Journal of Current Studies in SDGs
Homepage : https://journal.i-ros.org/index.php/JOCSIS
Email : jocsis@i-ros.org

e-ISSN 3089-7564
Vol. 2, No.1, March 2026

Energy Conservation Worksheets with Jigsaw Cooperative Learning Model to Improve Learning Outcomes Supporting SDG 4 in Science Education

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DOI : https://doi.org/10.63230/jocsis.2.1.146

Sections Info

Article history:
Submitted: May 17, 2026
Final Revised: May 24, 2026
Accepted: May 24, 2026
Published: May 25, 2026

Keywords:
Energy Conservation;
Learning;
Science;
SDG 4;
Worksheets.

ABSTRACT

Objective: *To produce energy conservation worksheets based on the Jigsaw type cooperative learning model that are suitable for use and effective in improving students' science learning outcomes to support SDG point 4.* ***Method:*** *A quantitative descriptive study using the Research and Development (R&D) method, aimed at developing and testing the effectiveness of the learning product. The development process uses the ADDIE model, which includes the following stages: Analysis, Design, Development, Implementation, and Evaluation. The research population was conducted at one school with a sample of 50 students.* ***Results:*** *Research shows that Jigsaw-based cooperative learning worksheets are valid, practical, and effective for use in science learning on energy conservation in elementary schools. The implementation of worksheets can significantly improve student learning outcomes, as evidenced by pre-test, post-test, difference test, and N-Gain values in the experimental class. In addition, students responded positively to the learning because discussion activities and group collaboration made it more active, interesting, and easier to understand.* ***Novelty:*** *The innovations in this worksheet development are relevant to SDG 4, particularly in energy conservation. In the context of science education, SDG 4 implementation aims to strengthen student learning outcomes through innovative learning approaches.*

INTRODUCTION

The Sustainable Development Goals emphasize the importance of quality education that is inclusive, equitable, and able to improve students' competencies in facing the challenges of the 21st century. In the context of science education, implementing SDG 4 aims to strengthen student learning outcomes through innovative learning. Science education in elementary schools is essentially expected to equip students with an understanding of scientific concepts related to everyday life, develop scientific attitudes, and foster logical and critical thinking habits from an early age (Septiliana & Surul, 2023; Sekaringtyas et al., 2024). In fourth grade, one topic that is highly relevant to real life is energy conservation, as students begin to frequently interact with various energy sources at home and at school, such as electricity, fuel, and heat energy (Chen et al., 2020; Poimenidis et al., 2022).

The hope is that energy conservation learning will not stop at memorizing definitions, but will encourage students to understand why energy needs to be conserved, the impact of energy waste, and how to consistently implement energy-saving behaviors. Science learning is also expected to provide a space for students to actively ask questions, discuss, observe, and draw simple conclusions, so that learning outcomes are not only reflected in final grades but also in changes in thinking and attitudes toward the environment (Nur'ariyani et al., 2023).

The reality of science learning in the field often shows that, including energy conservation, it is still dominated by a teacher-centered approach. The learning process is often one-way: the teacher explains, students take notes, and then they work on exercises whose answer patterns tend to repeat textbook material (Kusuma & Arifin, 2021; Priyantini et al., 2021; Yanti et al., 2024; Wuryani et al., 2025). In situations like this, students easily perceive the material as "information to be memorized" rather than "concepts to be understood and applied" (Andriani et al., 2025; Hardy et al., 2022; Pahmi et al., 2025; Vaiopoulou et al., 2023). As a result, when given problems that differ slightly from the examples or asked to explain the causes and effects of energy waste, some students experience difficulties. This situation can also result in low student engagement during learning. For example, only some students actively respond, while others tend to be passive, waiting for instructions, or simply following along without truly understanding (Han & Gutierez, 2021; He, 2024).

Based on observations conducted at SDN 4 Tegaldlimo in the even semester of the 2025/2026 academic year, the lecture method is still used by teachers for several reasons, including the extensive nature of the material and limited available time. Teachers tend to provide knowledge and then give practice questions. Students work individually, but only a few are actively working, while others are busy with other activities, such as playing with and chatting with their deskmates. This fact shows that the learning process students follow is still not in accordance with what the teacher expects. The Minimum Competency (KKM) value for the Social Sciences subject at SDN 4 Tegaldlimo for grade IV is 75. Facts in the field, based on the results of the final semester exam (UAS), show that 16 out of 25 students in grade IV did not reach the KKM, indicating that 64% have not reached the KKM. Based on this data, it can be concluded that student learning outcomes are still low.

