Evaluating Mathematical Representation Competence Among Primary Students: Insights from the Post-Pandemic Learning Recovery

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ABSTRACT

Purpose of the study: The study aims to investigate not only the fundamental mathematical knowledge of primary school students but also their mathematical representation skills, as these are essential for applying mathematical concepts in everyday life.

Methodology: A descriptive research design was employed without any treatment. The instrument included a test measuring representation skills through three indicators: forming equations or models from given representations, drawing diagrams to clarify and solve problems, and composing stories based on given representations. Secondary data were gathered through field notes and analysed using descriptive statistics, followed by triangulation with observation results.

Main Findings: The findings reveal that students' mathematical representation skills remain underdeveloped. The lowest performance was observed in the indicator involving drawing diagrams to support problem-solving. These results suggest a mismatch between students' learning needs and current instructional strategies, underscoring the need to implement differentiated and inclusive approaches to better support diverse learners.

Novelty/Originality of this study: The study introduces a validated diagnostic test administered prior to the main assessment, ensuring the reliability and validity of the research results. This approach minimises bias and provides a more accurate portrayal of students' actual representation abilities, offering new insights into differentiated learning in mathematics education.

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1. INTRODUCTION

The COVID-19 pandemic and its aftermath have significantly disrupted students' mathematical abilities, particularly at the primary education level. Numerous studies highlight a widespread pattern of learning loss, stagnation, and slower-than-expected progress in mathematics across various educational contexts. For instance, evidence from Virginia indicates a sharp 32% decline in math pass rates among students in Grades 3–8 during the first post-pandemic year compared to pre-pandemic levels [1]. Similarly, although Finnish third graders did not show an immediate drop in math scores, their developmental trajectory remained stagnant, signaling delayed cognitive progress post-lockdown [2]. Furthermore, among Head Start preschoolers in the United States, math performance was consistently lower than in pre-pandemic cohorts, despite language and literacy outcomes rebounding [3], [4]. Several researchers Scheibe underscore that math anxiety, exacerbated by pandemic-related stress, significantly hindered both conceptual and procedural learning, particularly when cognitive resources were depleted [5]. Collectively, these findings illustrate how the pandemic disrupted not only academic continuity but also the cognitive and emotional frameworks necessary for effective mathematics learning. As a result, recovery strategies must be underpinned by diagnostic tools capable of capturing shifts in students' mathematical representational abilities tools which are critically underdeveloped in current assessment practices.

In the post-pandemic context, Indonesian students especially at the primary school level have experienced a notable decline in mathematical proficiency. This learning loss has manifested most prominently in basic numeracy and representational skills, both of which are fundamental to mathematical understanding [6]-[9]. Multiple studies confirm that students struggled significantly with mathematics during the pandemic, especially as instruction shifted to online platforms [10]. The shift to remote learning not only diminished students' motivation and engagement but also restricted their ability to grasp abstract mathematical concepts [11]. For instance, younger learners faced considerable difficulties with basic arithmetic, which prompted the need for creative interventions, such as game-based learning, to restore foundational skills. Furthermore, research has shown that students' readiness to learn is closely tied to their ability to communicate mathematical ideas—an essential skill that became even more critical during the disruptions caused by COVID-19 [12]-[16]. Therefore, it is evident that recovery efforts must focus on rebuilding both procedural fluency and mathematical representation skills, which have been weakened due to prolonged school closures and ineffective online learning strategies [17]. In this context, representational skills must be prioritized, as they reflect students' ability to translate mathematical ideas into various forms—such as symbols, diagrams, or verbal explanations—which are essential for deep understanding and problem-solving. Evaluating these skills allows teachers to identify conceptual gaps that may not be visible through procedural tasks alone, ensuring more targeted and effective instruction.

