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INNOVATION OF A TEACHING AIDS FOR ENERGY TRANSFORMATION TO IMPROVE ELEMENTARY SCHOOL STUDENTS SCIENCE PROCESS SKILLS

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ABSTRACT
This study aims to develop learning media in the form of an energy transformation teaching aid kit to improve the science process skills of fourth-grade elementary school students. The type of research applied is Research and Development (R&D) using the ADDIE development model. Data collection was carried out using expert validation questionnaires, as well as questionnaires for teachers and students, along with learning outcome tests. The research subjects included 6 fourth-grade students in a limited-scale trial, followed by 18 fourth-grade students from SDN 32/II Muara Bungo in a wider trial. The data were analyzed through tests of validity, practicality, and effectiveness using a Likert scale approach. The results of the analysis show that (1) The validity of the media obtained a score of 96% and the validity of the material obtained a score of 95%, both of which are categorized as highly valid. (2) Practicality was assessed with teacher scores of 94% and student scores of 93% in the limited trial, and teacher scores of 94% and student scores of 92% in the wider trial, all of which are categorized as highly practical. (3) Effectiveness showed a classical completeness of 100%, indicating it is highly effective. Based on these results, it can be concluded that the developed energy transformation teaching aid kit is highly valid, highly practical, and highly effective, making it suitable for improving the science process skills of elementary school students in Grade IV Science (IPAS) learning

INTRODUCTION

Science (IPAS) education in elementary schools plays an important role in developing students' scientific thinking abilities, critical attitudes, and problem-solving skills from an early age. Science learning provides students with opportunities to develop curiosity through scientific ways of thinking about natural phenomena that occur(Handayani et al., 2021). Natural Science (IPA) is important in elementary schools because it teaches students to think critically, analytically, and logically, as well as to understand nature systematically as a process of discovering

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concepts, rather than merely memorizing facts (Barus, n.d.2021) However, abstract science concepts pose challenges for both teachers and students, such as difficulties in maintaining concentration, boredom, limited resources, and time constraints (Wujud & Sekolah, 2025)

In the implementation of the Merdeka Curriculum, science (IPAS) learning not only emphasizes mastery of concepts, but also the development of science process skills (SPS), such as observing, classifying, predicting, measuring, concluding, and communicating observation results. Science Process Skills (SPS) are very important in elementary science learning because they help students observe, classify, measure, analyze, formulate hypotheses, and draw conclusions systematically, thereby deepening their understanding of scientific concepts.(Nurjihan & Bunawan, 2025). Process skills are the intentional abilities to diagnose situations, formulate problems, critically evaluate experiments, analyze alternatives, seek information, design investigations, construct models, and develop coherent arguments.(Kemendikbud, 2022). Science process skills, as scientific procedures in science learning, are able to deepen students' mastery of concepts. Science process skills refer to basic abilities required for the application and understanding of scientific concepts.(Aryani et al., 2024).

However, in reality, learning in the classroom still tends to be teacher-centered and dominated by lecture methods, so students have fewer meaningful hands-on learning experiences. This condition causes students' science process skills in elementary school to not develop optimally. Based on observations conducted by the researcher in Grade IV of SD Negeri 32/II Muara Bungo, the IPAS learning process still faces many obstacles. The classroom is often not conducive, only a small number of students dare to answer the teacher's questions, and only a few students are able to complete assignments. The teacher still uses lecture methods and conventional learning resources such as textbooks and pictures, without any group-based learning activities. As a result, students tend to be passive, easily bored, and have low learning outcomes. This condition is also not in line with the demands of the Merdeka Curriculum and 21st-century skills, which emphasize critical thinking, creativity, collaboration, and communication. Ideally, learning should be student-centered, not teacher-centered. Therefore, a teaching aid is needed in the learning process that can encourage active student involvement while also improving learning outcomes..