Furthermore, many schools still rely on simple textbooks and assignment sheets containing practice questions, without guiding students through systematic learning steps and encouraging collaboration (Rahayu et al., 2023; Setyowati et al., 2024). As a result, science learning outcomes can appear less than optimal, both in terms of conceptual mastery, the ability to explain, and the application of energy conservation principles in everyday life. This gap can prevent students from achieving the desired learning outcomes, particularly in-depth understanding and the ability to relate concepts to real-world contexts. This gap raises serious issues, namely the design and implementation of energy conservation learning that can improve science learning outcomes while simultaneously encouraging active student involvement and collaboration.

Various previous efforts have been made to improve science learning outcomes in elementary schools, for example, through the use of more engaging learning media, the implementation of discussion methods, or the reinforcement of HOTS (Higher Order Thinking Skills)-based practice questions (Idawat et al., 2022; Narut & Wahyu, 2023; Oktadila et al., 2025). These efforts have demonstrated positive aspects: for example, concrete media can help students visualize concepts, discussions can open up communication, and challenging exercises can foster higher-order thinking. Furthermore, various cooperative learning models are widely recommended for their ability to enhance learning activities, a sense of responsibility, and conceptual understanding through social interaction (Parhati et al., 2025). These positive findings reinforce the potential of active and cooperative learning approaches to improve science learning outcomes.

In practice, these efforts also have limitations that need to be addressed. Learning media can sometimes become mere "decoration" if not integrated with focused thinking and discussion activities. Students view media but are not guided to build concepts gradually (Islamyati & Manuaba, 2021; Rahmiati et al., 2025). Even in cooperative learning, "free riders" often occur, namely, students who rely on their peers because the division of tasks is unclear or individual accountability is not established. This limitation shows that the success of active learning depends not only on the choice of model but also on learning tools that can guide activities, assign roles, and ensure that each student is truly learning.

In this context, the Jigsaw cooperative learning model offers characteristics that are both theoretically and practically relevant for addressing energy conservation (Soedimardjono, 2021). Jigsaw positions each student as a "critical part" of group learning, with each child playing the role of an expert on a specific subtopic and teaching it back to their original groupmates (Anjani, 2025; Dewi et al., 2025). This pattern encourages active involvement, increases individual accountability, and fosters communication skills. For energy conservation, subtopics can be clearly divided into: energy sources, forms of energy, examples of energy waste, the impacts of energy waste, and ways to conserve energy at home and school. With this division, students learn not only from the teacher but also from their peers, and the "re-teaching" process becomes a highly effective reinforcement of understanding at elementary school age.

Based on the description above, this research is grounded in the belief that improving science learning outcomes requires not only changes in teaching methods but also the strengthening of learning tools that guide students systematically throughout the learning process. Therefore, the developed worksheet is designed as a “roadmap” that supports the Jigsaw learning mechanism by helping students understand learning objectives, identify their tasks, master materials as experts, collaborate effectively in expert groups, and present the material coherently to their original groups. The novelty of this research lies in the development of an energy conservation worksheet specifically designed natively for the Jigsaw mechanism rather than a general worksheet merely adapted for Jigsaw implementation. The worksheet emphasizes students’ expert roles through expert summary formats, re-presentation guides, and individual accountability mechanisms embedded within the activities, thereby minimizing free-riding and unstructured discussions. In addition, the worksheet integrates contextual examples of energy conservation closely related to fourth-grade students’ daily lives, such as using lights, fans, gadget chargers, hot water, and turning off electrical devices, which are transformed into learning stimuli and collaborative tasks. Through these innovations, the research is expected not only to improve science learning outcomes but also to provide practical, tested, and relevant learning tools for fostering energy conservation habits from an early age.

