

DEVELOPMENT OF SCIENCE TEACHING AIDS USING RECYCLED MATERIALS TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS

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ABSTRACT

The Low Critical Thinking Skills of Fourth Grade Students at SDIT Nurul Ishlah and the Lack of Effective Learning Media and Teaching Aids are the Background of This Research. The purpose of this research is to measure the validity, analyze the practicality, and determine the effectiveness of science teaching aids made from recycled materials in improving students' critical thinking skills. The method used is Research and Development (R&D) with the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The results of the research indicate that the science teaching aids made from recycled materials were assessed as highly valid, with a percentage of 95.56% from media experts and 97.78% from material experts. In terms of practicality, the teaching aids were considered very practical, with a 94% rating from teachers. The effectiveness test using the One Sample T-Test produced a p-value of 0.05, indicating that these teaching aids are effective in improving students' critical thinking skills. Furthermore, the N-Gain test showed a score of 72.42%, indicating a high level of improvement in students' critical thinking skills. Overall, the science teaching aids made from recycled materials have been proven to be highly valid, practical, and effective in supporting the learning process and enhancing students' critical thinking skills.

Keywords: *critical thinking, science teaching aids, recycled materials*

INTRODUCTION

In the era of scientific and technological development in this century, there is an increasing demand for high-quality human resources. Given the tight challenges faced, a paradigm shift is needed in the education system to provide the skills students require. One way to achieve this is by improving the quality of learning to provide greater opportunities for the development of superior and competitive human resources (Puspa et al., 2023).

According to Wiratman (2023), one of the skills that is the main focus of education is critical thinking. Critical thinking skills are very important for students, especially at the elementary school level. Critical thinking is the ability to think logically, reflectively, and productively, which is applied in evaluating situations to make sound judgments and decisions (Cahyani et al., 2021). Through critical thinking, students should be sensitive to various events in the environment, analyze, and understand them using scientific work stages, thus thinking, feeling, and acting in a controlled manner in accordance with their potential, exhibiting healthy, quality behaviors with integrity. This type of critical thinking is crucial for students, as they are taught to be rational in analyzing various sources of information to make decisions and solve psychological problems (Susi Purnamasari, 2021).

The Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) announced the results of the 2022 PISA survey, which showed that “In terms of reading comprehension, Indonesia's ranking in PISA 2022 increased by five positions compared to previous years.” Indonesia's literacy ranking in PISA 2022 also rose by five places, and the science literacy ranking increased by six positions. According to PISA, this is the highest percentile ranking in Indonesia's history. However, it is a fact that Indonesian students' critical thinking skills are still relatively low. This is evidenced by research conducted by Arwan Wiratman (2023), which states that many elementary school students, including those at SDN 54 Salupikung, still have low critical thinking skills.

This is also supported by the results of observations, which show that students are unable to distinguish between facts and opinions, find it difficult to evaluate the reliability of information sources, struggle to draw conclusions by viewing situations from different perspectives, and have difficulty constructing effective arguments or conveying ideas in a way that others can understand. Additionally, students face challenges in communicating and collaborating with peers to achieve shared goals or are unable to resolve conflicts with team members in a healthy and constructive manner.

Based on observations conducted in the fourth-grade class at SDIT Nurul Ishlah, students in this class face similar barriers, with critical thinking abilities being classified as low. This is evident during lessons, where students tend to accept information at face value without questioning the truth or accuracy of the learning sources. They also show a lack of curiosity, difficulty solving

problems, lack of ability to argue, and perceive the learning material as difficult to understand and visualize, especially in abstract topics like energy transformation. This is because energy does not have a physical form that can be directly observed.

This is also due to the teaching strategies employed by educators, which have not yet facilitated students in training critical thinking skills. The teaching model still relies on lectures and discussions, which causes students to become bored and passive during lessons. Furthermore, there is a lack of teaching aids or learning media, resulting in low critical thinking abilities and concept mastery among students. This is reflected in the low academic performance of the students. Learning outcomes affect students' critical thinking abilities and concept mastery (Ramdani et al., 2020).

In elementary school science learning, teachers teach students to acquire knowledge by collecting data through experiments, making observations to cultivate curiosity, and training students to develop critical thinking skills so they can solve problems effectively and provide reliable explanations.

