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Abstract

Fraction instruction requires students to connect equal parts and quantities with symbolic notation. This study examined how fraction-board instruction was implemented and revised, and how achievement and participation changed in one rural fifth-grade classroom. Classroom action research involved 25 students, comprising 14 girls and 11 boys, at State Primary School 12 Pemunduran (SD Negeri 12 Pemunduran), Muaro Jambi Regency, Indonesia. Two cycles of two meetings each followed planning, action, observation, and reflection. Written assessments, structured observation, and classroom documentation were analyzed descriptively. The class mean increased from 60.0 before the intervention to 70.8 after Cycle I and 81.0 after Cycle II. The proportion meeting the school's mastery criterion of 70 increased from 16% to 60% and then 100%. Question-asking increased from 20% to 48% to 80%, while question-answering increased from 28% to 60% to 88%. Difficulties after Cycle I informed stronger teacher guidance, more varied tasks, and additional media access in Cycle II. These changes accompanied improved class-level performance but cannot establish the independent effect of the board. The absence of a comparison group, together with unreported psychometric validation and disaggregated outcomes, limits causal and equity claims. The study provides contextual evidence on guided use of concrete resources and identifies individual reasoning and participation opportunities as priorities for further evaluation.

Keywords: Fraction Understanding; Concrete Manipulatives; Classroom Action Research; Learning Participation; Rural Primary Education

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INTRODUCTION

Fractions require learners to coordinate equal parts, a referent whole, numerical magnitude, and symbolic notation. A scoping review identifies persistent obstacles across these interconnected demands [1]. Indonesian classroom studies document difficulties with fraction addition in Grade 5 [2], the interpretation of fraction problems [3], and the use of representations beyond familiar task contexts [4]. These findings make fraction instruction a question of how students gain access to mathematical meaning, as well as whether they can execute an algorithm. In a classroom where few learners participate and most score below the local mastery threshold, an instructional response should therefore attend to both achievement and opportunities to engage with the concepts.

Representation offers a basis for such a response. Mohamed et al. associate explicit connections among representations with the development of fraction understanding [5], while a bibliometric analysis locates concrete-to-abstract instruction within a substantial, methodologically diverse research field [6]. A fraction board can make equal partitioning and equivalence available for inspection: pieces can be aligned against the same whole, compared, and exchanged before their relationships are expressed symbolically. This provides an instructional rationale rather than evidence that physical handling itself produces understanding. Byrne et al. report mixed findings across physical-manipulative interventions and emphasize the importance of learning goals, materials, and guidance [7]. Foulkes et al. examined manipulative choices among researchers, teachers, and parents, identifying shared preferences for homogeneous three-dimensional objects; these findings concern material selection rather than children's learning gains [8].

Comparative research also argues against treating all manipulatives as interchangeable. Al Farra et al. found an advantage for concrete over virtual manipulatives in their fifth-grade fraction addition and subtraction setting [9]. Ahmad and Siller examined combined concrete and virtual instruction across different achievement groups [10]. These studies address different instructional arrangements, so neither establishes that a particular board will work equally well for every learner. Research on the concrete-representational-abstract sequence [11], a randomized intervention for struggling fifth-graders [12], and an intervention for at-risk third-graders [13] instead supports attention to how conceptual explanations and procedures are coordinated. A meta-analysis of rational-number interventions likewise provides evidence for structured support for learners with mathematics difficulties, while drawing together interventions that differ in content and delivery [14].

Digital instruction provides a useful comparison rather than a necessary alternative. Bush evaluated an adaptive intervention combining digital manipulatives, contexts, and feedback [15]. Zhang et al. reported similar immediate gains when part of conventional instruction was replaced by fraction games, with more favorable performance on their transfer assessment [16]. However, Tian et al. found that improved area-model estimation did not transfer to broader fraction-magnitude tasks [17], and Nuraydin et al. found improvements on a trained number-line measure without corresponding transfer to untrained fraction understanding or arithmetic [18]. Immediate success with a representation must therefore be distinguished from flexible knowledge that survives changes in task format. Work on unit fractions and number lines [19] and a school-delivered fraction-sense intervention [20] further

illustrates the value of specifying the mathematical ideas and instructional support embedded in an intervention.