The purpose of this study is to produce energy conservation worksheets based on the Jigsaw cooperative learning model that are feasible and effective in improving science learning outcomes for fourth-grade elementary school students. The feasibility includes aspects of content and construct validity, readability, suitability to student characteristics, and alignment with Jigsaw learning steps. Effectiveness is measured by improvements in student learning outcomes after using the worksheets, both in understanding the concept of energy conservation and in the ability to explain and apply examples of energy-saving behavior in the home and school. In addition, the practical goal is to provide tools that make it easier for teachers to carry out cooperative learning in a more structured manner, so that learning no longer relies solely on improvisation, but is supported by worksheets.

RESEARCH METHOD

The research conducted was quantitative descriptive. Quantitative research examines samples that produce numerical data and is analyzed statistically. The research in question is development or R&D (Research and Development) using the ADDIE model approach, which is useful for researching and developing products, as well as testing the effectiveness of the developed products. The stages used are Analysis, Design, Development, Implementation, and Evaluation (Branch, 2007; Rahmawati et al., 2022).

The analysis phase was conducted through observation and interviews to identify student needs for energy conservation. This was followed by the design of jigsaw-based cooperative worksheets and research instruments according to learning outcome indicators. During the development phase, the product was validated by experts and tested on a limited number of fourth-grade students. The implementation phase employed a true experimental design with both experimental and conventional classes, using pre- and post-tests. The evaluation phase aimed to determine the validity, practicality, and effectiveness of the worksheets in improving students' science learning outcomes. This research was conducted at SDN 4 Tegaldlimo in the 2025/2026 academic year, with fourth-grade students as subjects, following initial observations that identified a need relevant to the research focus. The study population comprised all students at SDN 4 Tegaldlimo, while the sample consisted of two fourth-grade classes totaling 50 students, selected purposively in accordance with research criteria (Lintangesukmanjaya et al., 2024).

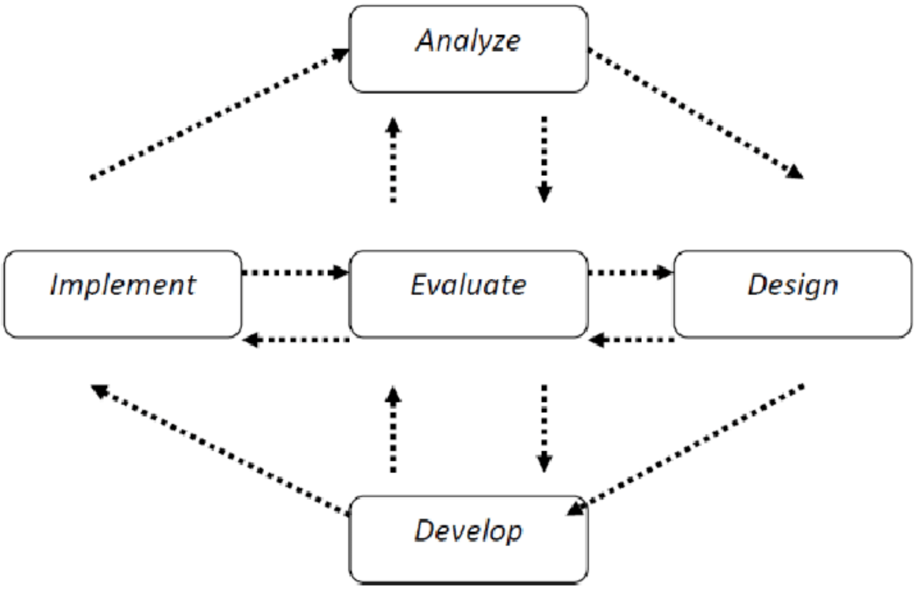

Figure 1. ADDIE Design

Data collection methods in this study included validation, observation, testing, and questionnaires. The validation method was used to assess the feasibility of research devices and instruments through evaluations by three expert validators. At the same time, observations were conducted to examine the implementation of learning and student learning outcomes during the learning process. Pre- and post-tests were used to assess student learning outcomes using cognitive-level indicators. In contrast, questionnaire methods were used to assess student responses, motivations, and perceptions of the applied learning. The teaching tools used consisted of teaching modules and worksheets based on the jigsaw cooperative model on energy conservation material. At the same time, research instruments included learning media validation sheets, observation sheets for learning implementation and learning outcomes, student learning outcome test sheets, and student response questionnaire sheets.

