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Improving Grade II Fraction Learning Outcomes through Problem-Based Learning Assisted by Folded Paper

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ABSTRACT

Mathematics learning outcomes on fractions among lower-grade primary students are often hindered by lecture-based instruction that requires them to grasp abstract concepts without concrete experience. This study aimed to describe the implementation of folded paper media through the Problem-Based Learning (PBL) model to improve students' learning outcomes on simple fractions. This classroom action research, following the Kemmis and McTaggart model, was carried out in two cycles of one meeting each, preceded by a pre-cycle stage, with 29 Grade II students at a public elementary school in Bandung. Data were collected through tests, observations of teacher and student activities, and documentation. Data were analyzed using quantitative and qualitative techniques. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed through data collection, data reduction, data presentation, and the drawing of conclusions and verification. The results indicate that the class average score increased from 58 in the pre-cycle to 72 in Cycle I and 86 in Cycle II. At the same time, classical mastery rose from 34.5% to 68% and 89.6%, exceeding the 80% success indicator. In Cycle I, grouping students into six large groups allowed some students to dominate the work and produced less symmetrical folds. Improvements in Cycle II, namely eight smaller groups, more intensive guidance, and the contextual "Fraction Garden" project, supported the gains. These findings indicate that combining folded paper as a manipulative with PBL can improve lower-grade students' fraction learning outcomes and offers teachers a simple, inexpensive instructional alternative.

Keywords: classroom action research; folded paper media; fractions; learning outcomes; problem-based learning

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INTRODUCTION

Education plays a strategic role in preparing excellent human resources who can compete in the global era (UNESCO, 2015). In this context, mathematics learning in elementary school equips students to think critically, work independently and collaboratively, and adopt a scientific attitude (Susanto, 2013). This role can be fulfilled when teachers can seek out and create engaging learning experiences (Mulyasa, 2013) and design meaningful mathematics lessons that encourage students to engage actively and think creatively (Lestari & Yudhanegara, 2017).

However, students often regard mathematics as complicated and boring. Preliminary observations in a Grade II class at a public elementary school in Bandung in the 2025/2026 academic year showed that students' learning outcomes on the concept of fractions remained below the minimum mastery criterion. Of the 29 students evaluated, the mean initial score was only 58.00. This problem stemmed from several factors: students struggled to grasp the abstract concept of fractions, particularly that a fraction comes from a whole object divided into equal parts; instruction still relied on one-way lecturing; and the concrete media available were limited.

In the early grades, students should learn fractions not by memorizing formulas or abstract numerals but through direct experience cutting or dividing a whole object into equal pieces (Heruman, 2018). Instructional media, communication tools that convey messages and support students' understanding (Kustandi & Darmawan, 2020), can support this. One relevant medium is folded paper, which functions as a manipulative for visualizing fraction concepts through hands-on folding, cutting, and pasting (Sundayana, 2018). Using this medium is more meaningful when it is combined with an instructional model that takes contextual problems as the starting point of learning, namely Problem-Based Learning (PBL). This model requires students to actively find solutions in groups, thereby training critical thinking skills (Shoimin, 2017). PBL consists of five syntax phases: (1) orienting students to the problem, (2) organizing students for learning, (3) guiding individual and group investigation, (4) developing and presenting work products, and (5) analyzing and evaluating the problem-solving process (Shoimin, 2017).

Previous studies have examined instructional models and media in elementary school mathematics. Astuti et al. (2021) examined implementing the PBL model to improve students' mathematics learning outcomes. Afiani and Faradita (2022) examined the use of paper-folding media to support Grade III students' understanding of fraction concepts. Meanwhile, Zahro et al. (2024) examined the implementation of PBL supported by concrete media in Grade II fraction learning. Ramadhani et al. (2023) applied PBL to improve fraction learning outcomes in elementary school, and a meta-analysis of manipulatives in mathematics instruction (Carbonneau et al., 2013) also provides evidence on concrete representations. These studies are related in their use of the PBL model and concrete media in mathematics learning. However, the implementation of PBL assisted by folded paper for simple fractions in Grade II, with a focus on improving learning outcomes, still needs further investigation.

Based on the foregoing, this study aims (1) to describe the implementation of folded paper media through the PBL model and (2) to improve Grade II students' learning outcomes on the topic of fractions. In this study, learning outcomes are understood as students' mastery and understanding across the cognitive, affective, and psychomotor domains (Purwanto, 2017; Santoso & Widiyanti, 2022). The results are expected to offer a simple, inexpensive, and easily implemented alternative strategy for teaching mathematics in the lower grades.

