

Problem-Solving Learning Using Recycled Materials to Improve Mathematical Literacy on Plane Figures

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Abstract

This study examined mathematical literacy on plane figures after problem-solving learning supported by recycled-material media. A one-group pretest-posttest design involved all 26 third-grade students at SDN 1 Suka Makmur, West Lombok. Data were collected through a 20-item test, observation, and documentation. Students identified problems, explored geometric properties, constructed models from discarded materials, and communicated solutions. The mean score increased from 70.58 (SD = 13.06) to 80.00 (SD = 12.41). Both distributions met the reported Shapiro-Wilk criterion ($p = .131$ and $p = .183$), and the reported comparison produced $t = -2.667$, $p = .010$. The results indicate significant improvement after the activities and suggest that recycled materials can support concrete mathematical reasoning. Because the design had no control group, the finding indicates improvement associated with the intervention rather than definitive causal proof.

Kata kunci:

Problem solving;

Bahan bekas; Literasi

matematika; Bangun

datar; Sekolah Dasar

Abstrak

Penelitian ini mengkaji literasi matematika materi bangun datar setelah pembelajaran problem solving berbantuan bahan bekas. Desain one-group pretest-posttest melibatkan 26 siswa kelas III SDN 1 Suka Makmur, Lombok Barat. Data dikumpulkan melalui tes 20 butir, observasi, dan dokumentasi. Siswa mengenali masalah, mengeksplorasi sifat bangun datar, membuat model dari bahan bekas, dan mengomunikasikan solusi. Nilai rata-rata meningkat dari 70,58 (SD = 13,06) menjadi 80,00 (SD = 12,41). Kedua distribusi memenuhi kriteria Shapiro-Wilk yang dilaporkan ($p = 0,131$ dan $p = 0,183$), sedangkan hasil perbandingan menunjukkan $t = -2,667$, $p = 0,010$. Hasilnya menunjukkan peningkatan signifikan dan potensi bahan bekas untuk mendukung penalaran matematika konkret. Karena tidak ada kelompok kontrol, temuan menunjukkan peningkatan yang berkaitan dengan intervensi, bukan bukti kausal mutlak.

INTRODUCTION

Mathematical literacy enables learners to formulate, use, and interpret mathematics in situations that arise in daily life. At the elementary level, it is not

limited to performing calculations; it also involves recognizing mathematical information, selecting a suitable strategy, explaining reasoning, and relating a result to its context. These abilities are especially important when students begin to study plane figures because geometric ideas are encountered in classroom objects, packaging, signs, and household materials.

Mathematics, however, is frequently perceived by elementary students as abstract and difficult. Learning dominated by textbooks and worksheets may give students few opportunities to manipulate objects, discuss alternative strategies, or test their ideas. When instruction emphasizes answers without the reasoning process, students can memorize names and formulas while remaining unable to use geometric concepts to solve contextual problems. This condition can reduce participation and limit the development of mathematical literacy.

Problem-solving learning offers an alternative because it organizes instruction around a problem that students must understand, investigate, and resolve. Students are encouraged to identify known and unknown information, propose possible solutions, select procedures, test results, and communicate conclusions. Such activity can stimulate critical thinking and make mathematical knowledge functional rather than merely procedural (Harefa, 2021; Maesari et al., 2020; Wedyawati et al., 2020). Problem solving is also relevant to elementary geometry because students can compare, classify, construct, and explain shapes through direct action.

The effectiveness of a learning model is influenced by the media used to represent ideas. Concrete media help younger learners connect symbols and verbal explanations with observable properties. Recycled materials such as cardboard, used packaging, bottle caps, and paper scraps are accessible and inexpensive. They can be cut, arranged, measured, and combined to represent squares, rectangles, triangles, and other plane figures. Their use may also foster creativity and environmental awareness while reducing dependence on commercially produced instructional aids (Mopi, 2016; Sundayana, 2018; Yuliarti, 2019).