Indonesian evidence provides a closer contextual starting point. Saleh et al. describe how chocolate-shaped fraction boards supported work on equivalence and simple operations in a fourth-grade classroom [21]. Mulyani and Yatri identify a need for fraction-board media in second-grade instruction [22]. These studies establish precedents for using boards, but they do not answer how an intact fifth-grade class responds when teachers revise the instruction after an initial cycle. The contribution sought here is consequently a documented local improvement process, rather than a claim that fraction boards are a new invention or that fifth-grade fraction instruction has not previously been studied.

Access to shared materials also has an educational-equity dimension. Research on universal design for learning encourages attention to representation, engagement, and ways of expressing understanding, although the evidence includes substantial methodological variation [23]. Reviews of children's mathematics attitudes [24] and gender-ability stereotypes [25] caution against assuming that classroom participation is independent of the social learning environment. At the same time, these literatures do not justify presuming that girls in a particular class are disadvantaged without examining local evidence. The present study includes girls and boys but reports only class-level outcomes. Its relevance to equitable learning lies in the organization of opportunities to manipulate, explain, and receive guidance; it does not test whether gender gaps were reduced.

This study examines two cycles of fraction-board instruction in one rural fifth-grade classroom in Muaro Jambi Regency, Indonesia. The research questions are: (1) How was fraction-board instruction implemented and revised across the two action-research cycles? (2) How did class-level achievement and observed learning participation change from the pre-intervention stage through Cycle I and Cycle II? The study connects an account of instructional revision with three assessment points and explicitly distinguishes demonstrated classroom change from untested explanations. Its practical purpose is to inform teachers' use of shared concrete resources while identifying the measurement needed to evaluate inclusive participation more rigorously.

METHODS

Research Design

The study used classroom action research organized around the Kemmis–McTaggart planning, acting, observing, and reflecting sequence. Two cycles were implemented, each consisting of two meetings. The design addressed a local instructional problem through collaboration between the researcher and classroom teacher. Assessment and observation informed the decision to revise the teaching in the next cycle. This was an improvement-oriented study of an intact class, without random assignment or a comparison group; the three measurement points document change over time but do not isolate a treatment effect.

Research Setting and Participants

The participants were all 25 students in the fifth-grade class of State Primary School 12 Pemunduran (SD Negeri 12 Pemunduran), Muaro Jambi Regency, Jambi Province, Indonesia:

11 boys and 14 girls, aged 10–11 years. The study took place during the even semester of the 2024/2025 academic year. Participation followed regular enrollment and active attendance during the intervention. The school was selected following preliminary observations of difficulties in fraction understanding and limited use of concrete instructional media. No probability sampling was used.

The classroom teacher delivered the lessons as a collaborator. The researcher designed the instruments, observed instruction, and analyzed the data. Before each cycle, they reviewed the lesson module and observation indicators; afterward, they discussed the outcomes and the changes needed. Teacher observations and classroom documentation provided an informal cross-check on the researcher's observations. This arrangement supported contextual interpretation but did not constitute independent observation or a formal inter-rater reliability assessment.

Instructional Materials and Procedure

The fraction board consisted of a rectangular base representing a unit whole and removable, color-coded pieces representing halves, thirds, fourths, fifths, and other fractional values. The pieces could be placed, compared, and exchanged to examine equal parts and equivalent quantities. Students worked in groups of four or five using the media and accompanying worksheets. An illustrative task was to show that two one-fourth pieces cover the same quantity as one one-half piece. The mathematical focus was the relationship between physical quantities and the fraction notation used to describe them.

In Cycle I, the teacher introduced the learning objectives, demonstrated the board, and guided group activities involving fraction meaning, comparison, and equivalence. Students arranged pieces, compared fractional quantities, and completed worksheet tasks. Observation accompanied the instruction, followed by an end-of-cycle written assessment. Reflection identified continuing difficulty with unlike denominators and dependence on close teacher guidance when using the board.

Cycle II responded through more systematic board use, more varied fraction tasks, stronger facilitation of group work, and additional media sets to maintain group access. Opportunities for independent exploration were also increased within the guided activities. The second cycle was followed by observation and a written assessment using the same class-level reporting framework. Several features changed together, so the effects of additional materials, guidance, task variation, and accumulated practice cannot be separated.

Instruments and Data Collection

The written assessments addressed four areas: explaining fraction meaning, comparing fractions, recognizing equivalence, and solving simple fraction operations. Scores were converted to a 0–100 scale. Parallel forms were used at the pre-intervention stage and at the end of each cycle, with content reviewed by the classroom teacher against the school's learning indicators. Separate psychometric validation and reliability statistics are not reported. Consequently, the total scores are treated as curriculum-aligned indicators of fraction performance, rather than a validated measure of every dimension of conceptual understanding. The observation checklist recorded whether students initiated a question to the teacher or a peer, responded to a teacher's question, followed the explanation without evident off-task behavior, physically manipulated the fraction board, or completed assigned worksheet items.