According to Richter (2020), the goal of science learning in elementary schools is to instill curiosity, a positive attitude toward science, technology, and society, and the ability to apply these concepts in daily life, with the aim of preserving, protecting, and appreciating the natural environment. In science lessons at elementary school, it is essential to focus on how to develop students' curiosity in testing a theory related to energy transformation through observation or simple experiments, which will in turn help foster critical thinking skills.

Based on the above explanation, there is a need for a learning method that can encourage students to improve their understanding and critical thinking skills. One approach to achieving successful learning outcomes in training students to think critically is by selecting appropriate learning media that match the material being taught. Teachers need to design lessons that can activate students' potential to use their critical thinking skills to solve problems (Azizah & Santoso, 2023). Teachers should create an engaging and interactive learning environment, involving students in simple experiments that can illustrate the material being taught.

A good science lesson, according to the Curriculum for Education Unit Levels, should not rely solely on textbooks but must include practical tools and be connected with the surrounding environment. Teachers should seek to address these issues by using teaching aids. Effective teaching materials can include teaching aids or learning media. Through the use of learning media, the teaching of science concepts, principles, and laws will lead to more effective learning (Sri Wahyu, 2023). Teachers should be creative and innovative in applying and developing science teaching by producing teaching aids that help clarify abstract science concepts in a more concrete way. Teaching that uses teaching aids optimizes the use of all five senses of students, thereby improving

the effectiveness of learning through hearing, seeing, touching, and applying logical and realistic thinking (Musthafa et al., 2022).

This aligns with research conducted by Fitriah (2023) titled "Development of Teaching Aids from Recycled Materials on the Energy Transformation Topic for Fourth Grade Students." Based on the results, the developed teaching aid was deemed practical, with a student response rate of 65%. Another related study by Ardhi (2022) titled "Development of Teaching Aids for the Human Circulatory System from Recycled Materials in Science Education for Elementary School Students" found that the learning media developed had a material expert validity rate of 90.2% (very valid) and a media expert validity rate of 85.7% (very valid).

This study focuses on developing teaching aids from inexpensive materials, primarily using recycled items, so that production costs are minimized and waste is utilized. The main paradigm of this research is how to enhance critical thinking skills by developing affordable, beneficial teaching aids that can explain science learning concepts in a tangible way. The teaching aids that help students do not necessarily have to be modern, expensive, or factory-made, but can be simple, inexpensive media made from recycled or leftover materials found in the environment. Even though the physical appearance may be simple, these aids can support the principles of the concepts being taught and help students improve their critical thinking abilities.

Previous research conducted by Ardhi (2022) titled "Development of Teaching Aids for the Human Circulatory System from Recycled Materials for Science Education in Elementary Schools" focused on developing teaching aids from recycled materials but only on the aid development itself. The difference between this research and previous studies is that, in addition to developing teaching aids from recycled materials, this study also aims to enhance students' critical thinking skills in solving problems they encounter during science lessons, specifically on the topic of energy transformation for fourth-grade students.

This study started from the urgent need to innovate in science education, aiming not only to improve students' critical thinking abilities effectively but also to reflect a commitment to sustainable learning approaches. With a focus on the fourth-grade class at SDIT Nurul Ishlah, the study aims to develop science teaching aids made from recycled materials and prove their effectiveness in enhancing critical thinking skills. The results of this research are expected to provide a significant contribution to the quality of learning at the school, particularly at SDIT Nurul Ishlah. The teaching aids are also expected to become a model for sustainable learning, stimulate student creativity, and promote environmental awareness among students.

Given the challenges in students' critical thinking skills and the limited availability of teaching aids at SDIT Nurul Ishlah, this study begins by identifying these obstacles and establishing a strong foundation for designing appropriate teaching aids based on students' needs and characteristics. Based

on the explanation above, there has been considerable research on the development of teaching aids from recycled materials at elementary schools. However, there is still a gap in research focusing on developing teaching aids to enhance critical thinking skills. Therefore, based on the background described, the researcher is interested in conducting a study entitled "Development of Science Teaching Aids Using Recycled Materials to Improve Critical Thinking Skills of Fourth Grade Students at SDIT Nurul Ishlah."

The objectives of this research are to measure the validity of science teaching aids made from recycled materials to improve students' critical thinking skills, analyze the practicality of these teaching aids, and determine their effectiveness in enhancing students' critical thinking skills.

