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Improving the Ability to Understand Mathematical Concepts Through Problem-Based Learning (PBL) and Manipulatives in Class V Students of MIN 2 Pariaman City

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ABSTRACT

Many primary school students struggle with conceptual understanding in mathematics, particularly in areas such as fractions, decimals, and measurement, which impedes problem-solving and transfer. This Classroom Action Research investigates whether a Problem-Based Learning (PBL) model reinforced with manipulatives and a small project task can improve the conceptual understanding of Grade V students at MIN 2 Kota Pariaman. The research employed two cycles of action: planning, action, observation, and reflection. Participants were 18 Grade V students. Instruments included an 18-item concept test (pre-test and post-tests), observation checklists, project rubrics, work samples, and semi-structured interviews. Quantitative data were analyzed descriptively (means, percent meeting KKTP) and, where appropriate, paired comparisons; qualitative data were analyzed thematically. Mean scores improved from 61.40 (pre-test) to 74.10 (post-test I) and 86.00 (post-test II). The percentage of students meeting the established Kriteria Ketercapaian Tujuan Pembelajaran rose from 39% to 67% and then to 94%. Qualitative data indicated enhanced modelling, argumentation, collaboration, and motivation.

ARTICLE INFO

Keywords:

problem-based learning;
manipulatives;
conceptual understanding; fractions.

ABSTRAK

Banyak siswa sekolah dasar kesulitan memahami konsep matematika, terutama untuk pecahan, desimal, dan pengukuran, yang menghambat pemecahan masalah dan transfer. Penelitian Tindakan Kelas (PTK) ini menyelidiki apakah model Pembelajaran Berbasis Masalah (PBL) yang diperkuat dengan manipulatif dan tugas proyek kecil dapat meningkatkan pemahaman konsep siswa Kelas V di MIN 2 Kota Pariaman. Penelitian ini menggunakan dua siklus tindakan: perencanaan, tindakan, observasi, dan refleksi. Partisipan penelitian adalah 18 siswa Kelas V. Instrumen yang digunakan meliputi tes konsep 18 butir (pra-tes dan pasca-tes), daftar periksa observasi, rubrik proyek, contoh soal, dan wawancara semi-terstruktur. Data kuantitatif dianalisis secara deskriptif (rata-rata, persentase yang memenuhi KKTP) dan, jika sesuai, perbandingan berpasangan; data kualitatif dianalisis secara tematis. Skor rata-rata meningkat dari 61,40 (pra-tes) menjadi 74,10 (pasca-tes I) dan 86,00 (pasca-tes II). Persentase siswa yang memenuhi Kriteria Ketercapaian Tujuan Pembelajaran yang ditetapkan meningkat dari 39% menjadi 67%, kemudian menjadi 94%. Data kualitatif menunjukkan peningkatan kemampuan pemodelan, argumentasi, kolaborasi, dan motivasi.

Kata Kunci:

pembelajaran berbasis masalah;
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PENDAHULUAN

Mathematics education at the elementary level establishes the cognitive architecture for later mathematical thinking. However, numerous classroom studies and practitioner reports indicate a persistent gap between procedural fluency and conceptual understanding (Hiebert & Carpenter, 1992). In MIN 2 Kota Pariaman, routine assessments and classroom observations suggested that students could perform calculation steps but struggled to explain underlying relationships—particularly in fractions, decimals and measurement. These topics require coherent mental models and the ability to transfer knowledge to novel contexts, skills that are often underdeveloped when instruction emphasizes rote procedures. A preliminary diagnostic administered by the teacher (pre-test) confirmed a mean score of 61.40 and only 39% of students meeting the KKTP targets for the tested items, signaling the need for intervention.

Problem-Based Learning (PBL) positions authentic problems at the core of learning, prompting students to define problems, seek resources, construct solutions and justify their reasoning (Hmelo-Silver, 2004). When PBL is combined with carefully structured manipulatives and guided modelling tasks, learners can bridge the tangible and abstract representations essential for conceptual change. Given the Kurikulum Merdeka's emphasis on relevance, student-centered learning and assessment for learning (KKTP/IKTP), this study explores a PBL-manipulative approach tailored to the local classroom context.

