teacher's obstacles in implementing the Merdeka Curriculum at elementary school. *Journal of Professional Teacher Education*. https://doi.org/10.12928/jprotect.v2i2.1109

Hidayah, I. R., Sa'dijah, C., Anwar, L., Yerizon, Y., & Arnawa, I. (2024). Empowering students' numeracy skills: Mathematics teachers' perceptions regarding the effectiveness and challenges of Indonesian national curriculum and the programs – A mixed method study. *Infinity Journal*. https://doi.org/10.22460/infinity.v14i1.p163-188

Hung, C.-M., Huang, I., & Hwang, G.-J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. *Journal of Computers in Education*, *1*, 151–166. https://doi.org/10.1007/s40692-014-0008-8

Hussein, M. H., Ow, S. H., Elaish, M. M., & Jensen, E. O. (2022). Digital game-based learning in K-12 mathematics education: a systematic literature review. *Education and Information Technologies*, *27*(2), 2859–2891. https://doi.org/10.1007/s10639-021-10721-x

Kaskens, J., Segers, E., Goei, S., Luit, J., & Verhoeven, L. (2020). Impact of Children's math self-concept, math self-efficacy, math anxiety, and teacher competencies on math development. *Teaching and Teacher Education*, *94*, 103096. https://doi.org/10.1016/j.tate.2020.103096

Katz, S. (2015). Enhancing Self-efficacy of Elementary School Students to Learn Mathematics. *Journal of Combinatorial Theory, Series A*, *4*, 42–55. https://doi.org/10.5430/jct.v4n1p42

Khomaria, I., & Jupri, A. (2024). Teachers' Perception of Numeracy in Mathematics Learning in the Merdeka Curriculum. *Mimbar Sekolah Dasar*. https://doi.org/10.53400/mimbar-sd.v11i2.71808

Mahmudah, W. N., Hermanto, Diri, E., Matematika, H. B., & Pembelajaran, D. (2024). Self Efficacy on Mathematics Learning Outcomes of Elementary School Students The Impact of Online Learning. *JPI (Jurnal Pendidikan Indonesia)*. https://doi.org/10.23887/jpiundiksha.v13i1.43030

Mulabbiyah, Desmawanti, R., & Sulong, R. (2024). Teacher Readines And Challenges In Implementation Of Merdeka Curriculum In Madrasah Ibtidaiyah. *El Midad*. https://doi.org/10.20414/elmidad.v16i1.9895

Nurhaswinda, Fitriani, A., Putri, A., Prorida, D., Valensi, O., Anggraini, P., & Anjani, T. (2025). Implementasi Pembelajaran Literasi dan Numerasi Berbasis Kurikulum Merdeka di Kelas IV SD Negeri 007 Bangkinang. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*. https://doi.org/10.31004/jerkin.v3i4.1410

Pellegrini, M., Lake, C., Neitzel, A., & Slavin, R. (2021). Effective Programs in Elementary Mathematics: A Meta-Analysis. *AERA Open*, *7*. https://doi.org/10.1177/2332858420986211

Pittalis, M., Sproesser, U., Demosthenous, E., & Odysseos, E. (2024). Enhancing functional thinking in grade 5–6 students through a dynamic mathematics intervention program. *Education and Information Technologies*, *30*, 1329–1361. https://doi.org/10.1007/s10639-024-12865-y

Ramdhani, R. A., Mujiwati, Y., Damayanti, A. M., Safiudin, K., & Kholis, N. (2024). Substantial Feasibility of Implementing the Merdeka Curriculum: Analysis of Teachers' Teaching Perspectives in Elementary School. *Madako Elementary School*. https://doi.org/10.56630/mes.v3i1.232

Reyes, J. (2024). Effectiveness of Abstract – Visual – Concrete Approach in Enhancing Students' Level of Conceptual Understanding and Mathematical Self-Efficacy. *International Journal of Contemporary Sciences (IJCS)*. https://doi.org/10.55927/ijcs.v1i12.11722