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METHOD

Research Design and Setting

This study uses classroom action research to address practical classroom problems while improving learning quality. The design follows the Kemmis and McTaggart model, a four-stage spiral cycle: planning, action, observation, and reflection. The study was designed in two cycles preceded by a pre-cycle stage, and Cycle I is reflection served as the basis for improving the action in Cycle II. The independent variable (the action) was mathematics learning using the PBL model supported by folded paper media, while the dependent variable was students' learning outcomes in simple fractions.

The study was conducted at a public elementary school in Bandung in the 2025/2026 academic year. The pre-cycle was held on Monday, May 11, 2026; Cycle I on Tuesday, May 12, 2026; and Cycle II on Monday, May 18, 2026, each consisting of one meeting.

Participants, Instruments, and Procedures

The participants were all Grade II students, totaling 29. The class was selected because pre-cycle observations showed low mathematics mastery, attributed to the dominance of conventional instruction. Data were collected using both test and non-test instruments. The test instrument consisted of essay questions designed to measure cognitive learning outcomes, specifically the understanding of fractional values, numerators, and denominators. The non-test instruments included observation sheets for both the teacher and the students; these were used to assess the affective domain (group collaboration, discipline, and confidence) and the psychomotor domain (precision in dividing paper into equal parts, as well as neatness in shading and pasting). A scoring rubric with a 1–3 scale was employed, supplemented by documentation in the form of activity photographs and score summaries. Observers completed the observation sheets by placing a checkmark (√) next to the aspects that were demonstrated.

Planning: The researcher prepared a teaching module using the five PBL syntax phases, prepared the student worksheet and assessment rubrics, provided colored folding paper (origami), and planned student grouping.

Action: In the pre-cycle, learning was conducted through interactive lecturing and teacher demonstration. In Cycle I, students learned in six groups to divide paper into three and four equal parts. In Cycle II, students learned in eight smaller groups through the "Fraction Garden" (Taman Pecahan) project using the fractions. $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$.

Observation: Observers watched the discussion activity, group cooperation, fold precision, and students' courage in presenting during the lessons, and documented the activities through photographs.

Reflection: The researcher analyzed the test results and observation notes to identify obstacles and design improvements for the next cycle if the success indicators were not achieved.

Data Analysis

Quantitative data in the form of student scores (0–100) were analyzed descriptively by calculating the class mean score and the percentage of classical mastery for the pre-cycle, Cycle I, and Cycle II, using the following formula*:*

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$$\text{Classical mastery} = \frac{\text{number of students achieving mastery}}{\text{total number of students}} \times 100\%$$

A student was considered to have achieved mastery when obtaining a score equal to or higher than the Minimum Mastery Criterion (MMC) of 70. Qualitative data obtained from teacher and student observation sheets and documentation were analyzed through data collection, data reduction, data presentation, and drawing conclusions and verification (Miles et., al., 2014) to describe changes in teaching and learning activities, student participation, group cooperation, and psychomotor skills from the pre-cycle to Cycle II. The study was considered successful if (1) the class mean score increased from the pre-cycle through Cycle I to Cycle II; (2) classical mastery reached at least 80% of the 29 students; and (3) student participation, group cooperation, and psychomotor skills improved based on the observation results.

RESULTS

The results are presented from the pre-cycle through Cycle II. **Table 1** and **Figure 1** summarize the improvement in cognitive learning outcomes, while the implementation and observation findings at each stage are described afterward and documented in **Figure 2.**

Table 1. Summary of Grade II students' learning outcomes in each stage (n=29)

Stage	Mean score	Students achieving mastery	Percentage achieving mastery	Students not achieving mastery	Percentage not achieving mastery
Pre-cycle	58	10	34.5%	19	65.5%
Cycle I	72	18	62.0%	11	38.0%
Cycle II	86	25	89.6%	4	13.7%