Previous studies have reported that problem-solving approaches can strengthen mathematical problem solving, metacognitive knowledge, creative thinking, and cognitive achievement (Limbanadi et al., 2020; Listiyowati, 2021; Lucky & Julyanti, 2023; Nuriana, 2019). Nevertheless, evidence remains contextual, particularly for lower elementary students learning plane figures through media made from discarded materials. At SDN 1 Suka Makmur, preliminary classroom information indicated that students had difficulty recognizing and understanding geometric concepts and that learning relied mainly on books and worksheets. Only 12 of 26 students were described as actively participating in mathematics lessons.

This study therefore aimed to examine the change in third-grade students' mathematical literacy scores after problem-solving learning supported by recycled-material media. The research question was whether students' performance on plane-figure literacy tasks differed between the pretest and posttest. The study was expected to provide practical evidence for teachers seeking low-cost, concrete, and participatory mathematics instruction.

Mathematical literacy connects school mathematics with the decisions and interpretations required in real situations. In geometry, a mathematically literate learner does more than identify a figure by name. The learner recognizes relevant attributes, distinguishes examples from non-examples, selects measurements, represents spatial relationships, and explains why a conclusion is reasonable. These processes require conceptual understanding, procedural knowledge, and communication to work together.

Plane figures provide an appropriate context for developing these capacities in the early grades. Squares, rectangles, triangles, and circles can be located in familiar objects, but everyday appearance does not automatically produce formal understanding. Students may recognize the shape of a door yet be unable to explain the number and relationship of its sides. Instruction must therefore guide learners from perceptual recognition toward explicit descriptions of properties and relationships. Concrete models can support this movement when teachers continually connect physical actions with mathematical language.

Literacy-oriented assessment also differs from exercises that only ask students to recall a definition. A contextual task may require students to choose a suitable shape, compare alternatives, calculate or estimate a dimension, and justify a choice. The 20-item assessment used in the present study was intended to capture students' understanding after they had interacted with the models. Although the available source data do not permit analysis by literacy indicator, the overall score provides an initial description of performance before and after the learning experience.

The developmental characteristics of third-grade students strengthen the rationale for concrete learning experiences. Learners at this level often benefit from manipulating objects before working with abstract symbols. Cutting, folding, arranging, and comparing materials make attributes visible and allow students to check their reasoning directly. When these actions are discussed in groups, the media become a shared reference that can reduce ambiguity and support the use of precise terms.

Problem-solving instruction is a structured learning process rather than a single exercise at the end of a lesson. The teacher presents or develops a meaningful problem, supports students in understanding its conditions, and encourages them to generate and examine possible strategies. Students then carry out a selected approach, evaluate the result, and communicate the reasoning that connects the problem to the solution. This sequence allows mistakes and revisions to function as part of learning.

For plane figures, recycled materials make the problem-solving process observable. A piece of cardboard can be transformed into several shapes, compared by side length, or combined to create a larger design. Packaging can be examined to identify faces that correspond to two-dimensional figures. Paper scraps can be rearranged to test whether different compositions produce the same outline. Each activity offers opportunities to ask what is known, what must be found, which properties matter, and how the answer can be verified.

The use of discarded materials also responds to practical constraints in elementary schools. Teachers do not need to wait for specialized kits, and students can contribute safe materials from their surroundings. Nevertheless, availability alone does not guarantee instructional value. Materials must be clean, safe, easy to manipulate, and selected according to the targeted concept. The teacher must prevent craft production from replacing mathematical reasoning by requiring students to name properties, compare solutions, and explain the meaning of their models.

The conceptual relationship examined in this study can therefore be understood as a sequence: problem-solving steps organize students' cognitive activity, recycled materials provide concrete representations, and discussion links those representations to mathematical language. Improved test performance is expected when students are able to transfer these experiences to questions about plane figures. This expectation informed the design of the classroom intervention and the interpretation of the posttest results

RESEARCH METHODS

The study used a quantitative pre-experimental approach with a one-group pretest-posttest design. One class was assessed before the intervention (O1), participated in problem-solving learning using recycled materials (X), and was assessed again afterward (O2). This design was selected to document within-class change under the actual school conditions.

The research was conducted at SDN 1 Suka Makmur in Gerung District, West Lombok Regency, during the 2023/2024 academic year. The population comprised all 26 third-grade students, consisting of 11 boys and 15 girls. Because the population was fewer than 100 students, total sampling was used and all members of the class participated.

