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OPTIMIZING PLASTIC WASTE TEACHING AIDS TO IMPROVE MATHEMATICS LEARNING OUTCOMES AMONG ELEMENTARY SCHOOL STUDENTS

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ABSTRAK

Penelitian ini dilaksanakan berdasarkan hasil observasi awal pada pembelajaran matematika peserta didik kelas V di SD Negeri 1 Jatianom. Hasil observasi menunjukkan bahwa hasil belajar matematika peserta didik masih belum optimal, khususnya pada materi penjumlahan bilangan pecahan, serta penggunaan media pembelajaran konkret belum dimanfaatkan secara optimal. Oleh karena itu, penelitian ini bertujuan untuk mengetahui efektivitas alat peraga berbahan limbah plastik terhadap peningkatan hasil belajar matematika peserta didik. Penelitian ini menggunakan metode *mixed method* dengan desain *one-group pretest-posttest* pada data kuantitatif dan observasi pembelajaran sebagai data kualitatif. Subjek penelitian terdiri atas 20 peserta didik kelas V yang dipilih menggunakan teknik total sampling. Data dikumpulkan melalui tes hasil belajar dan observasi aktivitas peserta didik selama penerapan alat peraga limbah plastik. Data kuantitatif dianalisis melalui perbandingan hasil *pretest* dan *posttest* serta *N-gain*, sedangkan data kualitatif dianalisis secara deskriptif untuk menggambarkan aktivitas peserta didik selama pembelajaran. Hasil penelitian menunjukkan adanya peningkatan hasil belajar setelah penerapan alat peraga limbah plastik, dengan rata-rata nilai meningkat dari 43,4 pada *pretest* menjadi 87,6 pada *posttest* dan peningkatan *N-gain* berada pada kategori tinggi. Hasil observasi juga menunjukkan bahwa peserta didik lebih aktif menggunakan alat peraga, bekerja sama, dan mengikuti kegiatan pembelajaran. Dengan demikian, alat peraga limbah plastik efektif mendukung peningkatan hasil belajar matematika sekaligus menciptakan pembelajaran yang konkret, kontekstual, dan ramah lingkungan.
Kata Kunci: *Alat Peraga; Hasil Belajar Matematika, Limbah Plastik.*

ABSTRACT

This study was conducted based on initial observations of mathematics learning among fifth-grade students at SD Negeri 1 Jatianom. The observations indicated that students' mathematics learning outcomes were still not optimal, particularly in addition of fractions, and the use of concrete learning media had not been optimally implemented. Therefore, this study aimed to determine the effectiveness of plastic waste-based teaching aids in improving students' mathematics learning outcomes. This study employed a mixed-method approach with a one-group pretest-posttest design for quantitative data and classroom observations for qualitative data. The participants were 20 fifth-grade students selected using total sampling. Data were collected through learning outcome tests and observations of students' activities during the implementation of plastic waste-based teaching aids. Quantitative data were analyzed by comparing pretest and posttest scores and calculating the N-gain, while qualitative data were analyzed descriptively to describe students' activities during the learning process. The results showed an improvement in students' learning outcomes after the implementation of the teaching aids, with the mean score increasing from 43.4 on the pretest to 87.6 on the posttest,

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while the N-gain was categorized as high. The observation results also indicated that students became more active in using the teaching aids, collaborating, and participating in learning activities. Thus, plastic waste-based teaching aids were effective in supporting the improvement of mathematics learning outcomes while creating concrete, contextual, and environmentally friendly learning.
Keywords: Teaching Aids; Plastic Waste; Mathematics Learning Outcomes.