This development research is based on the need for assessment instruments to measure Science Process Skills (SPS). So far, assessments have still emphasized science as a product/knowledge (Aisah et al., 2024). There are two types of Science Process Skills (SPS), namely basic SPS (observing, classifying, predicting) and integrated SPS (identifying problems, controlling variables, interpreting data)(Sayekti et al., 2017) Science education plays an important role in shaping students' understanding of the world around them. In Grade IV, students are introduced to basic science concepts, one of which is energy transformation. Energy transformations, such as electrical energy into light or motion into sound, as well as potential and kinetic energy, are also important parts of students' understanding of how energy plays a role in daily activities. (Aqiilah et al., 2024). Although this concept is fundamental, many students still experience difficulties in understanding it because teaching tends to be more theoretical and provides fewer opportunities for direct interaction with the learning material.

The use of teaching aids can be an effective means of bridging the gap between theory and practice, making learning more engaging, clarifying concepts, and increasing students' interest in learning(Fitri et al., 2023) Positive attitudes are associated with sensory stimulation from teaching aids, indicating that learning experiences influence students' attitudes toward energy (Chou et al., 2015). The Relationship Between the Use of Teaching Aids and Science Concept Understanding in Elementary School Students. This study found a positive correlation between the use of teaching aids and students' understanding of science concepts. Students who used teaching aids were more engaged, had a better understanding of concepts, and demonstrated higher retention compared to those taught using traditional methods, indicating the importance of integrating teaching aids into science learning(Souza et al., 2025) Similar findings from previous researchers explained that a battery-powered windmill diorama is effective in improving fourth-grade students' understanding of energy and its transformations, with an assessment score of 91% (very good), meeting all learning media criteria (Sarah Aulia Akbar et al., 2025). The role of instructional media is very important in teaching and learning methods implemented by teachers. This is because instructional media can function as a channel for delivering messages from the sender to the receiver in a more engaging way, and it can also help students

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understand and explain what the teacher has conveyed. (Arsyad et al., 2020).

Based on the initial observation at SDN 32/II Muara Bungo, particularly in Grade IV, it was found that the learning process is still dominated by the use of less varied instructional media. This condition has resulted in suboptimal student engagement in teaching and learning activities. The lack of innovation and attractiveness in the media used makes students tend to be passive, less enthusiastic, and not actively participate during the learning process. Therefore, the innovation of energy transformation teaching aids is very important to make science learning more engaging, contextual, and in line with the characteristics of elementary school students. Through this innovation, it is expected that students' science process skills can improve significantly, as effective and appropriate learning is highly needed in the context of science (IPAS) education in elementary schools

METHOD

This study is a Research and Development (R&D) study using the ADDIE model, which is a structured development framework consisting of Analysis, Design, Development, Implementation, and Evaluation.(Nur et al., 2024) which aims to innovate an energy transformation teaching aid to improve the science process skills of elementary school students

This study was conducted in two meetings. The first meeting aimed to observe students' learning interest in using teaching aids by involving a small sample of students and administering a pre-test instrument. The second meeting involved the use of the teaching aid as a treatment with a wider sample, namely all students, followed by a post-test at the end of the lesson, as well as an instrument to assess the implementation of science process skills (SPS) during classroom activities. The subjects of this study were 18 Grade VI students of SDN 32/II Muara Bungo, consisting of 4 male students and female students. The sampling technique used was total sampling. The selection of subjects was based on the classroom condition, which indicated that students' science process skills in IPAS learning were still low.

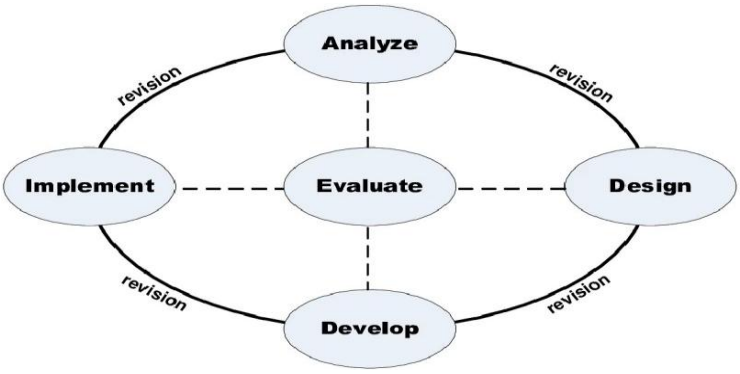

Figure 1. The ADDIE Model

Source: The ADDIE Model Branch Stages According to 2019)) Steps of the ((Anggraeni et al.,

In Figure 1, there are several stages in the ADDIE development model. The first step carried out by the researcher is to analyze the problems and the needs required by students in the learning process. Activities conducted at this stage include classroom observations and interviews with teachers and several students.