The learning activities addressed plane figures and were conducted in two meetings. Students first completed the pretest. During the intervention, the teacher introduced recycled materials and guided students through problem identification, investigation of geometric properties, construction of plane-figure media, collaborative discussion, and presentation of solutions. The class teacher observed implementation. All seven observation indicators—including introduction of the media, student participation, collaboration, understanding of plane figures, construction of learning media, and teacher guidance—were recorded as implemented.

Data were collected through a multiple-choice test, observation, and documentation. The test originally contained 20 items scored five points for a correct response and zero for an incorrect response. Content validity was reviewed by two experts: a university supervisor and the Grade III classroom teacher. The thesis reported that 14 items exceeded the *r*-table criterion of .388, while six items did not. This instrument evidence should be considered when interpreting the score results.

Descriptive statistics included the mean, median, mode, minimum, maximum, standard deviation, and standard error. Normality was examined with

the Shapiro-Wilk test because the sample was smaller than 30. The original analysis also reported Levene's test and an independent-samples t test comparing the two score sets at an alpha level of .05. Because the same students completed both assessments, a paired-samples analysis would ordinarily be preferable; however, individual paired scores were not available in the source document for recalculation. The inferential results below therefore reproduce the analysis reported in the thesis and are interpreted cautiously.

Learning Procedure

The intervention was organized into connected phases so that the media served the problem-solving process. Table 1 summarizes the learning procedure reconstructed from the lesson description and observation indicators in the thesis. The sequence began with orientation to the materials and concluded with reflection and assessment.

Table 1
Learning Procedure Using Recycled Materials

Phase	Teacher Activity	Student Activity	Literacy Emphasis
Orientation	Introduced safe recycled materials and the plane-figure problem.	Observed the materials and identified familiar shapes.	Recognizing mathematical information in context.
Problem identification	Asked guiding questions about sides, corners, size, and shape.	Stated known information and what needed to be determined.	Formulating a mathematical problem.
Exploration	Guided measurement, cutting, arrangement, and comparison.	Constructed and compared plane-figure models in groups.	Using representations and selecting strategies.
Solution development	Provided assistance when groups encountered difficulty.	Tested alternatives and revised the model or explanation.	Reasoning, checking, and interpreting results.
Communication	Facilitated presentation and peer responses.	Presented the model and explained geometric properties.	Communicating mathematical reasoning.
Reflection and assessment	Connected concrete models to formal concepts and administered the posttest.	Summarized learning and completed the assessment.	Transferring experience to formal tasks.

Data Quality and Analytical Considerations

Instrument review combined expert judgment and item-level empirical testing. Expert judgment considered correspondence between the test, theoretical framework, and learning objectives, as well as clarity of wording and the format

of the item grid. The empirical assessment compared item correlations with an r -table value of .388 at the .05 significance level. Fourteen items were reported as valid, while Items 4, 7, 8, 9, 17, and 20 did not meet the criterion. The thesis also described a test-retest approach to reliability, although a reliability coefficient was not reported.

The analysis used complete-class data, so there was no sampling-based loss of participants. Descriptive statistics were calculated for both measurements before assumption and hypothesis tests. The current article reports the numerical output available in the thesis without creating missing coefficients or student-level pairs. This approach preserves the original evidence while making the design and analytical constraints explicit.

RESULT AND DISCUSSION

Descriptive Results

All 26 students completed the pretest and posttest. Pretest scores ranged from 50 to 90, whereas posttest scores ranged from 60 to 100. The average increased by 9.42 points, from 70.58 to 80.00. The median also increased from 70 to 80, and the most frequent posttest score was 90. The similarity of the standard deviations indicates that the score spread remained relatively stable while the distribution shifted upward.

Table 2

Descriptive Statistics for Pretest and Posttest Scores

Assessment	N	Mean	SD	Minimum	Maximum
Pretest	26	70.58	13.06	50	90
Posttest	26	80.00	12.41	60	100

Distribution of Student Scores

The frequency distributions show that the improvement was not confined to a single score category. The lowest category shifted from 50 on the pretest to 60 on the posttest, while the highest category shifted from 90 to 100. Five students achieved a posttest score of 90, and four students reached scores above 90. Table 3 presents the reported frequencies.