INTRODUCTION

Mathematics learning in elementary schools should ideally not only focus on mastering procedures and calculations but also provide concrete and contextual learning experiences that enable students to actively construct conceptual understanding. The abstract nature of mathematics requires students to use concrete objects or representations so that concepts can be understood more easily. The use of teaching aids can connect mathematical concepts with students' real-life experiences. Previous studies have shown that concrete media can improve conceptual understanding, student engagement, and mathematics learning outcomes. Hartini (2022) found that the use of concrete media was able to improve students' participation and mathematics learning outcomes, while Setyowati (2023) reported an improvement in learning outcomes following the use of concrete media. In line with these findings, Huneroh, Darmini, and Widiawati (2024) demonstrated that the use of instructional media can improve elementary school students' mathematics learning outcomes. Therefore, the use of concrete media is an alternative approach to creating more meaningful mathematics learning.

This ideal condition has not yet been fully reflected in the mathematics learning of fifth-grade students at SD Negeri 1 Jatianom. Based on initial observations conducted during the second semester of the 2025/2026 academic year, learning activities still tended to rely on routine and procedural exercises, while the use of concrete instructional media was not yet optimal. This condition affected students' learning outcomes. Of the 20 students who participated in the initial evaluation, all students had not achieved the minimum learning criterion (KKTP) of 70. Students also experienced difficulties in analyzing information in problems, evaluating the correctness of answers, and developing concrete representations of mathematical concepts. This condition indicates a gap between the ideal mathematics learning process, which should provide concrete and contextual experiences, and the actual learning process, which remained relatively abstract and procedural.

The use of teaching aids is one alternative that can be applied to address these problems. Karunia et al. (2024) showed that the use of fraction block teaching aids had an effect on students' learning outcomes, while Sari, Rizkayanti, and Rimayasi (2024) demonstrated that realistic mathematics teaching aids could improve elementary school students' learning outcomes. Sapari and Samosir (2023) also found that the use of teaching aids through the demonstration method could improve students' understanding of fraction addition and subtraction operations. In line with these findings, Widiawati, Wahyuningsih, and Yulianti (2022) demonstrated that worksheets based on *Realistic Mathematics Education* (RME) for mixed fractions could support more contextual learning. These findings reinforce that concrete media and learning experiences can help students understand fraction concepts more meaningfully.

The school environment also has potential as a learning resource, including plastic waste. Materials that are initially regarded as waste can be transformed into concrete and functional teaching media. Sihotang et al. (2025) showed that plastic waste can be developed into learning media that support students' creativity and environmental awareness. Haerana and

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Iswatiningsih (2025) also demonstrated that plastic waste can be utilized as learning media for elementary school students. Meanwhile, Sumiati, Iman, and Rosiana (2023) showed that the use of instructional media can increase students' engagement and interest in learning. Thus, the use of plastic waste as teaching aids can combine instructional functions with contextual environmental utilization. This is relevant to the condition at SD Negeri 1 Jatianom, where the potential of plastic waste in the surrounding environment has not yet been optimally utilized as a learning resource.

Although previous studies have examined teaching aids and the utilization of plastic waste, research that specifically integrates used plastic bottles as fraction teaching aids in fifth-grade mathematics learning remains limited. The novelty of this study lies in designing used plastic bottles into equal fraction parts that can be directly manipulated by students to represent, combine, and compare fraction components. This helps students connect concrete representations with the symbolic process of fraction addition, including finding common denominators. In addition, the use of discarded plastic bottles provides a simple, contextual, creative, and environmentally friendly learning resource. Therefore, this study aims to determine the effectiveness of plastic waste teaching aids on the mathematics learning outcomes of fifth-grade students at SD Negeri 1 Jatianom and the improvement in their learning outcomes.

METHODS

This study used a mixed-method approach with an experimental method. The quantitative component employed a *one-group pretest-posttest* design to determine changes in students' mathematics learning outcomes before and after the treatment, while the qualitative component was used to describe students' activities during the learning process. The study was conducted in Grade V at SD Negeri 1 Jatianom during the second semester of the 2025/2026 academic year, involving 20 students as research subjects. A similar research design was used by Diniasih, Widiawati, and Hardiyanto (2025) in a mathematics learning study on fraction material.