Conceptual understanding in mathematics encompasses knowing what mathematical ideas mean, recognizing the relationships among them, and being able to apply them flexibly (Hiebert & Carpenter, 1992). Schoenfeld (1992) emphasized metacognitive skills and strategic knowledge as key components of mathematical competence. For elementary learners, representational fluency—moving between concrete manipulatives, pictorial representations and symbolic notation—is critical (Bruner, 1966; Carpenter et al., 1999). Problem-Based Learning has been widely studied in K-12 contexts. Hmelo-Silver (2004) reports that PBL supports deeper understanding, collaboration, and self-directed learning when problems are well-scaffolded. In mathematics, PBL fosters mathematical modelling, argumentation, and perseverance with complex tasks (Lester & Kehle, 2003). Empirical PTK studies at the elementary level also indicate that PBL combined with guided practice can raise achievement in targeted domains.

Manipulatives have a robust research base in early mathematics; meta-analyses suggest positive effects on achievement and attitudes when manipulatives are integrated with explicit instruction and representational connections (Carbonneau, Marley & Selig, 2013). In particular, fraction learning benefits from concrete–representational–abstract sequences supported by manipulatives (Siegler et al., 2011). Local studies in Indonesia (e.g., Rahmawati, 2021; Ramdani, 2022) demonstrate the value of contextualized problem tasks and manipulative use for improving elementary students' mathematical understanding. However, literature specific to madrasah contexts and combined PBL-manipulative designs remains limited, motivating the present PTK, which adapts international insights to local curricular aims.

METHODOLOGY

This study employed Classroom Action Research (PTK) using the Kemmis & McTaggart cycle (plan-act-observe-reflect) across two cycles. The research prioritized iterative improvement of teaching practice and student learning within the authentic classroom setting. The participants were 18 students of Class V at MIN 2 Kota Pariaman (balanced gender). The class is multi-ability, with a range of prior achievement as indicated by school records. Lessons occurred in the classroom and outdoor spaces (for measurement activities) during a six-week period. The intervention combined structured PBL scenarios with manipulative kits and a culminating small-scale project ("Design a Mini Play Area"). Each cycle contained three 2x35-minute lesson meetings. Cycle I focused on fraction concepts and decimal connections; Cycle II emphasized measurement and integrated fraction/decimal operations within project tasks.

Instruments and Measures: (1) Concept Test: 18 items (mixed short answer and contextual problems) aligned to IKTP; items sampled conceptual, representational and transfer demands. (2) Observation protocol: 8 indicators (engagement, collaboration, modelling, use of manipulatives, mathematical language, on-task behavior, problem solving strategies, reflection). (3) Project Rubric: criteria for modelling accuracy, mathematical reasoning, collaboration, and presentation. (4) Interviews: semi-structured guide for 6 purposively sampled students. (5) Documentation: student work, photos and teacher field notes. Validity and Reliability: Content validity was established through expert review by two PGSD lecturers. A small pilot on a parallel class checked item clarity; items with unclear wording were revised. Reliability for the concept test was estimated via Cronbach's alpha (pilot result $\alpha = 0.78$), indicating acceptable internal consistency.

Pre-action: administration of the pre-test, initial observation to capture baseline engagement, and teacher reflection to identify specific skill gaps. Cycle I: Lesson 1 (launch PBL problem: distributing resources fairly — modelling fractions with manipulatives), Lesson 2 (guided exploration and representational translation between concrete, pictorial, symbolic), Lesson 3 (application and formative assessment; post-test I). Reflection I: Teacher analyzed results and observations, adjusted prompts to support transfer, prepared additional manipulatives per group, and refined rubrics. Cycle II: Lesson 4 (PBL problem: measuring and allocating space for mini-play features—integrating measurement and fraction reasoning), Lesson 5 (project work and peer critique), Lesson 6 (presentation, post-test II, and interviews).