Percentages used the class size of 25 as the denominator. Observations were made during the meetings, but the available records provide only one percentage per indicator for each cycle. The rule for combining meeting observations is not documented, so the reported cycle percentages cannot be independently reconstructed from meeting-level data.

Baseline attention was recorded as limited attention or off-task behavior, whereas the later cycles used a positive attention indicator. These measures are reported separately. Board use and the intervention-specific task-completion indicator were not reported at baseline. Classroom photographs and students' work samples were collected as supporting documentation; no systematic coding of these materials or individual conceptual-learning trajectories is reported.

Data Analysis and Success Criteria

Analysis was descriptive. At each assessment point, the class mean was calculated as the sum of student scores divided by 25. Mastery was defined using the school's Minimum Learning Mastery Criterion (MLMC) of 70; the mastery percentage was the number of students scoring at least 70 divided by 25, multiplied by 100. Changes in mean scores are expressed in score points, and changes in proportions in percentage points. No significance tests, standardized effect sizes, or confidence intervals are reported because the analysis is limited to aggregate scores and proportions.

The outcome success criterion was at least 80% of students meeting the MLMC, together with improvement in the class mean. A process criterion was also specified of at least 75% actively using the media, discussing, and explaining fraction concepts. However, the reported checklist does not provide separate results for discussion and conceptual explanation or a combined process score. The reported behavior indicators are therefore evaluated individually; the aggregate results cannot independently verify the complete process criterion.

Ethical Considerations

Parental or guardian consent and student assent were obtained through the school before the intervention, and observation and testing were conducted within the teacher's ordinary instructional and assessment practice under the school's research-permission procedures. Results are presented at class level without naming individual students. Institutional ethics-review details are not reported separately from the school authorization and consent procedures.

RESULTS AND DISCUSSION

Results

Baseline Achievement and Participation

Initial instruction was characterized by teacher explanation and routine exercises, with little use of concrete media. Five students (20%) asked questions and seven (28%) answered teacher questions. Limited attention or off-task behavior was recorded for 11 students (44%). This negative baseline indicator is not treated as directly equivalent to the positive attention measure reported for the intervention cycles. The mean pre-test score was 60.0; four students (16%) met the MLMC and 21 (84%) did not.

Instructional Revision Across the Two Cycles

During Cycle I, board demonstration and group activities were accompanied by increased question-asking and question-answering. The class mean reached 70.8 and 15 students met the MLMC. Although the class mean exceeded 70, mastery was achieved by only 60% of the students. Reflection therefore focused on students who still needed support, particularly with unlike denominators and independent use of the board. The 80% class-mastery criterion was not met, and a second cycle was undertaken.

Cycle II combined additional media access with more varied tasks and closer facilitation. The class mean reached 81.0 and all 25 students met the MLMC. The outcome criterion was consequently satisfied, and the study ended after two cycles. The observed behavior percentages were also higher than in Cycle I, but this does not independently establish attainment of the composite process criterion described in Methods.

Table 1. Fraction achievement and mastery across the three assessment stages

Aspect Analyzed	Pre-Cycle	Cycle I	Cycle II
Number of students	25	25	25
Class mean score	60.0	70.8	81.0
Students meeting MLMC (≥ 70)	4	15	25
Students below MLMC	21	10	0
Percentage meeting MLMC	16%	60%	100%
Percentage below MLMC	84%	40%	0%

Table 1 shows mean-score gains of 10.8 points in Cycle I and 10.2 points in Cycle II (21.0 points overall). Mastery increased by 44 and 40 percentage points, respectively (84 percentage points overall). All students met the cutoff in Cycle II; this does not imply perfect scores or equal performance.

Changes in Observed Learning Participation

Table 2 shows question-asking increasing from 20% to 48% to 80%, and question-answering from 28% to 60% to 88%. Between Cycles I and II, positive attention rose from 80% to 96%, board use from 84% to 100%, and task completion from 76% to 92%. These frequencies do not establish participation quality, duration, individual trajectories, or the distribution of opportunities within groups.