The research instruments consisted of a learning outcomes test and an observation sheet. The learning outcomes test was administered before and after the treatment and was developed based on the topic of fraction addition and the learning achievement indicators. The use of tests as instruments for measuring learning outcomes was also applied by Rohaeni, Iman, and Darmini (2024) in a mathematics learning study through the administration of learning outcome tests to students. In addition, Siregar et al. (2024) used *pretest* and *posttest* instruments to obtain data on students' abilities before and after learning. Before being used, the learning outcomes test was tested for validity using the Pearson Product Moment correlation and for reliability using a reliability coefficient. An item was considered valid when the calculated correlation value exceeded the critical value, while the instrument was considered reliable when the reliability coefficient met the predetermined criterion. The observation sheet was used to obtain qualitative data on students' activities during the learning process.

The research was conducted in three stages: administering the *pretest*, implementing learning activities using plastic waste teaching aids, and administering the *posttest*. The 20 fifth-grade students were selected using total sampling because the entire population of Grade V was included as research subjects. During the treatment stage, students used teaching aids made from plastic waste as concrete learning media to help them understand the concept of fraction addition. After the learning activities were completed, students were given a *posttest* containing material and indicators equivalent to those in the *pretest*. A pre- and post-treatment

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measurement procedure was also used by Rahma and Kurniawati (2024) and Alvan et al. (2024) to determine changes in students' abilities or learning outcomes following the implementation of the learning treatment.

The quantitative data were analyzed by comparing the *pretest* and *posttest* results, including mean scores, the percentage of students achieving the learning criterion based on a KKTP of 70, and learning improvement using the *N-gain* score. The use of *N-gain* analysis to determine learning improvement was also applied by Purnama, Santia, and Hima (2024) to measure students' improvement after receiving the learning treatment. Before the hypothesis test, data normality was examined using the Shapiro-Wilk test. A Paired Sample *t*-Test was then conducted to determine the significance of differences between the *pretest* and *posttest* scores. Qualitative data obtained from the observation sheet were analyzed descriptively to describe students' activities during the learning process. The effectiveness of the teaching aids was determined based on the improvement in learning outcomes, the significance of the difference between the *pretest* and *posttest*, the *N-gain* results, and the achievement of at least 80% classical mastery. The 80% target was established as the indicator of classical learning mastery, meaning that the learning implementation was considered effective when at least 80% of students achieved the predetermined KKTP of 70.

RESULTS AND DISCUSSION

Results

The research was conducted in Grade V at SD Negeri 1 Jatianom, Susukan District, Cirebon Regency, in August 2026. The participants consisted of 20 students. The research aimed to determine the effectiveness of plastic waste teaching aids in improving students' mathematics learning outcomes on the topic of fraction addition. The teaching aid was designed using used plastic bottles and paint. The bottles were cleaned, dried, divided into several sections representing fractions, and colored to distinguish each fractional part. The teaching aid was used to help students identify, combine, and determine the results of fraction addition concretely. For fractions with different denominators, students were guided to equalize the denominators before combining the fractional parts.

Before analyzing the research results, the learning outcome instrument was tested for validity and reliability. The validity test used the Pearson Product Moment correlation. All 10 test items were declared valid because the calculated correlation coefficients were greater than the r-table value of 0.361. The reliability test produced a Cronbach's Alpha value of 0.900, which was greater than 0.361, indicating that the instrument was reliable and suitable for measuring students' mathematics learning outcomes.

The students' mathematics learning outcomes were measured through a pretest and posttest. The results are presented in Table 1.