Table 3

Frequency Distribution of Pretest and Posttest Scores

Score	Pretest Frequency	Posttest Frequency
50	3	0
55	2	0
60	3	3
65	3	2
70	3	3
75	3	3
80	3	3
85	3	3
90	3	5
95	0	2

100

0

2

The upward shift is visible at both ends of the distribution. No student remained in the 50 or 55 categories after the intervention, while the posttest introduced scores of 95 and 100 that did not appear on the pretest. At the same time, several students remained in the 60–75 range, indicating that the learning experience did not produce uniform mastery. Differentiated follow-up would therefore still be required for students who need additional support.

The reported mean gain of 9.42 points represents approximately 13.35% of the pretest mean. This percentage is a descriptive indicator rather than a standardized effect size because the paired raw data required for a reliable within-student effect calculation were unavailable. Even so, the combination of higher central tendency, a higher minimum, and movement toward the upper score categories provides convergent descriptive evidence of improvement.

Assumption Tests and Score Comparison

The Shapiro-Wilk significance values were .131 for the pretest and .183 for the posttest. Both values exceeded .05, so the score distributions met the normality criterion used in the study. Levene's test based on the mean produced $F = .116$ and $p = .735$, indicating similar variances between the two score sets under the reported analysis.

The reported t-test produced $t = -2.667$, $df = 50$, and $p = .010$. Because p was below .05, the thesis rejected the null hypothesis and concluded that the pretest and posttest scores differed significantly. The result aligns with the descriptive increase of 9.42 points. Table 4 summarizes the statistical evidence reported in the source study.

Table 4
Reported Assumption Tests and Score Comparison

Analysis	Statistic	df	p	Interpretation
Shapiro-Wilk pretest	.940	26	.131	Normality criterion met
Shapiro-Wilk posttest	.946	26	.183	Normality criterion met
Levene's test	.116	1, 50	.735	Equal-variance criterion met
Reported score comparison	-2.667	50	.010	Significant difference

DISCUSSION

The increase in students' scores suggests that problem-solving activities supported by recycled materials helped students engage with plane-figure concepts. Instead of encountering shapes only as printed diagrams, students manipulated concrete materials, observed sides and corners, constructed examples, and discussed how a shape could be recognized. These actions can bridge concrete experience and mathematical representation, which is especially relevant for third-grade learners.

The problem-solving sequence also changed the role of students in the lesson. Students were not positioned only as recipients of formulas; they participated in identifying a task, proposing a strategy, collaborating, and presenting a result. This pattern is consistent with the view that problem solving encourages learners to organize information and formulate conclusions (Harefa, 2021; Shoimin, 2017). The observation record, in which all implementation indicators were marked as completed, supports the conclusion that the intended learning steps were carried out.

The result is consistent with studies reporting positive effects of problem-solving models on elementary mathematics outcomes. Maesari et al. (2020) found that problem-solving instruction improved elementary students' mathematical problem-solving ability. Listiyowati (2021) reported benefits for creative thinking in data-processing tasks, while Lucky and Julyanti (2023) found an association with mathematical problem-solving performance. The present study extends this practical evidence to lower-grade geometry and shows that locally available discarded materials can be integrated into the model.

Recycled-material media may contribute through affordability, familiarity, and flexibility. Teachers can adapt cardboard, paper, and packaging into different geometric representations without specialized equipment. Students can also participate in producing the media, which may increase attention and ownership of learning. This approach supports the argument that mathematical media should help learners observe and act on concepts rather than function only as decoration (Sundayana, 2018).

The findings should nevertheless be interpreted within important limitations. First, the one-group design cannot rule out maturation, repeated-testing effects, or influences outside the intervention. Second, the treatment lasted only two meetings, so the persistence of learning was not assessed. Third, the original thesis used an independent-samples test even though the same students took both tests; a paired-samples test would be more appropriate when paired raw scores are available. Fourth, six of the original 20 test items did not meet the reported validity criterion. Future research should use a validated instrument, retain paired student-level data, include a comparison group, and examine delayed retention as well as students' reasoning processes.