As we consider the decline in students' mathematical skills, particularly in representing mathematical concepts like fractions, several studies provide evidence of this setback. For example, Unaenah et al. found that many students struggled with fraction-related problems due to gaps in basic arithmetic knowledge, while a study in Cimahi Selatan revealed that only 31.34% of fifth-grade students could solve fraction problems [18]. Similarly, Hanifah et al. reported that just 11.5% of fourth-grade students were able to solve fraction word problems [19]. The development of mathematical representation skills, which involve using symbols, diagrams, and other tools to express and solve problems, is essential for both understanding and communication. Several researchers highlights the importance of these skills in enhancing mathematical fluency and problem-solving abilities. To address these challenges, differentiated instruction, which tailors teaching to individual needs, has been suggested as a potential solution. This approach aligns with Ki Hajar Dewantara's educational philosophy of fostering each student's potential. Improving mathematical representation skills, especially in fractions, is thus a key component of enhancing students' overall mathematical development.

Recognising the diverse abilities of students in representing mathematical ideas whether in home-based or school-based learning contexts highlights the need for an assessment tool capable of accommodating such variability [20]. As learning processes are inherently differentiated, shaped by variations in students' prior knowledge, cognitive profiles, learning preferences, and progression rates, a standardised, one-size-fits-all approach to assessing mathematical understanding proves insufficient. When engaging with concepts such as fractions, students demonstrate differing capacities to represent and manipulate these ideas through symbolic, visual, physical, or verbal modes. An assessment tool that accounts for these variations enables a more precise evaluation of students' conceptual understanding and their competence in applying mathematical representations. Such differentiation is essential to ensure that recovery efforts are well-targeted and that instructional strategies effectively respond to each student's specific learning needs.

This study aims to critically examine how students' mathematical representation skills, particularly in the context of fractions, are developed during differentiated learning experiences. The research will focus on measuring how students with varying levels of understanding represent fraction-related problems using diverse mathematical tools and strategies. The central question of this investigation is: How can an assessment framework be designed to effectively capture and evaluate the diverse mathematical representation abilities of students in the domain of fractions? The novelty of this research lies in the development of a differentiated assessment framework designed to measure students' mathematical representation skills while responding flexibly to diverse learning contexts. By accommodating variations in instructional settings such as home-based and school-based environments as well as differences in learners' cognitive profiles and representational modes, the framework offers a context-sensitive approach that addresses the limitations of standardised assessment practices. This innovative approach ensures that the assessment reflects the full spectrum of students' abilities and offers a more personalized evaluation of their understanding of fractions.

2. RESEARCH METHOD

This study employed a descriptive research design to investigate students' mathematical representation abilities, particularly in the context of fractions. Despite the absence of experimental treatment, this study focusing solely on assessing the effects of existing conditions like COVID-19 offers significant insights that are instrumental in shaping subsequent strategic actions [21]-[23]. The research involved a sample of 23 fourth-grade students aged between 9 and 11 years. Prior to the assessment of representation skills, all participants underwent a diagnostic test to evaluate their basic mathematical competencies. Based on the diagnostic results, students were categorised into two groups: those requiring additional guidance and those demonstrating sufficient foundational understanding.

Participants were selected using a purposive sampling technique, with the selection criteria based on students' availability, their regular attendance in mathematics classes, and the variation in diagnostic test performance, which ensured a range of representation abilities could be observed. While the relatively small sample size is acceptable within the scope of a descriptive study, it limits the generalisability of the findings. Therefore, conclusions drawn from this research are intended to offer contextual insights rather than broad generalisations.