METHODS

The The research conducted is a type of development research, or Research and Development (R&D). According to Sugiyono (2011), the R&D research method is used to produce a specific product and test the effectiveness of the product. The development model used is ADDIE, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. Below are the five stages of development carried out in this research:

Analysis Stage

In this stage, the researcher conducts a needs analysis through observation and interviews with the fourth-grade teachers at SDIT Nurul Ishlah. This stage aims to obtain information about the potential or problems related to the students' critical thinking abilities.

Design Stage

The design stage is the first step in determining the form of the teaching aid that will be created. In this stage, the design of the teaching aid is prepared, which includes the materials to be used (recycled materials) and the working principles of the aid.

Development Stage

In this stage, the creation of the teaching aid is carried out, which includes the assembly of components. Additionally, validation by experts is also conducted to assess the validity of the developed teaching aid.

Implementation Stage

The implementation stage occurs after the development and validation tests are complete. The teaching aid is implemented in the science learning

process on the topic of transformation. In this process, the teaching aid is demonstrated in front of the students.

Evaluation Stage

The evaluation stage is the final stage of this research, in which the researcher analyzes data obtained from product trials to determine the practicality and effectiveness of the developed teaching aid.

In this research, the data collection instruments used include product validation sheets by subject matter experts and media experts, as well as product practicality sheets filled out by the fourth-grade teacher at SDIT Nurul Ishlah. Data analysis techniques were applied to obtain a quality teaching aid that meets the aspects of validity, practicality, and effectiveness.

Analysis of Validity and Practicality of the Teaching Aid

The data collected from this research consist of the results of the validation of the teaching aid by the experts, analyzed using quantitative analysis. The formula used is as follows:

$$P = \frac{f}{N} \times 100 \%$$

Where:

- P = Percentage of answers
- F = Frequency of answers
- N = Number of respondents

The scale used is the Likert scale. The researcher uses a Likert scale as shown in the table below:

Table 1. Likert Scale Used in the Study

<i>Percentage</i>	<i>Category</i>
0-25%	Very Unqualified
26%-50%	Less Qualified
51%-75%	Sufficiently Qualified
76%-100%	Very Qualified

Analysis of the Effectiveness of the Teaching Aid

One Sample T-Test

To test the effectiveness of learning, a One Sample T-Test is used. The One Sample T-Test is used to compare the average score of the sample being tested with the average score of an existing population. This test can also be used to test hypotheses in descriptive statistics. Since the One Sample T-Test is part of parametric statistics, the basic assumption is that the research data must be normally distributed. The hypothesis used is:

- **H₀**: The average score of students does not reach the target < 75
- **H_a**: The average score of students reaches or exceeds the target ≥ 75

N-Gain Test

The analysis of critical thinking ability is performed using the N-Gain test to determine the effectiveness of using a recycled-material science teaching aid. The data is normalized using the N-Gain formula to evaluate the increase or decrease in students' critical thinking skills during the learning process. The normalized N-Gain formula is as follows:

$$g = \frac{\text{posttest} - \text{pretest}}{\text{skor ideal} - \text{pretest}}$$

The increase in students' critical thinking ability is evaluated using the N-Gain test, with the following categories of achievement:

Table 2. N-Gain Test Categories for Evaluating the Increase in Students' Critical Thinking Ability

<i>Percentage</i>	<i>Category</i>
$g \geq 70$	High
$30 \leq g \leq 70$	Medium
$g \leq 30$	Low

RESULTS AND DISCUSSION

This research and development resulted in a product in the form of a science teaching aid made from recycled materials, which can be used as a learning medium for fourth-grade students at SDIT Nurul Ishlah in the subject of Integrated Science (IPAS), focusing on the topic of energy transformation in the first semester, in accordance with the Kurikulum Merdeka. The development of this teaching aid follows the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

Analysis Stage

In the analysis stage, the needs identified in the teaching of science at SDIT Nurul Ishlah's fourth grade were assessed. This process involved several steps, including:

Curriculum Analysis

The curriculum used at SDIT Nurul Ishlah is the Kurikulum Merdeka. Based on the curriculum analysis of the fourth-grade teacher's IPAS book and the student's IPAS book, Chapter IV focuses on energy transformation. The learning objective for this topic is to identify various forms of energy transformation in everyday life and to create simulations of energy transformations using simple charts or aids. Based on this learning objective,

the researcher developed a teaching aid from recycled materials, as it aligns with the goals outlined in the Kurikulum Merdeka.