For classroom practice, the evidence supports cautious use of recycled materials as a low-cost component of problem-solving instruction. Teachers should align each object with a clear mathematical purpose, guide students to explain the relationship between the model and the formal concept, and assess reasoning in addition to final answers. The value of the media lies not merely in using discarded objects, but in how those objects are embedded in purposeful mathematical inquiry.

Interpretation Through Mathematical Literacy Processes

The intervention can be interpreted through three connected literacy processes: formulating, employing, and interpreting mathematics. Students formulated mathematics when they identified the relevant geometric features of an object and translated a practical task into questions about sides, corners, and

arrangements. They employed mathematics when they compared shapes, constructed models, and selected a strategy. They interpreted mathematics when they checked whether a model satisfied the problem and explained its properties to classmates.

The materials were particularly relevant during formulation because they made the context visible. Students could point to an edge, rotate a model, or place two shapes together while explaining an idea. This shared visual field reduced the demand of holding every relation mentally and allowed the teacher to diagnose misconceptions. A student who classified a rectangle incorrectly, for example, could be asked to compare its opposite sides or corners directly.

During the employing phase, the problem-solving model encouraged more than one route to a result. Students could cut a new model, rearrange existing pieces, measure an attribute, or compare with a peer's construction. The possibility of revising a physical model made checking less abstract. It also gave the teacher opportunities to ask why one method was efficient or how two different models could represent the same concept.

Interpretation and communication were addressed when students connected the model to formal mathematical statements. This step is essential because concrete activity alone does not ensure abstraction. The instructional value emerges when learners articulate what the object demonstrates, which properties remain unchanged, and how those properties justify an answer. The reported improvement is therefore plausibly related to the combined use of manipulation, guided questioning, collaboration, and explanation rather than to the material objects in isolation.

Pedagogical Implications

The findings have several implications for elementary teachers. First, recycled materials can be planned as part of the lesson objective rather than added as an entertainment activity. A teacher should determine the specific property to be represented, the action students will perform, the question that will guide reasoning, and the evidence students must provide. This alignment helps ensure that the activity develops mathematical literacy.

Second, group work needs explicit roles and accountability. One student may prepare the material, another record observations, another check geometric properties, and another present the explanation. Rotating these roles can prevent a confident student from completing the construction while others remain passive. Individual exit questions can then show whether each learner can transfer the group experience to an independent task.

Third, teachers should prepare questions at different levels of challenge. Initial questions may ask students to identify or count attributes. Intermediate questions can require comparison and classification. More demanding questions can ask students to design a shape under specified conditions, defend whether a construction meets those conditions, or explain how changing one property affects classification. This progression supports students who begin at different levels.

Fourth, environmental messages should remain connected to the mathematical objective. Collecting and reusing clean materials can introduce responsible consumption, but the lesson should not imply that every discarded object is safe or appropriate for classroom use. Teachers need clear selection criteria, including cleanliness, absence of sharp edges, suitable size, and ease of handling. Preparing materials in advance also protects instructional time.

Finally, assessment should combine selected-response items with evidence of reasoning. Multiple-choice scores provide efficient comparisons, while short explanations, drawings, model demonstrations, or observation rubrics can reveal how students formulate and interpret mathematics. A broader assessment design would strengthen future evidence about which dimensions of literacy are most responsive to the intervention.

Study Limitations and Future Research

The present evidence is bounded by the design and the information retained in the thesis. A one-group pretest-posttest design is vulnerable to history, maturation, testing, and instrumentation effects. The two-meeting duration further limits conclusions about long-term learning. A future study should include a comparable class receiving regular instruction, apply the same validated assessments, and add a delayed posttest.

Future analysis should preserve matched pretest and posttest scores for every participant and apply a paired-samples test or a suitable nonparametric alternative. Reporting confidence intervals and a paired effect size would clarify the magnitude and precision of the change. Item-level analysis could also determine whether students improved most in recognizing properties, applying procedures, solving contextual problems, or explaining conclusions.