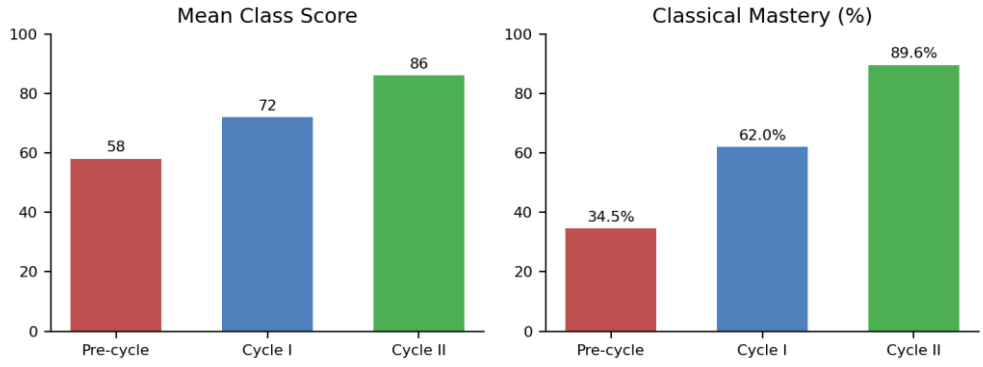

Figure 1. Increase in mean class score and percentage of classical mastery at each stage

As shown in **Table 1** and **Figure 1**, both the class mean score and the percentage of mastery increased at each stage, as did the number of students achieving mastery: 10 students (34.5%) in the pre-cycle, 18 (62.0%) in Cycle I, and 25 (89.6%) in Cycle II. Achieving a mastery percentage above 80% marked the end of this classroom action research. Therefore, the PBL model, supported by folded paper, improved mathematics learning outcomes in fractions.

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Implementation and Observation Findings

Pre-cycle.

Learning was conducted through interactive lecturing. The teacher explained the concept of fractions and demonstrated folding paper into two, three, and four parts while the class listened, then completed the test individually (see **Figure 2a**). The test results showed that students' understanding of the abstract concept of fractions was still very low.

Cycle I.

The teacher presented a contextual problem: a teacher needs three identical pieces of origami paper for a window decoration, and students were asked to find a way to fold them. Students worked in six groups (4–5 children each) to fold, shade, and paste the $\frac{1}{3}$ and $\frac{1}{4}$ folds onto the student worksheet (see **Figure 2b**), after which group representatives presented their results and the other groups gave feedback. Student enthusiasm increased, but the observations identified two problems: some students dominated the group work while other members remained passive, and the $\frac{1}{3}$ folds in several groups were not symmetrical. Classical mastery had not reached 80%, so the study continued to Cycle II.

Cycle II.

Based on the reflection on Cycle I, students were reorganized into eight small groups (five groups of four students and three groups of three students) and were given a project to make a flower garden from folded paper, with $\frac{1}{2}$ of the plot for roses, $\frac{1}{3}$ for jasmine, and $\frac{1}{4}$ for orchids (see **Figure 2c**). Each member had a role (folding, coloring, or pasting), and the teacher scaffolded groups that were still untidy. Task division became even more equitable; no student remained passive, folds were neater and more precise, and students' courage in presenting their work increased. The observers noted that the teacher carried out all PBL stages well and that most students followed the lesson smoothly.



Figure 2. Documentation of learning: (a) pre-cycle, (b) Cycle I, and (c) Cycle II

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A comparison of the implementation and observation findings in the two cycles is presented in **Table 2**.

Table 2. Comparison of implementation and observation findings in Cycle I and Cycle II

Aspect	Cycle I	Cycle II
Grouping	6 groups (4–5 students)	8 groups (3–4 students)
Problem and product	Dividing paper into 3 and 4 equal parts ($\frac{1}{3}$ and $\frac{1}{4}$)	"Fraction Garden" project with plots of $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$
Observation findings	Some students dominated group work; $\frac{1}{3}$ folds were not symmetrical	Member roles were evenly distributed; folds were neater and more precise; presentations were bolder.
Follow-up	Groups were made smaller, and scaffolding strengthened	Success indicators achieved; cycles stopped

Based on **Figure 2** and **Table 2**, student activity appeared more conducive, and students followed the lesson well at every stage. In Cycle I, groups were too large; in Cycle II, I reduced group sizes. I replaced the task of dividing paper into 3 and 4 equal parts with the "Fraction Garden" project to make it easier for students to understand. The Cycle I finding that some students dominated the work was addressed by assigning a specific role to every student. The Cycle I follow-up, namely strengthening guidance, was carried out in Cycle II until the target was achieved. These activities therefore support the success of this classroom action research.