The next stage is the design phase, where the researcher develops a design for the teaching aid to be created in accordance with students' needs. The teaching aid being designed is focused on meeting students' needs, particularly in science (IPAS) with the topic of energy transformation. The researcher begins the design process by collecting various tools and materials needed to construct the teaching aid.

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The next step is the development stage, where the researcher designs the product in accordance with the lesson plan and the previously determined material. At this stage, the developed teaching aid undergoes a validation process by several experts, namely media experts and content experts.

The implementation stage is carried out after the product has been declared valid and meets the requirements by the validators or reviewers. The next step is to implement the learning media in the classroom learning process. This process begins with a small-scale trial involving 5 Grade IV students of SDN 32/II Muara Bungo, followed by a wider trial involving 18 Grade IV students from SDN 32/II Muara Bungo.

The evaluation stage is the final stage that focuses on assessing the feasibility of the product based on the validation results obtained. If any deficiencies are found during the testing process, the learning media must be revised and retested until it meets the established standards. In addition, the effectiveness of the media is evaluated by comparing students' pre-test and post-test results related to the material that has been delivered.(Harnanto, 2016)

In this study, data collection was carried out using two types of instruments, namely questionnaires and tests. Questionnaires were used to assess the validity of the teaching aid and to obtain responses from teachers and students, while tests were used to measure the effectiveness of the learning media. The data analysis techniques used included quantitative descriptive analysis and qualitative descriptive analysis. These analyses aimed to determine the levels of validity, practicality, and effectiveness of the teaching aid media. The validity assessment was conducted by media experts and subject matter experts to determine the feasibility and validity of the developed product.(Mardani & Made Vina Arie Paramita, 2024).

Validity data were obtained through validation questionnaires to assess product aspects, while practicality data were collected through teacher and student questionnaires. Respondents marked a check (√) according to the actual condition for each statement. Effectiveness was analyzed based on the success of using the energy transformation kit in the learning process.(Saofah et al., 2024). The effectiveness of this teaching aid was measured through data analysis based on students' test scores (post-test results).

RESULT AND DISCUSSIONS

Analysis stage

The analysis stage is the initial stage in development research, conducted to identify learning problems and analyze students' needs as a basis for designing appropriate and effective learning. (Ihsan, Basyori & Jamilah, 2024). Problem and needs identification was carried out through an initial survey of teachers and students to determine difficulties in understanding the concept of energy transformation and process skills, as well as the lack of teaching aid facilities. During this stage, the researcher observed classroom activities and interviewed teachers and several students to obtain relevant and supporting data.

Design stage

The next stage is the design stage, where the researcher develops a design for the media to be created in accordance with the learning materials and students' needs. The media being designed is focused on meeting students' needs, particularly in science (IPAS) on the topic of energy transformation. The researcher begins the design process by collecting various tools and materials needed to construct the teaching aid. Several steps prepared by the researcher are as follows:

Preparing the materials and tools needed to construct the structure of the teaching aid, as shown in the figure below.