Table 2. Reported percentages of students exhibiting learning participation indicators

Observed Indicator	Pre-Cycle	Cycle I	Cycle II
Asking questions	20%	48%	80%
Answering questions	28%	60%	88%
Paying close attention	n.a. ^a	80%	96%
Using the fraction board	n.a. ^b	84%	100%
Completing assigned tasks	n.a. ^b	76%	92%

Note: n.a. = not available. ^a The baseline measure recorded limited attention or off-task behavior (44%), rather than positive attention. ^b Board use and intervention-specific task completion were not reported at baseline.

Discussion

Interpreting Achievement Alongside Participation

Class mean scores and mastery rates rose alongside the frequency of asking and answering questions. After Cycle I, continuing difficulties prompted stronger guidance, more varied tasks, and greater access to the boards. These findings address both research questions by linking classroom outcomes to successive teaching decisions. The changes concern the instructional package as a whole; the study cannot isolate the board's contribution. The increase in mean score was 10.8 points in the first interval and 10.2 in the second, despite the higher final mastery rate.

Guided-play research offers a useful but age-bounded comparison: Skene et al. found benefits for some learning outcomes, while also documenting variation in what guidance involved [26]. Spatial-training evidence similarly provides a plausible rationale for aligning, partitioning, and comparing objects [27], and Gilligan-Lee et al. directly compared hands-on and hands-off spatial training [28]. These studies concern broader developmental and spatial processes rather than this fraction board. Here, the proposed mechanism is that a stable whole and visible equal parts make relationships available for discussion, while the teacher connects those relationships to notation. Cognitive load, spatial reasoning, and the mediation of learning by participation were not measured, so this mechanism remains an interpretation.

The findings also require distinction between performing a visible action and understanding its mathematical purpose. Manipulating pieces can be completed through imitation, and finishing a worksheet does not necessarily demonstrate an explanation of equivalence. Research synthesizing virtual-manipulative interventions for students with disabilities reports benefits that vary with learner and intervention features [29]. Although that population differs from the present class, the variation reinforces the need to examine who benefits and under what conditions. The present class averages cannot supply that information, and no disability-related effect is inferred.

Teacher mediation deserves particular attention. Copur-Gencturk's study of elementary teachers found limitations in their explanations of fraction operations [30]. This makes subject-specific professional learning relevant to implementation: teachers need to explain the referent whole, justify equal partitioning, and identify why procedures work. The present study did not assess teacher knowledge, but its reflection record indicates that closer facilitation was considered necessary after Cycle I. Claims of easy replication should therefore account for teacher preparation and available instructional time as well as the materials themselves.

Inclusive Participation Without Assuming Equal Benefit

Shared materials can create opportunities for learners to contribute visible representations and verbal explanations. Nevertheless, universal board use at the class level does not show that all students had equal time, influence, or access to assistance. A student may handle a piece briefly while peers perform the reasoning. An inclusive implementation should therefore consider how materials and speaking opportunities are allocated, including whether students who are quieter or initially lower achieving receive support. These are implications for practice and future measurement, not documented features of the intervention.

The increase in observed participation should not be labeled a reduction in mathematics anxiety or an improvement in well-being. A meta-analysis associates mathematics anxiety with lower achievement [31], but the present checklist is not an anxiety measure. Home mathematics experiences are also associated with achievement across studies [32]; such experiences were not measured here and may have contributed to differences in students' readiness. These findings support a broader view of support needs without turning unmeasured influences into explanations for the observed gains.

Gender-responsive interpretation likewise requires restraint. Research on primary teachers' mathematics stereotypes highlights the relevance of classroom beliefs and interactions [33], while a systematic review of interventions addressing barriers to girls' participation and learning shows that educational equity involves context-specific obstacles beyond the availability of a learning tool [34]. In this study, the inclusion of 14 girls and 11 boys establishes the class composition, but no gender-disaggregated achievement, turn-taking, or participation results are available. The evidence therefore cannot establish gender parity in learning gains, greater benefit for girls, or a reduction in gendered barriers. Such questions should be investigated prospectively through appropriately protected individual records and observation of opportunities to contribute.

Media Design and Teacher Readiness

Studies in other subjects help distinguish teacher preparation, resource quality, and learning outcomes. Aridan et al. examine pedagogical, technological, and affective readiness among pre-service language teachers across Asian settings [35]. Hijriyah et al. assess expert judgments and student responses in developing digital comics for fifth-grade Arabic reading [36]. Masykur et al. evaluate the validity, practicality, and attractiveness of science e-modules based on science, technology, engineering, and mathematics (STEM) for Islamic schools [37]. These studies inform questions about implementation and resource evaluation, although their findings do not establish the effectiveness of physical fraction boards.