DISCUSSION

The improvement in learning outcomes from the pre-cycle to Cycle II suggests that using folded paper media through the PBL model was associated with Grade II students' improved understanding of fractions. The low pre-cycle results stemmed from lecture-based instruction that required lower-grade students to memorize fraction symbols without understanding their meaning. This condition reinforces Heruman's (2018) view that early-grade fractions should be introduced through direct experience of cutting or dividing real objects. Because students were not invited to divide objects fairly, most of them had difficulty understanding the concepts of numerator and denominator.

Implementing the PBL syntax in Cycles I and II was associated with an improvement in this situation. Contextual problems, dividing paper fairly and making a flower garden, encouraged students to think critically and solve challenges in groups, aligning with the characteristics of PBL (Shoimin, 2017) and the view that PBL helps students construct understanding through collaborative problem solving (Hmelo-Silver, 2004). This finding aligns with Taspiah et al. (2021) and Octaviana et al. (2018), who reported improved mathematics learning outcomes in elementary schools using the PBL model. Ramadhani et al. (2023) likewise used PBL to improve fraction learning outcomes in elementary school. Nofita's (2024) meta-analysis also supported these findings, showing PBL's effectiveness in improving elementary school students' mathematics learning outcomes. Nevertheless, Cycle I did not meet the success indicator, suggesting that PBL still requires implementation adjustments. Overly large groups led some students to dominate the activity while others remained passive. This became a key focus for reflection to improve implementation in Cycle II, including optimizing the use of folded paper so students would be more actively involved in understanding fraction concepts.

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The improvement in Cycle II may also be explained by using folded paper as a two-dimensional concrete medium that helps visualize abstract concepts (Kustandi & Darmawan, 2020). The paper's color helped attract students' attention, while the folding activity let them directly verify that a whole object can be divided into several equal parts (Sundayana, 2018). This aligns with meta-analytic evidence that teaching with concrete manipulatives can benefit mathematics learning (Carbonneau et al., 2013). The group work example in **Figure 3** illustrates this process. Students pasted pieces of paper folded into equal parts and shaded one part to represent a fraction. In Cycle II, the group showed the orchid plot as $\frac{1}{4}$, the smallest part, and noted that the parts must be equal in size. However, not every group was this accurate: another group named the rose plot, not the orchid plot, as the smallest. This finding aligns with Afiani and Faradita (2022) and Yuliandari et al. (2024), who discussed using folded paper media to support understanding of fraction concepts in elementary schools. The difference is that this study combined folded paper media with the PBL syntax, so that students not only manipulated the medium concretely but also used it to solve contextual problems in groups.

Interpret the main results in relation to the research problem, relevant theory, and previous studies. Explain why the observed findings may have occurred; compare similarities and differences with earlier research; and clarify theoretical or practical implications for mathematics education. Distinguish interpretation from the data themselves, acknowledge limitations, and avoid claims beyond the evidence. Together, Results and Discussion typically form the largest portion of the manuscript; the proportions suggested in the previous template are indicative rather than mandatory.

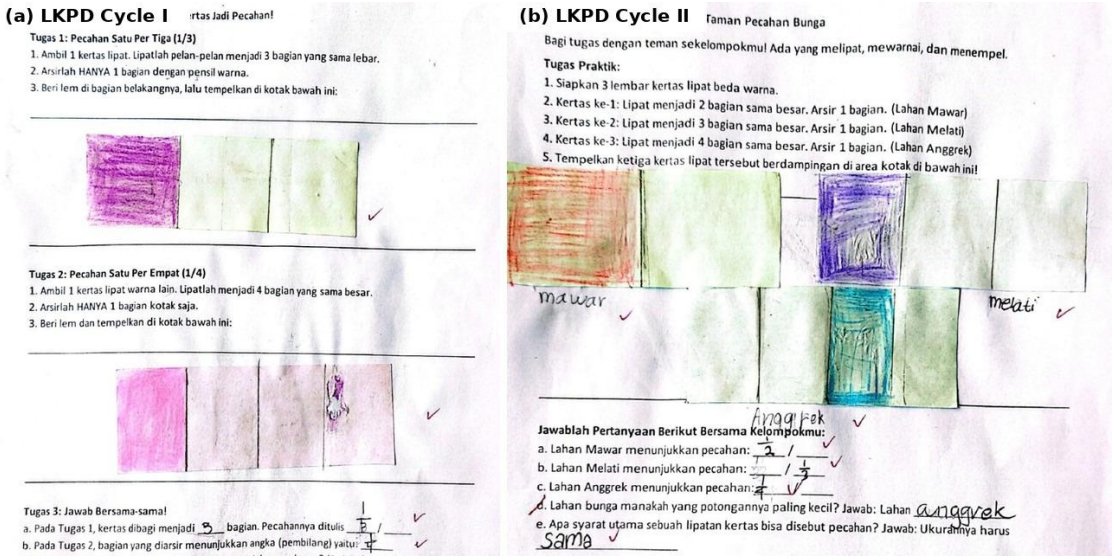

Figure 3. Examples of group work on the student worksheet: (a) Cycle I and (b) Cycle II