Table 1. Students' Mathematics Learning Outcomes Before and After the Use of Plastic Waste Teaching Aids

Learning Outcomes	*Prestest*	*Posttest*
Total Score	868	1.752
Mean Score	43,4	87,6
Highest Score	56	100
Lowest Score	24	72
Students Achieving Mastery	0%	100%

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Students Not Achieving Mastery	20 (100%)	0 (0%)
Mastery Criterion (KKTP)	70	70

Table 1 shows a substantial iprovement in students' mathematics learning outcomes after the implementation of plastic waste teaching aids. The mean score increased from 43.4 in the pretest to 87.6 in the posttest, representing an increase of 44.2 points. Before the intervention, none of the 20 students achieved the mastery criterion of 70. After the intervention, all 20 students achieved the criterion, with a classical mastery percentage of 100%. The posttest scores ranged from 72 to 100, indicating that all students exceeded the minimum mastery criterion.

In addition to learning outcomes, students' learning activities were observed in the affective and psychomotor domains. Before the implementation of the teaching aid, only 4 students (20%) were categorized as good in the affective domain. After the implementation, the number increased to 19 students (95%), indicating that the target of 80% had been achieved. In the psychomotor domain, the number of students categorized as good increased from 4 students (20%) before the intervention to 20 students (100%) after the intervention. The implementation of the learning module was also observed before and after the use of plastic waste teaching aids. Before the intervention, the learning module obtained a score of 12 out of a maximum score of 27, equivalent to 44.44%, and was categorized as sufficient. After the intervention, the score increased to 27 out of 27, equivalent to 100%, and was categorized as very good. These findings indicate that the learning implementation after the use of plastic waste teaching aids had achieved the research success target of 80%. Students' responses toward the use of plastic waste teaching aids were measured using a questionnaire consisting of 10 statements, including five positive and five negative statements. The questionnaire obtained a total score of 696, corresponding to 87%. This result was categorized as very good and exceeded the research success target of 80%.

Statistical Analysis Using SPSS

The quantitative data were analyzed using Statistical Product and Service Solutions (SPSS) version 22. The analysis included the Shapiro-Wilk normality test, Levene's homogeneity test, and paired sample t-test. The results of the SPSS analysis are presented in Table 2.

Table 2. Results of Statistical Analysis Using SPSS

Analysis	Statistic	df	Sig.	Interpretation
Shapiro-Wilk	0,931	20	0,163	Normal
Shapiro-Wilk	0,931	20	0,164	Normal
Levene's Test	0,033	1,38	0,856	Homogeneous
Paired Sample t-test	-21,877	19	<0.001	Significant

The Shapiro-Wilk normality test showed a significance value of 0.163 for the pretest and 0.164 for the posttest. Both values were greater than 0.05, indicating that the pretest and posttest data were normally distributed. The Levene's test produced a significance value of 0.856, which was also greater than 0.05, indicating that the variances of the data were homogeneous. The hypothesis test was conducted using a paired sample t-test because the research compared students' scores before and after the same treatment. The SPSS output showed a mean difference of -44.200, with a standard deviation of 9.036 and a standard error

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mean of 2.020. The 95% confidence interval for the difference ranged from -48.429 to -39.971. The test produced a t-value of -21.877 with 19 degrees of freedom and a significance value of $p < 0.001$. The negative t-value resulted from the calculation being performed as pretest minus posttest; if the calculation is reversed as posttest minus pretest, the t-value is +21.877. Since $p < 0.05$, the null hypothesis was rejected and the alternative hypothesis was accepted. Thus, there was a statistically significant difference between students' mathematics learning outcomes before and after the implementation of plastic waste teaching aids.

N-Gain Analysis

The N-Gain analysis was conducted to determine the level of improvement in students' mathematics learning outcomes from the pretest to the posttest. The results are presented in Table 3.

Table 3. N-Gain Score of Students' Mathematics Learning Outcomes

Komponen	Minimum	Maximum	Mean N-Gain	Std. Deviation	Category
20	0.50	1.00	0.7882	0.14626	High

The mean N-Gain score was 0.7882, with a minimum score of 0.50 and a maximum score of 1.00. Based on the N-Gain classification used in the study, a value of $0.70 \leq g \leq 1.00$ is categorized as high. Therefore, the N-Gain result of 0.7882 indicates a **high level of improvement** in students' mathematics learning outcomes after the implementation of plastic waste teaching aids. Importantly, the N-Gain value itself indicates the magnitude of learning improvement and should not be interpreted as direct evidence of effectiveness.