The research employed a diagnostic assessment instrument specifically developed to evaluate students' higher-order mathematical representational skills. This instrument was constructed based on three carefully defined indicators, each representing a distinct yet interrelated aspect of mathematical reasoning and communication. The indicators were designed not only to assess procedural knowledge but also to capture the depth of students' conceptual understanding in applying mathematics to various representations. The first indicator measured students' ability to construct mathematical equations or models derived from a given non-symbolic representation, such as diagrams, verbal descriptions, or contextual situations. This task required students to translate visual or linguistic information into formal mathematical language, reflecting their capacity for abstraction and symbolisation. The second indicator assessed students' ability to create visual representations, such as drawings or schematic diagrams, to clarify a problem and facilitate its solution. The aim was to determine whether students could strategically use imagery to support reasoning, particularly when dealing with abstract or complex concepts. The third and final indicator involved the construction of narrative scenarios that appropriately matched a given mathematical representation. In this case, students were required to develop contextual stories or situations that aligned with equations, models, or graphical data. This task assessed their ability to contextualise mathematical ideas within meaningful and coherent settings, thus bridging the gap between formal mathematics and its application in real life.

The instrument used in this study consisted of eight mathematics questions specifically designed to assess students' mathematical representation skills in the topic of fractions. In this study, mathematical representation competence is examined through three key indicators. The first refers to the ability to construct appropriate equations or mathematical models from a given representation, demonstrating the capacity to translate visual or contextual information into formal mathematical expressions. The second involves the creation of drawings or diagrams that serve not only to illustrate the problem more clearly but also to facilitate the problem-solving process itself. The third indicator concerns the composition of written narratives that align with a given mathematical representation, reflecting the student's ability to connect symbolic or visual information with coherent verbal explanations. Collectively, these indicators provide a comprehensive lens through which to assess students' representational skills in mathematics, particularly within the context of primary education.

Prior to implementation, the instrument underwent content validation by three experts, comprising two mathematics education lecturers with expertise in elementary mathematics pedagogy and one curriculum specialist familiar with assessment design. The validation process involved a structured review of each item for content relevance, clarity, and alignment with representation indicators. In addition to expert validation, the instrument was subjected to empirical testing, including analyses of reliability, item discrimination, and difficulty index. The reliability test yielded a high coefficient of $r = 0.64$ with $t_{hit} = 3.81 > t_{ta\beta le} = 1.72$, indicating statistical significance. The item discrimination values ranged from 0.18 to 0.58, with most items falling into the "adequate" to "good" categories. The difficulty index for all items fell within the "moderate" range. A summary of the instrument analysis is presented in the following table 1.

Table 1. Summary of Instrument Analysis

Aspect	Result	Interpretation
Reliability	$r = 0.64$; $t_{hit} = 3.81$	High, statistically significant
Item Discrimination	0.18 – 0.58	1 item poor; others adequate/good
Difficulty Index	0.40 – 0.64	All items in moderate category

Data collection was conducted following regular classroom instruction, in accordance with the pre-existing school schedule. The assessment was administered in the form of a paper-and-pencil test, conducted in small groups within the students' regular classroom setting. Each session lasted approximately 60 minutes. The assessment was facilitated by the researchers in collaboration with the classroom teacher, who ensured that students were comfortable and that the testing environment remained conducive to focused work. Importantly, no intervention was applied during the instructional process, as the teaching strategies were fully determined by the classroom teacher. This approach ensured that the learning environment remained natural and authentic, thereby capturing students' abilities in real classroom settings. Data obtained from students' responses were analysed using both descriptive and inferential statistical techniques. Descriptive analysis was employed to summarise the general trends and performance levels across different student groups, while inferential analysis aimed to explore potential differences or relationships between students' diagnostic categories and their representation abilities.

3. RESULTS AND DICUSSION

The initial diagnostic assessment of fundamental mathematical concepts revealed that only 4 out of 23 fourth-grade students (17.4%) demonstrated sufficient mastery of foundational concepts related to fractions, including part–whole relationships, equivalence, and basic arithmetic involving fractional values. This finding is particularly significant, as these students were selected into a class generally characterised by above-average cognitive abilities, suggesting a possible mismatch between instructional pacing and students' conceptual readiness. The limited conceptual readiness among the majority of students raises critical concerns about the effectiveness of prior instructional approaches and the adequacy of foundational mathematical development. It also underscores the urgent need for tailored teaching strategies that address conceptual gaps and support differentiated learning. As such, this result not only informs the current study but also has broader implications for designing future interventions in mathematics education targeting higher-order representational skills.