Student Characteristics Analysis

Following interviews with teachers, it was identified that fourth-grade students at SDIT Nurul Ishlah faced challenges in critical thinking skills, which were categorized as low. This situation indicates the need for a more structured teaching approach to enhance students' critical thinking abilities.

Learning Needs Analysis

The learning needs analysis at SDIT Nurul Ishlah revealed that a lack of teaching aids was one of the primary obstacles. Therefore, the development and use of relevant teaching aids, such as those made from recycled materials, would address this learning need effectively.

Design Stage

In the design stage, the teaching aids to be developed were planned. This included the creation of teaching aids that are appropriate for the learning objectives. The design of the science teaching aid involved using recyclable materials such as glass bottles, plastic bottles, cardboard, and used cans to create engaging and educational aids. The design also included creating sketches or prototypes of the aids, which consisted of several units that produced sound, fire, and movement. Some of these units used a dynamo motor, batteries, wires, and musical instrument components.

Development Stage

In the development stage, the teaching aid was created according to the design that had been formulated. This stage involved several processes: content development, production, and validation. The content used was the energy transformation topic from Chapter 4 of the IPAS subject in the first semester. The next step was to gather the appropriate recycled materials that matched the design of the teaching aid. Afterward, the teaching aid was evaluated for its suitability and effectiveness by validators.

Collection of Recycled Materials

The collection of various types of recycled materials that can be used to create the teaching aid, such as cardboard, plastic bottles, cans, glass bottles, and other materials that are still in good condition and safe for use.



Figure 1. Recycled Materials

Creation of Teaching Aid

This stage involves combining and painting the recycled materials to form the appropriate shapes for the teaching aid.



Figure 2. Painting the Teaching Aid



Figure 3. Assembling the Teaching Aid

Display of the Teaching Aid Made from Recycled Materials

This teaching aid development utilizes recycled materials, transforming waste or unused items into useful tools for teaching activities. Below is the appearance of the assembled teaching aid:



Figure 4. Teaching Aid Made from Recycled Materials

Validation of the Teaching Aid's Feasibility

Media Expert Validation

The purpose of this validation is to gain recognition from experts, ensuring that the developed teaching aid is suitable and can be used in learning activities. The validation includes assessing the relevance of the teaching aid to the material, its functionality, safety for students, and its aesthetic qualities.

The validation results from the media expert for the recycled materials-based teaching aid are calculated using the following formula:

$$\text{Validation Percentage} = \frac{f}{N} \times 100\%$$

$$\text{Validation Percentage} = \frac{43}{45} \times 100\%$$

$$\text{Validation Percentage} = 0,9556 \times 100\%$$

$$\text{Validation Percentage} = 95.56\%$$

Based on the media expert's evaluation, the recycled materials-based teaching aid received an average score of 95.56%, with the result categorized as very valid.

Material Expert Validation

The purpose of this validation is to gain recognition from subject matter experts, ensuring that the developed teaching aid is appropriate and can be used effectively in learning activities. This includes evaluating the quality of the content presented through the teaching aid, covering aspects such as the alignment of the material, the relevance of the content to the learning objectives, and its contribution to enhancing students' critical thinking abilities.

The validation results from the material expert for the recycled materials-based teaching aid were calculated using the following formula:

$$\text{Validation Percentage} = \frac{f}{N} \times 100\%$$

$$\begin{aligned}\text{Validation Percentage} &= \frac{44}{45} \times 100\% \\ \text{Validation Percentage} &= 0,9778 \times 100\% \\ \text{Validation Percentage} &= 97.78\%\end{aligned}$$

Based on the material expert's assessment, the recycled materials-based teaching aid received an average score of 97.78%, with the result categorized as very valid.

Implementation Results

Practicality of the Teaching Aid

To assess the practicality of the teaching aid, several key indicators were considered, including ease of use, durability, cost-effectiveness, and its ability to engage students. The assessment was carried out through a questionnaire filled out by the class teacher. The questionnaire was administered to the teacher of class IV A at SDIT Nurul Ishlah. Based on the results, the recycled materials-based teaching aid received a score calculated using the following formula:

$$\begin{aligned}\text{Practicality Validation Percentage} &= \frac{f}{N} \times 100\% \\ \text{Practicality Validation Percentage} &= \frac{47}{50} \times 100\% \\ \text{Practicality Validation Percentage} &= 0,94 \times 100\% \\ \text{Practicality Validation Percentage} &= 94\%\end{aligned}$$

From the practicality assessment by the class IV teacher, it can be concluded that the developed teaching aid is considered highly practical, with a percentage score of 94%.