Figure 3 shows increased activity from Cycle I to Cycle II in drawing fraction forms. Viewed through the three domains of learning outcomes (Purwanto, 2017), students visually verified the fractions. $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ in the cognitive domain using the area of folded paper and in the psychomotor domain, folding, pressing the fold lines, and shading trained students' precision and neatness. In the affective domain, the smaller groups in Cycle II reduced individual dominance and fostered responsibility, discipline, courage in presenting, and cooperation. These findings suggest that direct learning experience through concrete media can help students build understanding of the concepts they are learning.

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The link between the PBL phases and fraction understanding can be explained as follows. In the orientation phase, the contextual problems (three identical pieces of origami paper for a window decoration and a flower-garden plot) created a need to divide a whole into equal parts. In the investigation phase, folding allowed students to check equality by overlapping the folds, so the equal-parts condition of a fraction was tested through action rather than memorized. In the presentation phase, students explained which part was shaded and how many equal parts the whole had, stating the numerator and denominator in their own words. In the evaluation phase, discussion of the results led students to correct unequal folds. As an area representation, the folded paper provided a concrete bridge from physical action to the symbolic fraction (Carbonneau et al., 2013), while the PBL structure guided students to construct and explain this understanding collaboratively (Hmelo-Silver, 2004).

These explanations should be read with caution, because several components changed at the same time between Cycle I and Cycle II: group size (from six groups of four to five students to eight groups of three to four students), task design (from dividing paper into thirds and fourths to the "Fraction Garden" project with three fractions), role assignment, and the intensity of teacher scaffolding. The three stages were held within eight days, and the worksheets differed in content. They were not equated for difficulty, so familiarity with the topic and differences in task difficulty may also have contributed to the higher scores. Therefore, the gains cannot be attributed to PBL with folded paper alone or to any single component of the intervention; they are best understood as associated with the combined set of changes.

CONCLUSION

Using folded paper media through the Problem-Based Learning (PBL) model was associated with improved learning outcomes on simple fractions among Grade II students. The implementation involved presenting a contextual problem, organizing students into small groups, guiding students to fold, shade, and paste paper, having them present their work, and jointly evaluating the problem-solving process. The class mean score and classical mastery increased at every stage, and mastery exceeded the 80% success indicator in Cycle II, with smaller groups and the contextual "Fraction Garden" project as the key improvements.

Theoretically, combining the PBL model with simple manipulative media can serve as a basis for further research. Practically, using folded paper in PBL can offer lower-grade teachers an alternative because the medium is inexpensive, easy to obtain, and encourages students' active involvement. This study has several limitations. First, it involved only 29 students in one Grade II class at one school and had no comparison group, so the findings cannot be generalized to other classes or settings. Second, the intervention was short, with one meeting per stage (May 11, 12, and 18, 2026), and neither retention nor longer-term effects were examined. Third, the analysis was descriptive only, and no inferential test was applied; in addition, several changes were introduced together in Cycle II, so their individual effects cannot be separated. Finally, the researcher was also the class teacher, and the observers were colleagues from the same school, which may have introduced bias. Future research could include multiple classes or schools, a comparison group, a longer intervention period with a delayed post-test, and inferential analysis.

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DECLARATIONS

Author Contributions: Muji Rahayu: Conceptualization, investigation, and original draft. Siti Maryam Rohimah: Supervision, methodology, and review. Yunengsih: Data collection and validation. Olis Kurniasih: Data analysis and interpretation. Mamat Sudrajat: Methodology and validation. Tati Rosmiati: Resources and data curation. Ronny Kartiwa: Review and editing. All authors approved the final manuscript.

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Ethics Approval and Consent: The study was approved by the school. Student and school identities remain confidential; permission documents are available upon request.

Data Availability: Student score summaries and selected worksheets are available from the corresponding author upon reasonable request, subject to confidentiality.

Conflict of Interest: The authors declare no conflicts of interest.

Use of Generative AI: The authors declare that no generative AI tools were used in preparing this manuscript.

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