Ruijia, Z., Talib, O., Burhanuddin, N. A. N. B., & Wenling, L. (2022). The Effect of Math Self-Concept and Self-Efficacy on the Math Achievement of Sixth-Grade Primary School Students. *International Journal of Academic Research in Progressive Education and Development*. https://doi.org/10.6007/ijarped/v11-i3/14721

Rustini, T., Komariah, K., Wahyuningsih, Y., Dewi, D. A., Fujiyana, A., Asti, I. S., & Zahrana, Z. (2023). Implementation Workshop of the Merdeka Curriculum for Elementary School Teachers in Pangandaran Regency. *Jurnal Pengabdian Masyarakat*. https://doi.org/10.32815/jpm.v4i2.1883

Safiyah, S., & Widyastuti. (2022). The Relationship Between Academic Self-Efficacy and Mathematics Anxiety in Upper Elementary School Students. *Academia Open*. https://doi.org/10.21070/acopen.7.2022.5459

Saleh, M., Prahmana, R., Isa, M., & Murni, M. (2017). Improving The Reasoning Ability Of Elementary School Student Through The Indonesian Realistic Mathematics Education. *Journal on Mathematics Education*, *9*, 41–54. https://doi.org/10.22342/jme.9.1.5049.41-54

Sephiawardani, N. A., & Bektiningsih, K. (2023). Review of Teacher Readiness in Implementing Merdeka Curriculum at Public Elementary Schools. *Jurnal Pendidikan Dan Pengajaran*. https://doi.org/10.23887/jpp.v56i3.67628

Sutinah, C., Riyadi, A., Muftianti, A., Wulandari, M., & Ruqoyyah, S. (2024). Navigating Change: An Analysis of Elementary School Teachers' Readiness and Implementation Challenges with the Merdeka Curriculum. *AL-ISHLAH: Jurnal Pendidikan*. https://doi.org/10.35445/alishlah.v16i2.5142

Tarkar, A., Matalka, B., Cartwright, M., & Kloos, H. (2022). Student-Guided Math Practice in Elementary School: Relation among Math Anxiety, Emotional Self-Efficacy, and Children's Choices When Practicing Math. *Education Sciences*. https://doi.org/10.3390/educsci12090611

Thu, H. L. T., & Linh, H. V. (2024). Some Measures to Develop Abstract and Generalizing Thinking for 4th-Grade Students in Teaching the Topic of Calculations with Fractions. *International Journal of Social Science and Human Research*. https://doi.org/10.47191/ijsshr/v7-i10-85

Tran, T. A., & Duong, V. (2023). Improving Mathematics Learning Outcomes Using Concrete Props in Grade V Elementary School Students. *IRAONO: Journal of Elementary and Childhood Education*. https://doi.org/10.56207/iraono.v1i1.115

Umuhoza, R., & Hakizimana, T. (2024). Concrete Pictorial Abstract Approach Use in Teaching Mathematics on Secondary Students' Participation in Six Selected Schools in Kicukiro District, Rwanda. *African Journal of Empirical Research*. https://doi.org/10.51867/ajernet.5.4.102

Yu, S., Jantharajit, N., & Srikhao, S. (2024). An instructional approach in mathematics learning for fourth-grade students based on collaborative learning and inquiry-based learning. *Asian Journal of Contemporary Education*. https://doi.org/10.55493/5052.v8i2.5099

Yunitasari, D., Suastra, W., Lasmawan, W., Jl, H., Tgkh, M., Abdul, Z., No, M., & 132, S. (2023). Implementation challenges of merdeka curriculum in primary schools. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*. https://doi.org/10.33394/j-ps.v11i4.8079

Živković, M., Pellizzoni, S., Doz, E., Cuder, A., Mammarella, I., & Passolunghi, M. (2023). Math self-efficacy or anxiety? The role of emotional and motivational contribution in math performance. *Social Psychology of Education*, 1–23. https://doi.org/10.1007/s11218-023-09760-8