NO	COMPONENT NAME	FUNCTION	FOUND

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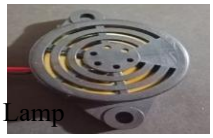
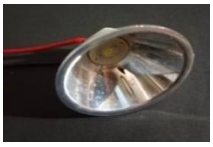
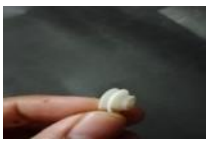
1.	Switch 	To interrupt and connect the electric current in a circuit	Found in electronic devices such as TVs, blenders, tape recorders, speakers, etc.
2.	Battery 	Converts chemical energy into electrical energy. A battery also functions as a backup energy source or electrical energy storage.	Found in electronic devices such as wall clocks, toys, flashlights, etc.
3. A,B,C	Dynamo 	A dynamo functions to convert mechanical (motion) energy into electrical energy (generator), or conversely, to convert electrical energy into mechanical energy.	Found in various devices that have rotating components; a dynamo can be found in remote-controlled toy cars, Tamiya cars, and portable fans.
4.	Buzzer 	To convert electrical energy into sound energy, usually functioning as a sound indicator or alarm.	Found in schools, such as school bells, and in vehicles, such as turn signal indicators.
5.	Lamp 	Converts electrical energy into light energy, functioning to illuminate the environment or dark areas.	Found in ceiling lights in homes, flashlights, truck beds, and toys.
6.	V-belt 	To transmit rotational force from one shaft to another.	V-belt is found in tape recorders, speakers, and DVD players.
7.	Gear 	As a support for the V-belt and a transmitter of power from one dynamo to another, usually mounted on the dynamo shaft.	Gears are found in DVD players, tape recorders, and printers.

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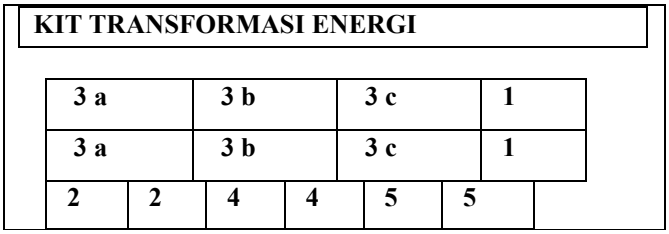
8.	Pipe 	As a base/holder for placing and positioning the components of the teaching aid kit.	Made from pipes that are shaped in such a way to fit and adjust the layout arrangement.
9.	cable 	Functions as a connector for electric current.	Easily found in various electronic devices.

Source: researcher documentation (2026)

Figure 2. Materials and Tools for the Energy Transformation Kit

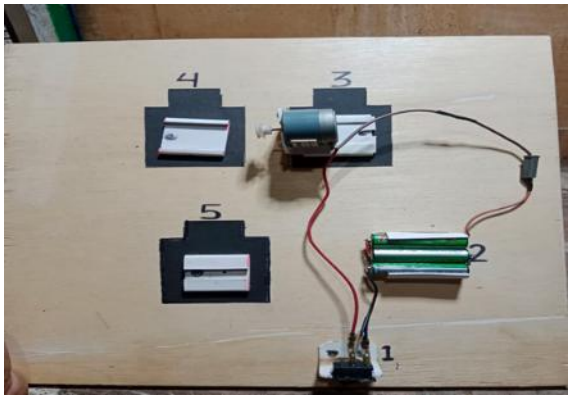
Then prepare numbers along with the names of the teaching aid kit components, as shown in the figure below, to facilitate the order of assembling the components in the energy transformation teaching aid kit.



Source: researcher documentation (2026)

Figure 3. Numbering Sheet for Sequence Arrangement

Preparing plywood as the layout base for the teaching aid kit components, then attaching the numbering to the plywood and the components according to the installation sequence, followed by assembling several components as shown in the figure below.



Source: researcher documentation (2026)