3.1. An Overview of Students' Mathematical Representation Abilities

Analysis of the mathematical representation test revealed that the four students identified with "sufficient" foundational abilities (from the initial diagnostic) also achieved scores in the "Good" category (≥ 70), as detailed in Table 2. This strong correlation suggests a crucial link between students' conceptual understanding and their ability to effectively represent mathematical ideas. These results highlight the importance of reinforcing fundamental mathematical concepts, as such understanding appears to support the development of accurate and meaningful representations of mathematical problems and solutions.

A strong mastery of mathematical concepts is intrinsically linked to the ability to effectively represent mathematical ideas. This has been thoroughly researched and published across a range of sources [24]. When students have a firm grasp of the foundational principles, they are better equipped to translate abstract concepts into various forms of representation, such as equations, graphs, and visual models. This conceptual understanding provides a solid framework for students to make connections between different mathematical ideas, facilitating more accurate and meaningful representations. Moreover, a deep understanding allows students to approach problems with greater confidence, apply appropriate strategies, and choose the most suitable representation to solve a given task. Thus, the quality of mathematical representation is directly influenced by the depth of conceptual knowledge, underscoring the importance of a comprehensive understanding of core mathematical principles in fostering advanced representational skills [25]. Table 2 also indicates that the most frequently occurring student scores fall within the "Requires Support" category. These findings are certainly concerning, suggesting that students' conceptual understanding and representational skills have been considerably affected by their learning experiences, particularly during the Covid-19 pandemic. To illustrate the varying levels of students' mathematical representation competence, their scores were grouped into four categories. The following table 2 presents the distribution across these categories.

Table 2. Distribution of Students' Mathematical Representation Scores

Score Range	Number of Students	Description
< 40	3	Requires Intensive Support
40–59	10	Requires Support
60–69	6	Sufficient
≥ 70	4	Good
Total	23	
Mode	40–59	Requires Support

As indicated in Table 2, the majority of students (10 out of 23) are within the 40–59 score range, classified as 'Requires Support'. Only a few students (4) achieved a 'Good' level, while three fell into the lowest category, requiring intensive support. The mode of the data further confirms that most learners are still in need of focused instructional guidance to strengthen their mathematical representation skills. However, during the

Covid-19 pandemic, when students were primarily engaged in home-based learning, these connections and representations were significantly disrupted. The lack of face-to-face interaction and immediate teacher feedback hampered students' ability to engage deeply with the material. Psychologically, students struggled with the isolation and lack of motivation that often accompanies remote learning, further limiting their cognitive engagement with complex concepts. Pedagogically, the absence of interactive, hands-on learning experiences meant that students found it difficult to translate mathematical symbols and visual representations into coherent written explanations. This gap in both emotional and instructional support has left many students with a weakened ability to understand and represent mathematical concepts effectively, highlighting the crucial role of direct teacher involvement and collaborative learning environments in fostering these skills.

This observation strongly aligns with Vygotsky's socio-cultural theory, which underscores the crucial role of social interaction and the zone of proximal development (ZPD) in facilitating learning. According to Vygotsky, learners develop most effectively when guided by more knowledgeable peers or educators, who provide the necessary scaffolding to advance their understanding [26]. In the context of remote learning, however, the absence of such direct interactions presents a significant barrier, limiting students' ability to process, internalise, and apply complex concepts. Furthermore, cognitive load theory [27], [28] bolsters this argument by highlighting that learning is severely hampered when students lack immediate access to guidance and feedback. This is particularly problematic in subjects like mathematics, where the active engagement in problem-solving and concept application is essential. The inability to receive timely feedback in a remote environment not only increases cognitive load but also disrupts the construction of mental representations, thereby impeding students' ability to translate abstract symbols into meaningful, contextualised understanding. Consequently, these disruptions represent a critical breakdown in both psychological and pedagogical processes that traditionally support the development of mathematical reasoning and representation skills. These theoretical frameworks illustrate the necessity of direct, supportive interactions to bridge the gap between abstract mathematical concepts and their practical application, highlighting the essential role of teacher-student engagement in the learning process [29]-[31].