Data analysis techniques in this study include analysis of validity, reliability, practicality, and effectiveness of learning products. Analysis of the validity of the device and instrument was carried out using the Percentage of Agreement (PoA) based on assessments by three expert validators. At the same time, reliability was analyzed using the Cronbach Alpha coefficient (α) with the help of IBM SPSS Statistics software. The analysis of learning implementation was conducted descriptively, using observation sheets to determine the level of learning success in the experimental and conventional classes. Furthermore, analysis of student learning outcomes was carried out using prerequisite tests, including Kolmogorov-Smirnov normality tests and homogeneity tests, followed by paired-sample t-tests if the data were normally distributed or Wilcoxon Signed-Rank Tests if the data were not normal. Improvements in learning outcomes were analyzed using the N-Gain test to determine the category of student ability improvement. In contrast, student response questionnaire data were analyzed using a Likert scale, expressed as percentages, to determine the level of student response and acceptance of the applied learning.

RESULTS AND DISCUSSION

Results

Validation Results of Jigsaw Type Cooperative Worksheet Devices

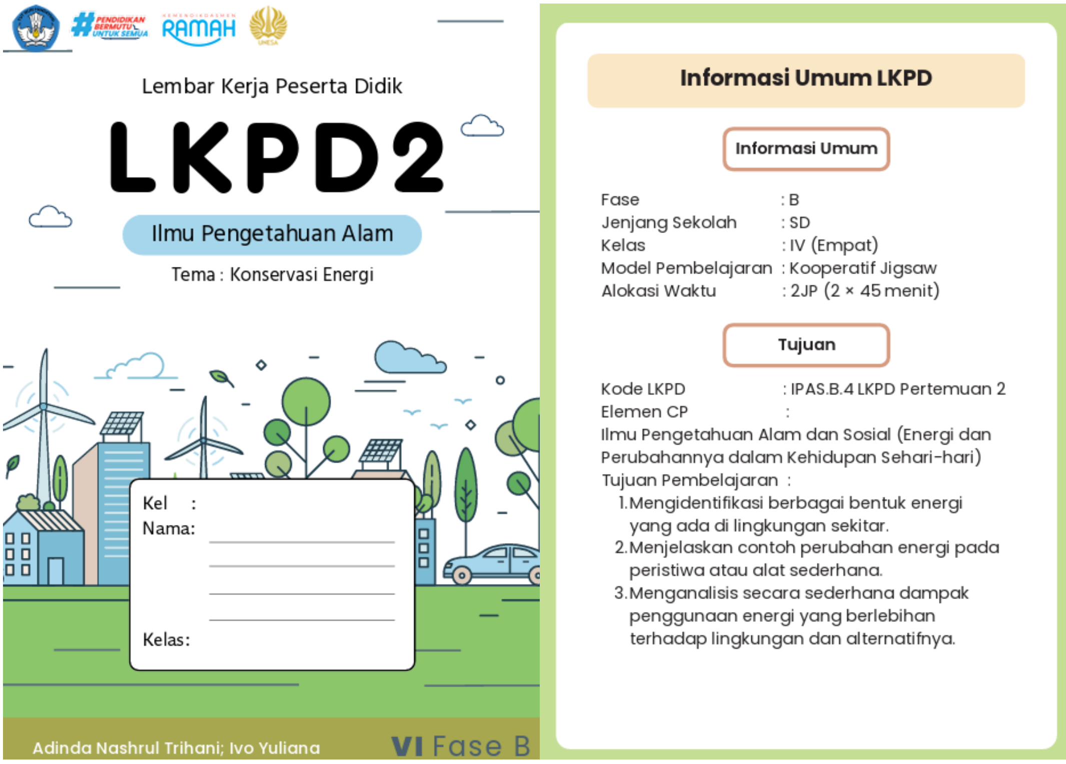

Figure 2. Results of the Development of Jigsaw Type Cooperative Worksheets

The Jigsaw Cooperative Student Worksheet (LKPD) is a learning medium developed to improve students' cognitive abilities. This addresses the importance of learning strategies that can transform students' learning experiences into more active, collaborative, and structured ones. One relevant model to address this need is the Jigsaw cooperative learning model (Kahar, 2020). This LKPD establishes mechanisms to encourage active involvement, increase individual accountability, and simultaneously train communication skills. In the energy conservation material, the division of sub-materials can be clearly defined, for example: definitions and sources of energy; forms of energy; energy changes in everyday appliances; energy waste and its impact; and ways to save energy at home and school. With this division, students not only receive information from the teacher but also build understanding through the process of learning together and "teaching a friend," which, pedagogically, strengthens conceptual understanding.