RESULT AND DISCUSSION

Interpretation of quantitative results: The class mean increased by 12.70 points from pre-test to post-test I, and by an additional 11.90 points to post-test II, yielding a total improvement of 24.60 points (approximately 40.07% relative improvement from baseline). The marked increase in the percentage of students meeting KKTP—from 39% to 94%—indicates significant class-level gains. These gains are particularly notable given the short intervention duration and classroom-scale implementation.

Table 1. Quantitative Result

Step	Score Average	Percentage of KKTP
Pre-action (pre-test)	61.40	39
The first cycle (post-test I)	74.10	67
The second cycle (post-test II)	86.00	94

To further understand distributional change, the teacher categorized student scores into low, medium and high bands. The distribution shifted markedly toward the high band by post-test II, reducing the proportion of low-performing students and narrowing performance gaps. This redistribution aligns with observed improvements in participation and task completion during lessons. Thematic analysis of observation notes and interviews revealed four dominant themes: (1) enhanced modelling and representation, (2) stronger mathematical communication, (3) improved collaborative practices, and (4) increased learner agency and motivation. Below each theme is elaborated with evidence from field notes and student utterances.

Enhanced modelling and representation: Students progressively used manipulatives in disciplined ways—constructing fraction strips, partitioning drawn areas, and annotating measurements on scaled diagrams. Several groups produced accurate scaled sketches for their mini-play designs and justified fractional area allocations. Mathematical communication: During group presentations, students used subject-specific vocabulary more confidently (e.g., numerator, denominator, equivalent fraction, unit conversion). The teacher observed clearer explanations of reasoning steps and more frequent use of supporting diagrams when presenting solutions.

Collaborative practices: Project rubrics documented role allocation within teams—planners, measurers, calculators, and presenters—and peer feedback loops were evident during work sessions. Such structures fostered accountability and deeper engagement. Learner agency and motivation: Field notes and informal comments indicated increased enjoyment and ownership. Students reported pride in presenting concrete artefacts and appreciated the opportunity to 'solve real problems' rather than merely practicing exercises.

The teacher undertook informal item analysis to identify persistent difficulties. Items requiring flexible transfer—such as converting a contextual fraction to an appropriate decimal and applying it in a measurement scenario—showed lower correct-response rates on pre-test and improved by post-test II, yet still lagged compared to modeled item types. This suggests that while representational fluency improved, explicit instruction and varied practice on transfer problems should be continued. Pedagogically, the teacher noted that targeted questioning and insistence on 'tell me why' during group work accelerated conceptual consolidation.

The results support the proposition that PBL, scaffolded with manipulatives and culminating in a project, can significantly bolster conceptual understanding in elementary mathematics. Quantitative gains are consistent with qualitative shifts in classroom behaviour: increased talk about mathematical ideas, more disciplined use of representation, and greater willingness to engage with non- routine problems. Mechanistically, PBL created meaningful contexts that made abstract relations visible, manipulatives provided cognitive anchors, and project work offered a purposive reason for precision and coherence.

The findings intersect with broader literature: Carbonneau et al. (2013) meta-analysis on manipulatives, Hmelo-Silver (2004) on PBL, and Siegler et al. (2011) on fraction learning. The combined PBL-manipulative approach appears especially suited to topics that require both conceptual restructuring and procedural integration (e.g., fraction-decimal links and measurement conversions). Practical implications: Teachers should design PBL scenarios with graded complexity, incorporate brief modelling workshops at the outset of each unit, and use project milestones as formative checkpoints. Administrators should facilitate access to low-cost manipulatives and provide scheduling flexibility for longer, integrative tasks.

CONCLUSION

This research demonstrates that a well-structured Problem-Based Learning approach supplemented with manipulatives and project tasks can produce notable improvements in Grade V students' conceptual understanding of fractions, decimals, and measurement. The combination of contextual problems, scaffolded modeling, collaborative work, and reflective checkpoints contributed to a classroom culture oriented toward reasoning and application rather than mere procedures. Given the observed improvements (mean 61.40 → 86.00; KKTP 39% → 94%), teachers are encouraged to adopt similar designs while continuing iterative refinement based on student data.

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