Based on the research findings, it was also observed that teachers often failed to acknowledge the diversity among their students during instruction. This lack of attention to diversity extended beyond the commonly cited differences in learning styles such as visual, auditory, or kinaesthetic preferences and included a more critical oversight: the variation in students' prior knowledge as identified through diagnostic assessments. Teachers tended to treat students as though they possessed similar levels of ability, thereby delivering uniform instruction without differentiation [32], [33].

This approach neglects the significant disparities in students' learning experiences, particularly those shaped during the COVID-19 pandemic, when educational access and engagement varied greatly. Some students may have had consistent support and structured learning at home, while others experienced substantial disruptions, leading to uneven conceptual development. By not tailoring instruction to reflect these differences, teachers risk widening the learning gap and impeding students' progress, especially in areas requiring cumulative understanding such as mathematics [34]-[36]. These findings underscore the urgent need for more responsive and inclusive pedagogical practices that are informed by accurate diagnostic insights and sensitive to students' diverse educational backgrounds.

3.2. The Average Scores of Each Mathematical Representation Indicator

The analysis of each indicator reveals that the lowest level of mathematical representational ability among students lies in their capacity to create visual representations to clarify problems and support their resolution. Students tend to rely on rote memorisation of procedural steps in mathematical operations, which often leads to a limited conceptual understanding. This lack of conceptual grasp, in turn, hinders their ability to mentally visualise and apply these operations in real-life contexts. For instance, in the context of slicing bread, a student may struggle to conceptualise the situation in which one slice of bread is divided among four people, and subsequently, one of those quarters is divided again into four smaller parts. Students often find it difficult to comprehend what fraction of the whole the resulting smaller portion represents. A detailed overview of these findings is presented in Figure 1.