Figure 4. Stage 1 of the Energy Transformation Kit Construction

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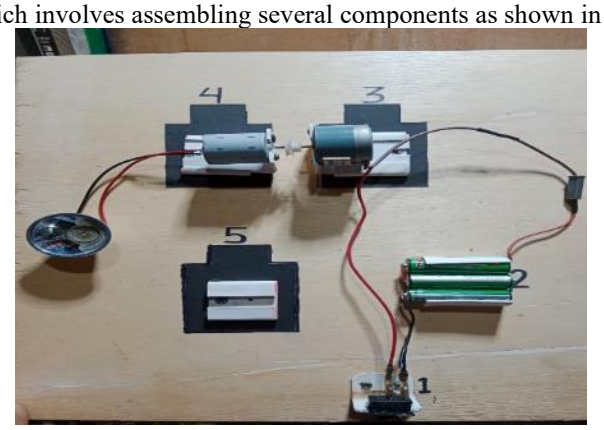
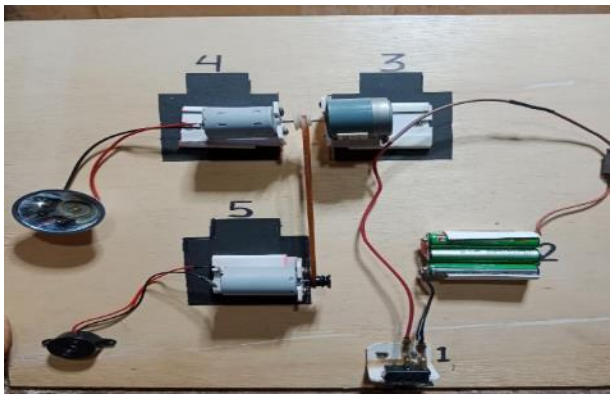
Then continue with stage 2, which involves assembling several components as shown in the figure below.



Source: researcher documentation (2026)
Figure 5. Stage 2 Assembly of the Energy Transformation Kit

In stage 3, the final performance of the energy transformation kit is determined by assembling all teaching aid components so that they are interconnected.



Source: researcher documentation (2026)
Figure 6. Stage 3 Assembly of the Energy Transformation Kit

Development stage

The next step is the development stage, where the researcher designs the product in accordance with the lesson plan and the previously determined material. At this stage, the developed teaching aid undergoes a validation process by media experts and subject matter experts to assess the feasibility of the product being developed.(Anwar, 2023). This validation involved two parties, namely subject matter experts and media experts. The trial in this context aimed to obtain assessments and feedback on the energy transformation teaching aid product. The trial was conducted in two main stages: validation by experts and implementation with students. The feasibility test was carried out before the media was applied in learning, with the aim of examining the feasibility of the developed media so that it could be considered appropriate and suitable for testing with students.(Hasmalia et al., 2025). The results of this trial were used as a reference for improving the product. The following presents the trial data from the experts.

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Table 1. Validation Results by Subject Matter Experts and Media Experts of the Energy Transformation Kit

No	Description	Presentase	Category
1.	Material Validation	95%	Very Valid
2.	Media validation	96%	Very Valid

Based on Table 1, the validation results of the Energy Transformation Kit teaching aid used to improve students' science process skills in Grade IV IPAS learning show that the material validation level reached 95%, while the media validation obtained 96%. The material validation percentage of 95% indicates that the presented content is highly appropriate to the established learning objectives. This suggests that the systematically arranged material has a strong relevance in supporting the students' learning process. On the other hand, the media validation result of 96% proves that the Energy Transformation Kit teaching aid is highly valid and suitable for use in improving students' science process skills in Grade IV IPAS learning.

Implementation stage

The implementation stage is carried out after the product has been declared valid and meets the requirements by the validators or reviewers. The next step is to implement the learning media in the classroom learning process. At this stage, the developed energy transformation kit teaching aid is applied, and the results obtained are related to its level of practicality and effectiveness, based on student response questionnaires and the comparison of pre-test and post-test results. (Apriani et al., 2023). Then, to determine the level of practicality of the energy transformation kit teaching aid, it can be assessed through teacher and student questionnaires regarding the use of the kit to improve elementary school students' science process skills in Grade IV IPAS learning..

Table 2. Teacher and Student Questionnaire Results in the Limited-Scale Trial

No	Description	Presentase	Category
1.	Teacher Questionnaire	94%	Very Valid
2.	Student Questionnaire	93%	Very Valid

Table 3. Teacher and Student Questionnaire Results in the Wide-Scale Trial

No	Description	Presentase	Category
1.	Teacher Questionnaire	94%	Very Valid
2.	Student Questionnaire	92%	Very Valid

Based on Tables 2 and 3, the questionnaire results for the energy transformation kit teaching aid show that this media is very effective in improving Grade IV students' science process skills in the topic of energy transformation. The responses from both teachers and students indicate that the teaching aid is highly engaging and enjoyable, and is able to increase students' curiosity regarding energy transformation concepts. Students feel more confident and actively participate during the learning process, indicating that the teaching aid successfully creates a positive learning environment. In addition, students experience improvement in their abilities and learning outcomes. Therefore, it can be concluded that the energy transformation kit teaching aid is highly practical for use in IPAS learning in elementary schools.