The validation stage is the stage for collecting validity data for the research tools. The validation method involves submitting the teaching tools and research instruments to three expert validators in their fields. Data on the validity of the research tools is collected using a research tool validation sheet. The Cooperative Jigsaw worksheets must go through the validation stage before use. Descriptive analysis (mean) is performed based on the values of each aspect to determine the validity criteria for the tools and research instruments. In addition, the validity data is used to determine the reliability of the product and tools through the Cronbach Alpha (α) value (Rizki et al., 2023). The following are the specific results for each validity value, validated by three experts in their fields.

Table 1. Validity of Jigsaw Type Cooperative Worksheets Media

No	Rated aspect	Validator		
		1	2	3
	Worksheets Instructions			
1	Instructions for using worksheets are stated clearly.	3	4	4
2	Worksheets contains activity objectives.	2	3	4
3	Activity steps in worksheets according to the Jigsaw learning model	3	4	4
	Suitability of Content			
4	The material in the worksheets is in accordance with learning objectives	4	4	4
5	Materials are appropriate to the developmental level of elementary school students	3	4	4
6	Energy material is presented correctly and clearly	3	3	3
7	Suitability of worksheets with teaching material needs	3	4	4
8	Worksheets presents problems related to everyday life	4	4	3
9	Worksheets helps students understand the concept of energy	3	4	3
10	Worksheets encourages students to discuss in groups	4	3	3
11	Worksheets encourages students to discover concepts through learning activities	4	4	4
12	Worksheets helps students draw conclusions from learning activities	3	4	4
13	Worksheets connects the concept of energy with everyday life	3	3	3
	Language			
14	Worksheets can be read well	3	4	4
15	Worksheets has clear information	3	3	3
16	Compliance of worksheets with Indonesian language rules	4	4	4
17	Effective and efficient use of language	3	4	3
	Presentation			
18	Worksheets has clear learning objectives	3	4	3
19	Worksheets has a complete structure (title, LKPD instructions, objectives, supporting information, learning activities)	3	3	3
20	Worksheets already has a regular system	3	4	3

No	Rated aspect	Validator		
		1	2	3
	Graphics			
21	Worksheets uses good and attractive font types and sizes.	3	4	3
22	Worksheets has an attractive layout	3	3	3
23	Worksheets has good illustrations/pictures/photos and is related to the concept	4	4	4
24	Worksheets has an attractive display design	4	4	4
Total Assessment Score			251	
Average Assessment Score			3,48	

Practical Results of Learning Tool Development

In the development stage, a limited test was conducted on 1 class using a cooperative learning model assisted by cooperative jigsaw model worksheets. The limited test was administered to a sample of 25 students. The implementation of learning was assessed through observations at each learning phase, yielding 85.26%. During the implementation stage, cooperative learning activities assisted by cooperative jigsaw model worksheets were conducted in one school across 2 classes: experimental and control. Cooperative model-learning activities were given to the experimental class in 2 meetings, using 2 worksheets. Teacher activities during learning were observed through the results of 3 observers' assessments of the implementation of learning, yielding an average implementation of 90.75%.