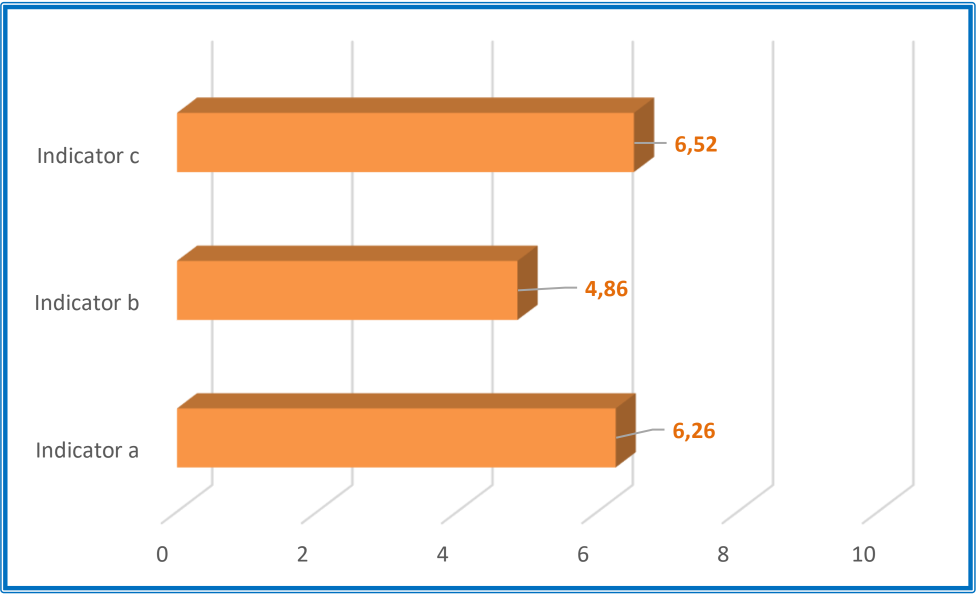

Figure 1. Average Scores of Students' Mathematical Representation Indicator

As illustrated in Figure 1, the assessment framework for students' mathematical representation competence comprised three indicators. Indicator A pertains to the ability to construct equations or mathematical models from given representations, reflecting the skill of translating visual or contextual information into formal mathematical expressions. Indicator B involves the creation of drawings to clarify problems and support their resolution, capturing students' capacity for visual reasoning. Indicator C addresses the composition of written narratives that align with a given representation, demonstrating students' ability to interpret and communicate mathematical ideas through coherent textual explanations.

In contrast, the highest performance was observed in the indicator related to composing narratives that align with the mathematical representations provided. This task tends to be more accessible for primary school pupils, as it primarily requires them to interpret existing information rather than generate abstract representations independently. From a psychological perspective, this aligns with the cognitive developmental stage of most primary-aged children, who are generally situated within Piaget's concrete operational stage. At this stage, children begin to develop logical reasoning; however, their thinking is still predominantly tied to tangible objects and familiar contexts. As such, interpreting a given mathematical scenario and constructing a related story aligns more closely with their natural learning inclinations and lived experiences.

An interesting additional finding is that all four students, who scored at the "sufficient" level on the diagnostic test defined as achieving scores within the 60–69 range, indicating a basic but incomplete understanding of foundational fraction concepts also performed poorly on the indicator of "creating drawings to clarify the problem and facilitate its solution." For example, one student drew a rectangle divided into unequal parts when asked to represent 3/4, and another simply copied a figure from the question without any modification or explanation, suggesting a lack of representational intent. This pattern suggests that, although these students demonstrated a surface-level grasp of the content, they lacked the deeper conceptual understanding required to translate abstract ideas into visual representations. The difficulty in creating meaningful drawings may reflect underdeveloped mental models or limited flexibility in shifting between forms of representation skills that are essential for visualising mathematical relationships and solving problems effectively.

These findings indicate a potential gap in instruction, where students may advance in their procedural fluency without developing the visual and spatial reasoning needed for more complex tasks. Therefore, even when students meet a minimal threshold of understanding, targeted instructional support remains necessary to foster the representational competencies that underpin meaningful mathematical problem-solving. It appears that, despite being classified as having a sufficient understanding, these students struggled with a crucial aspect of mathematical thinking, highlighting the importance of instructional approaches that nurture the flexible use of multiple representation modes.

Such findings imply that students may require further support in developing their ability to visualise mathematical problems, an essential skill for effective problem-solving, especially in more complex contexts. This difficulty underscores the need for targeted instructional strategies to address these challenges and enhance students' ability to represent mathematical problems graphically. Pedagogically, tasks that involve storytelling can draw upon students' linguistic strengths and background knowledge, enabling them to make meaningful connections between mathematical ideas and everyday life [37], [38]. Nevertheless, it is important to recognise that the relative ease of this task does not necessarily reflect a deep or accurate conceptual understanding. Many pupils may rely on superficial cues or prior exposure to similar problems, leading to interpretations that are contextually plausible yet mathematically imprecise. Without sufficient scaffolding and opportunities for feedback, students may develop misconceptions that persist despite apparent task success.

Therefore, while narrative construction tasks are valuable for engaging learners and fostering connections between mathematics and real-world contexts, educators must carefully assess the depth and accuracy of students' interpretations. Effective pedagogical approaches should incorporate guided discussions, visual supports, and reflective questioning to ensure that students' stories not only align contextually with the mathematical representations but also demonstrate accurate reasoning and conceptual clarity.