For the present intervention, these distinctions identify work still needed. A usable board should have accurately proportioned pieces, clear labels, and enough sets for group access. Its educational value should be judged using tasks that require students to explain and apply fraction relationships, not solely satisfaction or handling frequency. Material costs, preparation time, durability, and accessibility were not measured. The board can therefore be described as a non-digital instructional option, but its affordability, cost-effectiveness, and suitability for learners with particular sensory or motor needs remain untested.

Implications for Assessment and Classroom Improvement

The reported tests provide evidence of improved curriculum-aligned performance, but more detailed assessment is needed to establish conceptual change. Morano and Riccomini demonstrate how analysis of students' representations can reveal information about fraction-magnitude knowledge [38]. A future cycle could preserve anonymized explanations and drawings alongside item-level scores, allowing the teacher to distinguish an incorrect referent whole from unequal partitioning or an error in symbolic calculation. Retention and transfer assessments should also be separated from immediate mastery, particularly because improvements in a trained representation do not consistently extend to unfamiliar tasks.

Studies of non-digital fraction gamification [39] and different approaches to fifth-grade fraction teaching [40] offer further implementation comparisons. They suggest that the design of tasks and interactions should be evaluated alongside the chosen medium. For comparable classrooms, a reasonable sequence is to establish the whole, model a relation with pieces, ask students to explain it, and connect the explanation to symbolic work. Group access and questioning should be monitored while support is adjusted to students' difficulties. This is a practice implication grounded in the intervention and surrounding literature, not a tested universal protocol.

The study documents how the teacher responded when initial gains left 40% of the class below the mastery cutoff. Further guidance, task variation, and media access accompanied improvement until all students met the criterion. This account may help teachers plan and evaluate successive classroom adjustments. Whether the changes can be sustained or reproduced in other schools, and whether learners benefit equitably, remains to be examined.

CONCLUSION

Two cycles of fraction-board instruction in this rural fifth-grade class were accompanied by an increase in the mean score from 60.0 to 70.8 and then 81.0, and an increase in mastery from 16% to 60% and then 100%. Observed questioning, responding, and intervention-stage participation indicators also increased. Reflection after Cycle I informed additional media access, more varied tasks, and closer teacher facilitation in Cycle II. The study contributes contextual evidence on how concrete resources can be incorporated into an iterative classroom improvement process. It supports continued investigation of guided fraction-board instruction while preserving a clear distinction between observed change and causal effectiveness. Attention to individual reasoning and the distribution of learning opportunities is necessary before concluding that benefits are durable, transferable, or equitable across groups.

LIMITATIONS

The study involved one intact class of 25 students in one school. Without a comparison group, improvement cannot be separated from accumulated instruction, practice, repeated assessment, maturation, or other contextual influences. Several instructional components changed together, preventing attribution to the board or any single Cycle II adjustment. The descriptive results do not estimate a population effect. Measurement also limits interpretation. Formal psychometric validation of the teacher-reviewed tests is not reported, and the reported total scores do not distinguish conceptual understanding from procedural performance. Student-level scores, dispersion statistics, and matched trajectories are not reported. Observation was not independently rated, the aggregation of meeting observations remains unspecified, and the baseline attention indicator differs from the intervention-stage measure. Discussion and conceptual explanation were not separately quantified, limiting evaluation of the stated process criterion. No delayed assessment, transfer test, cost analysis, or direct measure of accessibility, anxiety, or well-being is reported. Gender-disaggregated outcomes and information on socioeconomic circumstances or disability were not reported. The study consequently cannot establish subgroup equity or wider social effects. Future research should combine documented

materials and scoring rubrics with individual follow-up measures, explicit participation coding, and a credible comparison condition across more than one classroom.

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AUTHOR CONTRIBUTIONS

J. conceptualization, methodology, investigation, data curation, formal analysis, and writing the original draft; S. supervision, methodological refinement, and writing—review and editing; J.V. interpretation of findings, visualization, and writing—review and editing. All authors share responsibility for the integrity of the work.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

ChatGPT assisted with language editing, structural refinement, and reference organization. Responsibility for the accuracy of the content, citations, and interpretations, and for approval of the final manuscript, rests with the authors.

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