Qualitative evidence would complement score comparisons. Classroom video, student work, interviews, and teacher reflection could document how students use the materials, which misconceptions arise, and how group discussion influences reasoning. Research across several schools and grade levels would then indicate whether the approach is transferable beyond the specific classroom examined here.

CONCLUSION

Third-grade students' mathematical literacy scores on plane-figure material improved after problem-solving learning supported by recycled materials. The mean increased from 70.58 to 80.00, and the statistical comparison reported in the thesis was significant at $p = .010$. The learning approach provided concrete and accessible media through which students could explore geometric properties, collaborate, and communicate solutions.

The findings offer practical support for integrating recycled materials into elementary mathematics instruction, particularly in schools with limited instructional resources. However, the absence of a control group, the short intervention, the instrument-validity concerns, and the use of an independent-samples test for repeated observations limit causal interpretation. Replication with

a stronger quasi-experimental or experimental design and a paired analysis is recommended

REFERENCE

- Harefa, D. (2021). Model-model pengajaran dan pembelajaran: Isu-isu metodis dan paradigmatis. Pustaka Pelajar.
- Huda, M. (2015). Model-model pengajaran dan pembelajaran: Isu-isu metodis dan paradigmatis. Pustaka Pelajar.
- Jalinus, N. (2021). Riset pendidikan dan aplikasinya. UNP Press.
- Limbanadi, S., Subandi, S., & Munzil, M. (2020). Pengaruh model pembelajaran problem solving-think pair share terhadap pengetahuan metakognitif siswa. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 5(6), 774. <https://doi.org/10.17977/jptpp.v5i6.13607>
- Listiyowati, I. (2021). Pengaruh metode pembelajaran pemecahan masalah terhadap kemampuan berpikir kreatif siswa dalam menyelesaikan soal pengolahan data kelas VI SD. *Jurnal EDUPENA*, 2(1), 17–26.
- Lucky, Y., & Julyanti, E. (2023). Pengaruh model pembelajaran creative problem solving terhadap kemampuan pemecahan masalah matematis siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 12(1), 1408. <https://doi.org/10.24127/ajpm.v12i1.7012>
- Maesari, C., Marta, R., & Yusnira, Y. (2020). Penerapan model pembelajaran problem solving untuk meningkatkan kemampuan pemecahan masalah matematika siswa sekolah dasar. *Jurnal Pendidikan dan Konseling*, 2(1), 12–20. <https://doi.org/10.31004/jpdk.v1i2.531>
- Mopi, S. (2016). Pemanfaatan barang bekas sebagai media pembelajaran IPA di SDN 4 Telaga.
- Nuriana, S. A. (2019). Pengaruh model problem solving terhadap kemampuan menyelesaikan soal cerita materi volume bangun ruang kelas V sekolah dasar. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar*, 7(3), 3050–3060.
- Rufa Hera. (2018). Pengaruh model pembelajaran problem solving terhadap hasil belajar siswa pada materi kalor. *Genta Mulia*, 9(1), 147–156.
- Shoimin, A. (2017). 68 model pembelajaran inovatif dalam Kurikulum 2013. Ar-Ruzz Media.
- Sudaryono. (2016). Metode penelitian pendidikan. Kencana.
- Sugiyono. (2019). Metode penelitian kuantitatif dan kualitatif. Alfabeta.
- Sundayana, R. (2018). Media dan alat peraga dalam pembelajaran matematika. Alfabeta.
- Wedyawati, N., Setyawan, A., & Margareta, P. (2020). Pembelajaran SD berbasis problem solving method. *Literasi Nusantara*.
- Yenni, N. L., Swistoro, E., & Purwanto, A. (2019). Pengaruh pembelajaran dengan model problem solving fisika terhadap hasil belajar kognitif dan kemampuan berpikir kritis siswa. *Jurnal Kumparan Fisika*, 2(2), 121–128. <https://doi.org/10.33369/jkf.2.2.121-128>

Yuliarti. (2019). Pemanfaatan sampah atau barang bekas di lingkungan sekitar.
Yayasan Clean