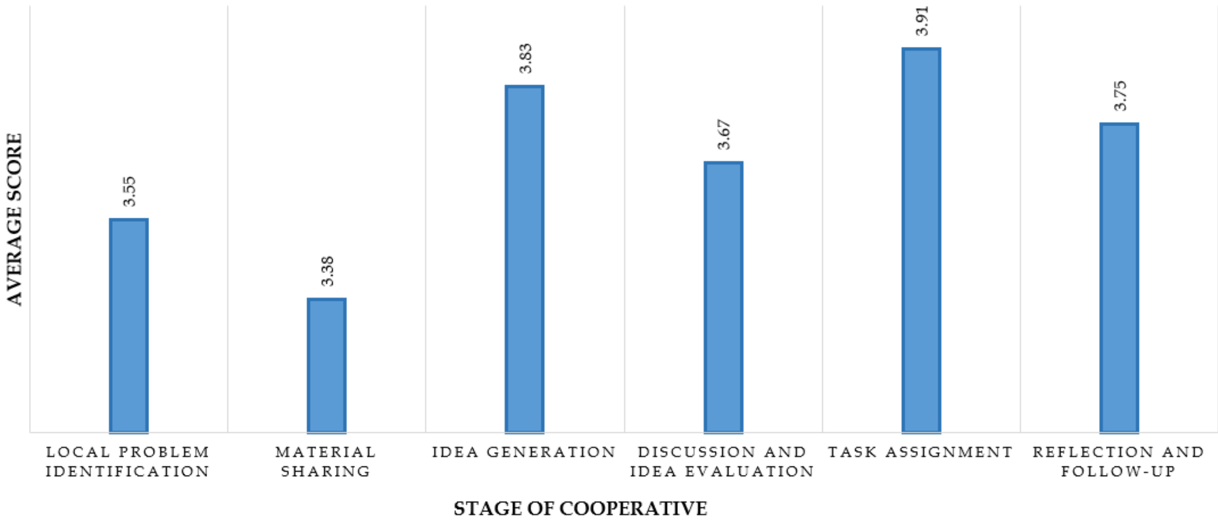

Figure 3. Comparison Chart of Average Implementation Scores

Based on Figure 3, each phase has a very good score with a score above 3. The phase with the highest percentage of implementation is the evaluation and confirmation phase of 3.91, this means that the teacher is very good at ending and accompanying the evaluation and confirmation activities of the concept. Cooperative learning activities emphasize learning activities through group collaboration so that students are more enthusiastic and learning is more meaningful.

Results of the Effectiveness of Learning Devices in Implementation

To determine the improvement in student learning outcomes more broadly, a research instrument in the form of a pre-test and post-test was used in a large-scale test. The pre-test and post-test questions consisted of the same questions with a total of 10 questions consisting of 4 multiple-choice questions and 6 essay questions. The pre-test questions were given at the beginning of learning in each class, while the post-test questions were given at the end of learning in each class. Based on the results of the pre-test and post-test obtained in 2 classes at the same school, the following statistical data were obtained.

Table 2. Descriptive Statistics of Large Scale Tests

Hasil	**N**	**Valid N (listwise)**	**Min**	**Max**	**Mean**	**Std. Deviation**
Pre-test Experiment	25	25	17	43	29.72	8.434
Post-test Experiment	25	25	57	90	72.52	8.140
Pre-test Control	25	25	17	43	28.56	8.491
Post-test Control	25	25	40	73	55.84	7.375

Prerequisite test results are a basic concept used as a reference for determining the test statistics to be used. The results of the first prerequisite test, namely the normality test, from this study are as follows.

Table 3. Results of Normality and Homogeneity Tests

<table>
<tr><th rowspan="3">Kelas</th><th colspan="6">Normality</th><th rowspan="3">Homogenity</th></tr>
<tr><th colspan="3">Kolmogorov-smirnov[a]</th><th colspan="3">Shapiro-Wilk</th></tr>
<tr><td>Statistic</td><td>df</td><td>Sig.</td><td>Statistic</td><td>df</td><td>Sig.</td></tr>
<tr><td>Pre-test Eks</td><td>0.147</td><td>25</td><td>0.170</td><td>0.928</td><td>25</td><td>0.079</td><td rowspan="4">0.456</td></tr>
<tr><td>Post-test Eks</td><td>0.124</td><td>25</td><td>0.200</td><td>0.972</td><td>25</td><td>0.706</td></tr>
<tr><td>Pre-test Kontrol</td><td>0.113</td><td>25</td><td>0.200</td><td>0.923</td><td>25</td><td>0.060</td></tr>
<tr><td>Post-test Kontrol</td><td>0.112</td><td>25</td><td>0.200</td><td>0.977</td><td>25</td><td>0.825</td></tr>
</table>

Table 3 shows that based on the analysis of pre-test and post-test scores using SPSS software, all sig. values were > 0.05, thus H0 was accepted. It was concluded that the data were normally distributed. In addition, statistically homogeneous data across two classes is one of the requirements for valid data in research (Usmadi, 2020). This test was conducted on the pre-test and post-test scores to determine whether the data were homogeneous. Based on the mean value that had a significant. value > 0.05, which was 0.456. It was concluded that all data were homogeneously distributed for the pre-test and post-test assessments. Furthermore, a difference test was conducted to determine the effect on student learning outcomes of implementing learning in each research class. Because the normality test indicated that the data were normally distributed, a parametric test was used.