3.3. What is The Follow-up Action for Making Education Better?

The COVID-19 pandemic has left a profound impact on education systems worldwide, with some of the most significant disruptions observed in the domain of mathematics, particularly at the primary education level. The abrupt transition to remote learning posed numerous challenges that hindered the development of foundational skills, leading to considerable learning loss, stagnation, and delays in students' cognitive development. As we now transition into a post-pandemic educational landscape, it is imperative to consider a range of responsive follow-up measures, particularly within mathematics education, to mitigate these setbacks and promote sustainable improvement [39]-[42].

The observed decline in mathematical proficiency across educational systems presents a multifaceted challenge. Addressing this decline requires recovery strategies that encompass both cognitive and emotional dimensions of learning. Studies from various contexts including Virginia, Finland, and the United States have consistently documented diverse patterns of learning loss, highlighting how student populations were unequally affected. For example, Virginia reported a 32% decline in mathematics proficiency among students in grades 3–8, signalling a particular vulnerability of mathematical learning to educational disruptions. Furthermore, the rise in mathematics anxiety following the pandemic has made it increasingly difficult for learners to engage meaningfully with mathematical concepts, further exacerbating the problem (see Figure 1).

The first necessary follow-up action is the reinforcement of basic mathematical concepts. The findings of this study affirm that students who achieved "satisfactory" scores in diagnostic assessments performed better when they demonstrated a strong grasp of fundamental concepts. This underlines the importance of consolidating core knowledge such as numeracy and mathematical representation prior to progressing to more complex topics. A robust conceptual foundation enables learners to connect abstract mathematical ideas to real-world contexts, enhancing their ability to interpret, represent, and solve problems effectively.

As shown in Table 1, the instrument used in this study demonstrated adequate psychometric qualities to capture these foundational skills. The reliability coefficient ($r = 0.64$; $t_{hit} = 3.81$) indicates a high and statistically significant consistency in measuring the intended constructs. Most items showed acceptable to good discrimination indices (ranging from 0.18 to 0.58), suggesting the instrument could distinguish between students of varying ability levels. Furthermore, all items fell within the moderate difficulty range (0.40–0.64), indicating that the test was appropriately challenging for the target group. These characteristics support the conclusion that students who performed well did so because the instrument effectively captured essential aspects of their mathematical understanding, particularly their grasp of basic concepts necessary for higher-order representation skills.

The second essential action involves the integration of differentiated teaching strategies. In the context of post-pandemic recovery, it is clear that a uniform approach to instruction is insufficient [6]. This study revealed that teachers frequently neglected to acknowledge the diversity present within their classrooms. Such diversity should not be understood solely in terms of learning styles visual, auditory, or kinaesthetic but also in relation to students' prior knowledge, cognitive readiness, and socio-emotional experiences. Worryingly, some educators assumed a homogeneous level of ability among students, overlooking valuable diagnostic insights that revealed substantial variation in students' learning trajectories, particularly those shaped during the pandemic.

Given that students have emerged from the pandemic with highly heterogeneous learning experiences some having benefited from structured home environments, others facing considerable disruption it is vital that instruction now accommodates these differences. Differentiated teaching must respond not only to students' learning preferences but also to their ability to absorb and process information through various instructional approaches. This includes multimodal strategies, scaffolded tasks, and flexible groupings that reflect students' readiness and support meaningful engagement with mathematical content. Such an approach is also consonant with Ki Hajar Dewantara's educational philosophy, which advocates for the holistic development of each learner according to their individual potential.

The third follow-up measure involves the development of assessment tools that effectively capture the range of students' mathematical abilities, particularly their representational skills. This study found that although many students could recall procedural steps or articulate narratives around mathematical tasks, they struggled significantly with visual representations [28]. Their difficulty in constructing diagrams or graphs to aid problem-solving reflects a gap in conceptual understanding that cannot be addressed through conventional assessment alone [43]-[45]. Therefore, it is imperative to design instruments that not only test procedural knowledge but also reveal students' depth of comprehension and their capacity to translate abstract ideas into various representational forms.