Effectiveness data were measured through learning mastery results obtained from pre-test and post-test scores. The pre-test is a test given to students before the teaching aid is applied in the learning process. Meanwhile, the post-test is a test given after students use and operate the teaching aid in the learning process. By analyzing these learning mastery results, the level of effectiveness of the teaching aid in learning can be determined.

Table 4. Effectiveness Test Results of the Teaching Aid

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Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	18	10,00	65,00	45,0556	16,84347
Posttest	18	75,00	95,00	86,6667	6,85994
Ngain	18	,50	,92	,7491	,12188
Valid N (listwise)	18				

Based on the results of descriptive statistics analysis using IBM SPSS Statistics, pre-test, post-test, and N-Gain data were obtained from 18 respondents as follows.

Before the use of the learning media, the students' pre-test scores had a mean of 45.06, with a minimum score of 10 and a maximum score of 65. The standard deviation of 16.84 indicates that the students' initial abilities varied considerably. These results show that students' understanding before using the learning media was still relatively low.

After the use of the learning media, the post-test scores showed an improvement with a mean of 86.67, a minimum score of 75, and a maximum score of 95. The standard deviation of 6.86 indicates that students' scores after the learning process were more consistent compared to the pre-test results. This increase in the average score shows that the learning media used was able to help students understand the material more effectively.

In addition, the N-Gain calculation results obtained an average of 0.7491 or approximately 74.91%. Based on the N-Gain criteria, this value is classified as high because it falls within the range of g>0,7g > 0,7g>0,7. This indicates that the learning media used is effective in improving students' learning outcomes.

Overall, it can be concluded that there is a significant improvement in students' learning outcomes between before and after the use of the learning media. Therefore, the learning media is considered effective for use in the learning process..

Evaluation stage

The evaluation stage in R&D research is carried out through product trials, revision, and validation to ensure that the developed product is effective and feasible to use. Evaluation is an important part of refining the development results before they are implemented on a wider scale.(Torang Siregar, 2023) Evaluation in research and innovation projects is used to assess the progress of innovation during the development stage. Evaluation helps measure the maturity of the innovation and the success of the research project in a systematic manner. (Klessova et al., 2022)

CONCLUSION

Based on the results of the development research that has been conducted, the following conclusions can be drawn. The validity of the energy transformation kit teaching aid is proven through validation results from two expert validators, namely a subject matter expert and a media expert. The validation results show that the score for the material aspect reached 95% and the media aspect reached 96%, with an overall average of 95.5%. Based on these results, the energy transformation kit teaching aid is declared highly valid and feasible to use without revision. The practicality of this media is evidenced by positive responses from teachers and students, where in the limited-scale trial teacher responses reached 94% and student responses 93%, while in the wider-scale trial teacher responses reached 94% and student responses 92%, indicating that the teaching aid is highly practical for use in learning. In addition, the effectiveness of the energy transformation kit teaching aid is shown by the mastery scores of students' learning outcomes in improving science process skills in elementary school students, obtained from two testing stages, namely pre-test and post-test. Based on descriptive statistics analysis using IBM SPSS Statistics, the pre-test data showed that students' pre-test scores had a mean of 45.06. with a minimum score of 10 and a maximum score of 65. The standard deviation of 16.84 indicates that students' initial abilities varied considerably. These results show that students' understanding before using the learning media was still relatively low.

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Overall, it can be concluded that there is a significant improvement in students' learning outcomes between before and after the use of the learning media. Therefore, the learning media is considered effective for use in the learning process.

Based on these results, it can be concluded that the teaching aid as a learning media, the "energy transformation kit," which has been developed, is highly valid, highly practical, and highly effective. Therefore, this teaching aid media is feasible to be used to improve elementary school students' science process skills, especially in Grade IV.

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