Table 4. SPSS Paired Sample T-Test Test Results

Value	Mean	Std. Error Mean	t	df	Sig. (2-Tailed)
Pre-test-Post-test Eks	-42.800	2.260	-18.0940	24	0.000
Pre-test-Post-test Kon	-27.280	1.969	-1.858	24	0.000

Table 4 shows that the results of the t-test difference test based on the Asymp. Sig. (2-tailed) value obtained by both classes are <0.05, namely 0.00, so H0 is accepted or there is a difference in student learning outcomes from the pre-test and post-test in each class, this difference is in the form of an increase in student learning outcomes (Afifah et al., 2022). Next, the N-gain Test was conducted to determine the results of the analysis of the level of increase in student learning outcomes after being given learning treatment through the results of the student's pre-test and post-test. Table 5 shows the results of the N-Gain calculation for each student.

Table 5. N-Gain Calculation Results

Class	Statistic	Category
Experiment	0.6044	High
Control	0.3760	Suciffient

There is a final result, namely the analysis of the large-scale test responses obtained from the implementation stage carried out in one experimental class. The response questionnaire was given during the implementation activity to 25 students in the experimental class in grade IV of elementary school to determine how the response was related to the development of cooperative worksheets with the jigsaw model.

Table 6. Results of Response Questionnaire

No	Rated aspect	Agreement (%)
1	The teacher's explanation was easy for me to understand.	100
2	The LKPD used helped me understand the material.	100
3	The language in LKPD is easy to understand.	100
4	Discussion activities make me more active in learning.	92
5	Discussions in expert groups helped me understand the material well.	88
6	I feel responsible for the material I study.	68
7	I can explain the material again to my group mates.	76
8	The friends in the group work together well.	88

No	Rated aspect	Agreement (%)
9	I dare to express my opinion during group discussions.	80
10	Overall, I found this learning enjoyable.	92

Based on the recapitulation data of the large-scale test response questionnaire, it can be obtained that the implementation of the cooperative learning model assisted by cooperative worksheets with the jigsaw model to improve student learning outcomes received a good response. This is seen from the good average agreement. So that the results of this response analysis can be an innovation and motivation for students in the spirit of learning. The distribution of response questionnaires to students has been carried out with maximum results, especially in knowing what is felt by all students in the experimental class.

Discussion

Jigsaw Cooperative Worksheets are learning tools designed to enhance students' cognitive abilities. This addresses the importance of learning strategies that transform students' learning experiences into more active, collaborative, and structured ones. One relevant model to address this need is the Jigsaw cooperative learning model (Jeppu et al., 2023). This tool is structured to encourage active engagement, increase individual accountability, and foster communication skills. For energy conservation, the clear division of subtopics allows for a clear understanding, for example: the definition and sources of energy, forms of energy, energy transformations in everyday appliances, energy waste and its impact, and ways to conserve energy at home and school. With this division, students not only receive information from the teacher but also build understanding through collaborative learning and "teaching a peer," which pedagogically strengthens conceptual understanding.

Practical learning tools are evident in the activity's elements, namely, their effective implementation in learning. Based on the results of the learning implementation in limited and extensive tests, the cooperative learning model assisted by the Jigsaw model worksheets showed a positive increase. In the limited test, the average learning implementation scored 3.42 and achieved 85.26% in the very good category. Furthermore, in the extensive test, the average implementation increased to 3.63, with 90.75% in the very good category. This increase indicates that the implementation of learning in the next meeting ran more smoothly because the teacher and students began to get used to the syntax of the Jigsaw-type cooperative learning model. In addition, each phase of learning saw increased implementation, especially in the discussion and unification phase of understanding, as well as in the evaluation and confirmation phase, indicating that students were increasingly active in the learning process.

Improved learning outcomes also indicate that teachers are increasingly able to control and manage student activities during the lesson. During the limited test, some students were still unfamiliar with working in groups, resulting in a less conducive classroom atmosphere that required more intensive guidance. However, during the extensive test, teachers appeared more capable of managing time allocation, guiding group discussions, explaining procedures for using worksheets, and maintaining student focus on learning objectives. Teachers were also more active in providing motivation, feedback, and guidance to groups experiencing difficulties, resulting in a more focused and effective learning process. This demonstrates that the experience of implementing the limited test positively affects teachers' ability to manage cooperative learning.