Furthermore, this study points to the necessity of embedding visual representation tasks within the mathematics curriculum [46]-[49]. Many students, while proficient in verbal reasoning, demonstrated notable weaknesses when required to express mathematical ideas graphically. These shortcomings suggest an urgent need for instructional interventions focused on strengthening visual literacy in mathematics through modelling, structured drawing, guided decomposition of problems, and other representational strategies. Such interventions can significantly enhance students' problem-solving capacity and promote a deeper engagement with mathematical content.

Narrative-based tasks, which require students to explain mathematical ideas through stories, also have pedagogical value. However, it is crucial that educators distinguish between narrative coherence and conceptual accuracy. While students may provide plausible storylines based on prior knowledge, these do not always reflect a sound understanding of mathematical principles. To ensure conceptual clarity, such tasks should be supplemented with reflective questioning, peer discussions, and structured feedback loops that help students refine their reasoning and align their explanations with accurate mathematical logic [50]-[54].

From a theoretical standpoint, Vygotsky's sociocultural theory provides a valuable lens through which to interpret these findings. The absence of direct interaction with teachers during remote learning significantly impaired students' opportunities for scaffolded learning within the zone of proximal development. Teachers serve as 'more knowledgeable others' who mediate learning and guide students through increasingly complex tasks. The loss of this social mediation during the pandemic particularly in mathematics hindered students' cognitive and affective engagement with the subject. As such, follow-up strategies should prioritise the restoration of rich, interactive learning environments where meaningful dialogue and feedback can once again support student development.

Cognitive load theory further reinforces the argument that students benefit most when immediate feedback is available. Without timely guidance, learners especially in mathematics can become overwhelmed by extraneous cognitive demands, impeding their ability to internalise new concepts and develop mental schemas [28], [51]. Therefore, recovery efforts must include the re-establishment of classroom structures that allow for real-time support, collaborative problem-solving, and teacher-facilitated feedback that reduces cognitive burden and promotes clarity [5], [19], [24], [55], [56].

Improving education in the post-pandemic era requires a comprehensive and multidimensional approach. Educational recovery must include the reinforcement of core mathematical concepts, the implementation of differentiated and inclusive teaching practices, the development of nuanced assessment tools, and the revitalisation of meaningful teacher-student interaction [57]. Equally important is the recognition of the diverse learning experiences shaped by the pandemic and the need to accommodate them through responsive and equitable instructional design. By addressing both the cognitive and affective dimensions of learning, we can foster more resilient, inclusive, and effective mathematics education for all learners [58]-[60].

4. CONCLUSION

This study highlights a concerning gap in primary students' mathematical representation skills, particularly in their ability to generate visual models to support understanding and problem-solving. Among the three assessed indicators, visual representation emerged as the most underdeveloped, indicating the need for more targeted pedagogical interventions. The findings underscore the persistence of undifferentiated instructional approaches that fail to accommodate the diverse cognitive and experiential backgrounds of students an issue that may have been exacerbated by the disruptions caused by the COVID-19 pandemic. There is a pressing need for adaptive, multimodal instructional models that provide scaffolding aligned with students' developmental readiness and varied learning profiles. Situated within constructivist and sociocultural frameworks, this study supports the notion that visual and contextual learning experiences are central to concept formation in mathematics. It proposes a conceptual implication: mathematical representation should not be treated as a peripheral skill but as a core component of early mathematics instruction, one that enables students to bridge abstract reasoning with concrete understanding. While these findings offer valuable insights, the study is limited by its small sample size, which may affect generalisability. Future research should explore how differentiated, representation-focused strategies can be designed, implemented, and evaluated across broader contexts and age groups. Moreover, there is a need to further theorise how representation competencies develop over time, and how instructional practices can systematically cultivate them. Implications for practice include the integration of visual reasoning into core curriculum design, enhanced teacher training in representation-based pedagogy, and the development of assessment tools that capture students' representational thinking. Such efforts are critical to ensuring that all learners are equipped to engage meaningfully with mathematical ideas in increasingly complex learning environments.

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