The N-Gain percentage was 78.82%. If the effectiveness classification of N-Gain ≥76% is used, this result falls within the effective category; however, this classification must be explicitly supported by the reference used in the research methodology. Therefore, the N-Gain result in this study is primarily interpreted as showing a high level of improvement, while the conclusion regarding effectiveness is supported separately by the classical mastery criterion.

Effectiveness of Plastic Waste Teaching Aids

The effectiveness of the teaching aid was determined based on the percentage of students achieving the learning mastery criterion. The effectiveness was calculated using the following formula:

$$\text{Effectiveness} = (\text{Number of students achieving mastery} / \text{Total number of students}) \times 100\%$$

$$\text{Effectiveness} = (20 / 20) \times 100\% = 100\%$$

The results showed that all 20 students achieved the KKTP of 70 after the implementation of the plastic waste teaching aid. The classical mastery percentage was therefore 100%. Based on the effectiveness criterion used in the study, a percentage of 90%–100% is categorized as effective. Thus, the plastic waste teaching aid can be categorized as effective in supporting students' mathematics learning on fraction addition.

Overall, the findings indicate that the use of plastic waste teaching aids was followed by an increase in students' mathematics learning outcomes, a high N-Gain score, improved learning activities, better learning-module implementation, and positive student responses. The statistical test also confirmed a significant difference between the pretest and posttest scores. Therefore, the combination of the learning outcome data, statistical analysis, classical mastery, observation results, and student responses provides evidence supporting the effectiveness of plastic waste teaching aids in Grade V mathematics learning.

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Discussion

The research results showed that the implementation of plastic waste teaching aids improved the mathematics learning outcomes of fifth-grade students at SD Negeri 1 Jatianom. The improvement was reflected in the changes in learning outcomes before and after the implementation of the teaching aids, as well as the *N-gain* score, which was categorized as high. This condition indicates that the use of concrete objects can help students understand fraction addition through more tangible learning experiences. This finding is consistent with the study by Fauziah, Darmini, and Widiawati (2024), which showed that the use of puzzle media in mathematics learning could improve learning outcomes while making students more active and enthusiastic in participating in learning activities. This similarity indicates that media that can be used directly can provide visual and manipulative experiences that help students understand mathematical concepts.

The use of plastic waste teaching aids in this study also provided contextual learning experiences because the materials used came from the students' surrounding environment. Learning activities did not only direct students to obtain answers but also provided opportunities to observe fraction components, combine them, and determine the results of addition directly. This is in line with the study by Widiawati, Sujarwo, and Saptono (2025), which showed that the use of Moodle-assisted electronic modules could support numeracy literacy learning through media designed to help students connect learning with real-world problem solving. Although the forms of media used were different, both studies demonstrate the importance of learning media that can connect mathematical concepts with meaningful learning activities.

The improvement in learning outcomes in this study also demonstrates the importance of using media that actively engages students. Ikhlaula, Dianasari, and Iman (2024) showed that media-assisted learning could improve students' learning outcomes through active involvement during the learning process. This finding supports the results of the present study, indicating that the use of plastic waste teaching aids can create more active learning while helping students understand the material concretely.

In addition to improving learning outcomes, the implementation of teaching aids also encouraged student engagement during the learning process. Students had opportunities to use the teaching aids, discuss, collaborate, and complete activities related to the learning material. This finding is consistent with Wati et al. (2025), which involved Bagus Nurul Iman in research on the use of Wordwall media to improve student engagement in mathematics learning. The study showed that attractive learning media can encourage students' involvement in learning activities. The difference lies in the characteristics of the media, as the present study used concrete objects that could be touched and manipulated directly.