Jigsaw cooperative learning also proved suitable for implementation with the worksheets developed in this study. Worksheets help students understand the structured learning steps, from dividing material and forming expert group discussions to consolidating understanding within their original groups. The use of worksheets allows students to participate more actively in discussions, take responsibility for the material they are learning, and re-explain information to their groupmates. Furthermore, Jigsaw-based worksheets can create more interactive and meaningful learning because students not only receive material from the teacher but also learn through collaboration and information exchange among group members. Therefore, integrating the Jigsaw cooperative learning model with the developed worksheets can support improved learning activities and outcomes for elementary school students in energy conservation.

Different analyses were conducted to determine the effectiveness of the cooperative learning model, assisted by Jigsaw-type worksheets, in improving student learning outcomes through limited and extensive tests. In the limited test, the results of the normality test showed that the data were not normally distributed, so the analysis was continued using the Wilcoxon test, which produced a significance value of 0.000 (<0.05), indicating a significant difference between the pre-test and post-test scores, with an N-Gain value of 0.362 in the medium category. Meanwhile, in the extensive test involving the experimental and control classes, the results of the normality and homogeneity tests indicated that the data were normally distributed and homogeneous, allowing a paired-samples t-test. The analysis showed a significance value of 0.000 (<0.05) in both classes. However, the increase in learning outcomes in the experimental class was higher than in the control class, with an N-Gain value of 0.6044 in the high category. In contrast, the control class had an N-Gain of 0.3760 in the medium category. These results indicate that the cooperative learning model, assisted by Jigsaw worksheets, effectively improves student learning outcomes in energy conservation through active, collaborative, and structured learning.

The results of student response questionnaires in both the limited and extensive trials indicate that cooperative learning using Jigsaw worksheets led to increased learning engagement, group collaboration, and understanding of energy conservation. The extensive trial saw more responses than the limited trial, particularly regarding the use of worksheets and discussion activities. Aspects of individual responsibility and the courage to express opinions still need to be improved through mentoring and learning activities that encourage greater student participation.

CONCLUSION

Fundamental Finding: Research shows that Jigsaw-based cooperative learning worksheets are valid, practical, and effective for teaching energy conservation in elementary schools. The implementation of worksheets can significantly improve student learning outcomes, as evidenced by pre-test, post-test, difference test, and N-Gain values in the experimental class. In addition, students gave a positive response to the learning because discussion activities and group collaboration made learning more active, interesting, and easier to understand. **Implication:** The results of this study indicate that the Jigsaw cooperative learning model can be an alternative, innovative learning strategy to improve learning outcomes and student engagement in elementary schools. The use of structured worksheets also helps teachers manage learning in a more interactive, collaborative, and student-centered manner. These findings support strengthening active learning in science education to achieve higher learning quality in line with SDG 4. **Limitation:** This research is still limited to energy conservation materials, and the number of samples is relatively small, so the research results cannot be generalized to all elementary school science materials. **Future Research:** Further research is planned to develop Jigsaw-type cooperative media based on digital media on other science and science materials with a wider sample coverage to increase the effectiveness and interactivity of learning.

AUTHOR CONTRIBUTIONS

Adinda Nashsrul Trihani contributed to the conceptual framework, research design, and validation process; **Ivo Yuliana** was involved in methodology development, data analysis, sourcing references, and drafting the manuscript. All listed authors have reviewed and approved the final version of this submission.

CONFLICT OF INTEREST STATEMENT

The authors confirm that there are no conflicts of interest, either financial or personal, that may have influenced the content or outcome of this study.

ETHICAL COMPLIANCE STATEMENT

This manuscript complies with research and publication ethics. The authors affirm that the work is original, conducted with academic integrity, and free from any unethical practices, including plagiarism.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors acknowledge the use of digital tools, including AI-based technologies, as support in the research and writing stages of this article. Specifically, Grammerly for a writing aid that offers various advantages, especially in terms of improving the quality and clarity of writing in English. All outputs generated with digital assistance were critically evaluated and revised to ensure academic rigor and ethical standards were upheld. The final responsibility for the manuscript rests entirely with the authors.

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