Evaluation Stage

Data analysis was conducted using SPSS with two types of tests: the One Sample T-Test and the N-gain test, to measure the changes and improvements in students' critical thinking skills before and after using the teaching aid.

One Sample T-Test

The One Sample T-Test is used to test the effectiveness of the recycled materials-based science teaching aid in improving students' critical thinking skills.

Test Value = 75

	T	Df	Significance		Mean Difference	95% Confidence Interval of the Difference
			One-Sided p	Two-Sided p		Lower
			Posttest	9.285		32

Based on the SPSS output, the results of the One-Sample T-Test show a p-value < 0.001. This indicates a significant difference between the posttest average score and the expected score of 75. Since the p-value < 0.05, the null hypothesis (H_0) is rejected. Therefore, the alternative hypothesis (H_a), which states that "the posttest average score of students ≥ 75 ," is accepted. This result provides strong evidence that the use of the recycled materials-based science teaching aid has been effective in improving students' critical thinking skills related to energy transformation.

N-Gain Test

The N-Gain test data was normalized to determine whether there was an increase or decrease in students' critical thinking skills. The formula for normalized gain is as follows:

$$g = \frac{\text{posttest} - \text{pretest}}{\text{skor ideal} - \text{pretest}}$$

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
NGain	33	.38	1.00	.6057	.11328
Valid (listwise)	N 33				

Based on the SPSS output table, the average N-Gain score is 0.7242, which falls into the "High" category. This indicates a significant improvement of 72.42% in students' critical thinking skills after using the recycled material-based science teaching aids.

This study employed the ADDIE model, consisting of the analysis, design, development, implementation, and evaluation stages. During the analysis phase, it was found that students' critical thinking skills were low, which highlighted the need for the development of a teaching aid that aligns with the learning objectives.

In the design phase, the main focus was on designing a teaching aid that matched the learning material and students' needs. This process began with designing the aid to ensure that each tool could clearly demonstrate the science concepts. The design included selecting the materials and the final form of the aid. The materials used were recycled items that were still usable, such as glass bottles, plastic bottles, cardboard, and used cans. Each tool was designed to explain energy transformation concepts in a visual and interactive way, making it easier for students to understand the material and enhance their critical thinking skills.

During the development phase, the teaching aid was created based on the designed plans. This process involved gathering recycled materials, building the teaching aids, and validating them by media and subject matter experts. The validation results indicated that the teaching aids were highly valid, receiving a score of 95.56% from the media expert and 97.78% from the subject matter expert. Suggestions for improvement from the media expert included fixing the fan blades and replacing weak batteries. The subject matter expert recommended adding energy transformation cards to further clarify the material.

In the implementation phase, the tools were used over three days, on July 16, 17, and 19, 2024. On the first day, students took a pretest to measure their initial understanding of energy transformation. On the second day, students used the developed teaching aids. The third day concluded with a posttest to assess the improvement in students' understanding after using the aids. Based on the questionnaire filled out by the class IV A teacher, the teaching aids received a 94% validity percentage, indicating that the aids were very practical to use.

In the evaluation phase, data analysis was performed using pretest and posttest results, as well as statistical tests using SPSS. The One Sample T-Test also supported this, with a p-value < 0.001 , indicating a significant difference between the average posttest score and the expected score of 75. Based on the SPSS output table, the average N-Gain score was 0.7242, which falls into the high category. This indicates a significant improvement of 72.42% in students' critical thinking skills after using the recycled material-based science teaching aids.

CONCLUSION

Based on the results of the study, the teaching aid developed from recycled materials received very valid evaluations from both media and subject matter

experts. The teaching aid was considered highly practical by the teacher. The teacher felt that the teaching aid assisted in the learning process, motivated the students, and made the learning environment more engaging. According to the results of the One Sample T-Test and N-Gain tests used to measure changes and improvements in students' critical thinking skills, the teaching aid was proven to be effective in enhancing students' critical thinking abilities.

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