The use of plastic waste as teaching aid materials provides additional value because materials that were previously unused can be transformed into learning media. In this study, plastic bottles were cleaned, colored, and then designed into components representing fractions. This design enabled students to directly observe the relationships between fraction components. This finding is consistent with Jumiati, Arjudin, and Rosyidah (2020), who used fraction blocks as teaching aids to help students understand fractions. Although the materials and forms of the teaching aids were different, both served the same function, namely providing concrete representations of fraction concepts so that abstract material could be observed and understood more easily.

The use of visual and concrete media in fraction learning is also supported by Subrata and Muhimmah (2023). A review of various studies showed that the use of learning media, particularly visual media, can support students' understanding and learning outcomes in

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fraction material. In this study, the colors and shapes of the plastic bottles provided visual representations of fraction components, enabling students to connect the observed objects with the mathematical concepts being learned. Thus, the use of plastic waste not only serves as an alternative material for learning media but also has a pedagogical function in visualizing fraction concepts.

The research results also showed that the implementation of teaching aids had an impact on students' learning activities in the affective and psychomotor domains. Students became more active in using the teaching aids, collaborating, and carrying out learning activities. This condition is consistent with Asifah, Sati, and Widiawati (2025), which showed that the use of learning media could improve mathematics learning outcomes, as well as Helvianti, Sati, and Abdul Karim (2026), which showed that active student involvement could improve the quality of learning. Thus, the use of plastic waste teaching aids not only helps students understand fraction material concretely but also encourages their active participation in learning.

The use of the environment as part of learning is also important in this study. Plastic waste is not only viewed as material that should be discarded but can be processed into concrete and contextual learning media. Pangaribuan and Pangaribuan (2021) showed that teaching aids made from plastic waste for elementary mathematics learning were valid, practical, and effective. This finding strengthens the view that plastic waste can be utilized as a learning media resource while providing environmental value.

The results of this study also show that plastic waste teaching aids can be used in learning that positions students as active subjects. This is consistent with Santi, Syahid, and Martini (2023), who showed that the use of recycled materials as mathematics teaching aids could improve the learning outcomes of fifth-grade students. The use of easily accessible materials also provides opportunities for students to become directly involved in the learning process. Therefore, plastic waste teaching aids can support more active learning while helping students understand mathematical concepts concretely.

Overall, the effectiveness of plastic waste teaching aids in this study was reflected not only in the improvement of learning outcomes but also in increased student activity and learning implementation. The high *N-gain* score indicates that the use of teaching aids provided a meaningful improvement in learning achievement. The novelty of this study lies in the use of used plastic bottles as concrete teaching aids for fraction addition in Grade V. The teaching aids combine visual, manipulative, contextual, and environmentally friendly functions in a single learning medium. Thus, plastic waste can be developed into a simple and accessible learning resource while helping students understand mathematical concepts through direct learning experiences.

CONCLUSION

The implementation of plastic waste teaching aids was effective in supporting mathematics learning on fraction addition among fifth-grade students at SD Negeri 1 Jatianom. The use of teaching aids provided concrete and contextual learning experiences that enabled students to understand fraction concepts more easily, participate actively, and engage directly in the learning process, thereby supporting improved learning outcomes. These findings demonstrate that learning media made from plastic waste can serve not only as a practical instructional resource but also as an innovative alternative that connects mathematical learning with students' real-life environment. Furthermore, the utilization of plastic waste provides added value by transforming materials that are commonly regarded as waste into useful learning resources while fostering students' awareness of environmental responsibility. Thus, the use of

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plastic waste teaching aids has potential to support meaningful mathematics learning that integrates cognitive, practical, and environmental aspects. In the future, these teaching aids can be further developed for other mathematics topics, refined in terms of design and functionality, and tested across different grade levels and student characteristics to broaden their applicability and strengthen their contribution to mathematics learning.

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