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Development of Inquiry-Based Student Worksheets (LKPD) on The Material of Changes in the State of Substance to Improve Critical Thinking Abilities

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Abstract

This study aims to develop inquiry-based Science Student Worksheets (LKPD) on the material of changes in the state of matter to improve critical thinking skills of fifth-grade students of SDS Islam Azizi Medan. The background of this study is based on the low involvement of students and suboptimal critical thinking skills in science learning which is still dominated by lecture methods and the use of textbooks. This study uses the Research and Development (R&D) method with the ADDIE model which includes the stages of analysis, design, development, implementation, and evaluation. The research subjects consisted of fifth-grade students of SDS Islam Azizi Medan as well as validators of material experts, media experts, and learning experts. Data collection techniques used observation, questionnaires, documentation, and critical thinking ability tests. The results showed that the developed LKPD obtained a validation percentage of material experts of 90%, media experts of 90%, and learning experts of 90% with a very valid category. The results of the practicality of LKPD obtained an average percentage of 90% with a very practical category. The effectiveness of the LKPD is seen from the increase in the average pretest score of 58 to 86 in the posttest with an N-Gain value of 0.68 in the moderate category. The use of inquiry-based LKPD can increase students' learning activity and critical thinking skills in the indicators of interpretation, analysis, evaluation, and inference. Thus, the inquiry-based science LKPD is suitable for use as a teaching material to improve the critical thinking skills of elementary school students.

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INTRODUCTION

Basic education is an important foundation in developing quality human resources who are intelligent, skilled, and able to think critically(Salimah, 2022). At the elementary school level, the learning process emphasizes not only mastery of knowledge but also the development of thinking skills, scientific attitudes, and problem-solving skills related to everyday life. One subject that plays a significant role in developing these skills is Natural Sciences (IPA)(Alfin, 2023). Science learning in elementary schools aims to help students understand natural phenomena scientifically, foster curiosity, and develop logical and critical thinking skills from an early age. explains that science learning is not simply a process of memorizing concepts, but a process of discovering knowledge through thought activities. Inquiry strategies emphasize observing, proposing hypotheses, collecting data, interpreting, and communicating results so that students are actively involved in learning.Inquiry learning encourages students to find their own answers through critical and analytical thinking processes in solving problems(Tanjung, 2016).

One of the science topics often considered difficult by fifth-grade students at Azizi Islamic Elementary School in Medan is changes in the state of matter. This topic covers the concepts of melting, freezing, evaporation, condensation, and sublimation, which require an understanding of

the processes and observation of the events that occur. If the learning is delivered only verbally without accompanying exploratory activities, students will struggle to grasp the concepts deeply. They tend to memorize without truly understanding how and why changes in state of matter occur(Firdaus & Wilujeng, 2024). This situation indicates that learning still doesn't provide students with the opportunity to directly experience the scientific process. Science learning should, however, involve students in independent investigation, observation, and concept discovery through an inquiry approach, so that students not only receive information but also construct their own knowledge through scientific thinking(Sakti, 2020).

This condition shows that science learning not only requires changes in methods, but also needs to be directed at developing high-level thinking skills, especially students' critical thinking skills(Siswanto et al., 2024). Critical thinking skills are one of the important competencies that students must have in the modern era and 21st century learning(Hosnan, 2024). This ability includes skills in analyzing information, interpreting data, evaluating a problem, and drawing logical conclusions(Rustaman, 2016). Therefore, science learning should be designed in such a way that it can train and develop students' critical thinking skills optimally.

To realize learning that is able to develop critical thinking skills, appropriate, innovative learning strategies, media and teaching materials are needed, and are centered on student activities.According to (Permatasari et al., 2024), the use of media and teaching materials that are appropriate to the characteristics of students can increase learning motivation, understanding of concepts, and student involvement in the learning process(Iqsandri & Utama, 2021).

In line with this, (Zainuddin, 2019) stated that learning that involves direct student activities can improve conceptual understanding and high-level thinking skills. Safran (2021) also emphasized that the use of teaching materials that encourage student activity can create a more interactive learning atmosphere and help students understand the material more deeply(Safran, 2021). In addition, Trianto (2018) stated that teaching materials that are designed contextually and activity-based can help students build conceptual understanding independently(Trianto, 2018). Manurung (2018) explains that media and learning resources are important components in learning because they can increase student activity and motivation(Manurung, 2018). Teaching materials must be systematically designed to improve students' understanding, attitudes, and skills. Teaching materials serve not only as a medium for conveying information but also as a means of encouraging students to think critically, solve problems, and apply knowledge in everyday life (Nasution et al., 2024).

Critical thinking skills in this study refer to the opinion of Facione (2015) who stated that critical thinking includes several main indicators, namely: (1) interpretation (the ability to understand and explain meaning), (2) analysis (the ability to identify relationships between information), (3) evaluation (the ability to assess the credibility and logic of statements), and (4) inference (the ability to draw conclusions rationally). These indicators are used as the basis for compiling activities and questions in the developed LKPD(Facione, 2011).

ThusAppropriate strategies and teaching materials should be implemented through an inquiry approach. The inquiry approach emphasizes the active involvement of students in discovering knowledge through asking questions, investigating, observing, analyzing, and drawing conclusions independently. Through inquiry-based learning, students not only receive information from the teacher but also build conceptual understanding through scientific thinking processes. This approach plays a crucial role in developing critical thinking skills because it directly involves students in problem analysis, hypothesis testing, and drawing conclusions based on data and facts(Nurhayati & Hadi, 2021).

Therefore, teaching materials are needed that are able to facilitate the systematic application of the inquiry approach in science learning, one of which is through the development of inquiry-based Student Worksheets (LKPD). Like the research conducted by Rambe, AH (2023) which focused on the development of Student Worksheets (LKPD) in Madrasah Ibtidaiyah/elementary schools with an approach that emphasizes active student

involvement(Rambe, 2023). Inquiry-based LKPD allows students to learn through direct experience, so they can connect science concepts with everyday life(Agustin & Aziz, 2025). According to Damanik et al. (2022), guided inquiry-based student worksheets (LKPD) train students to conduct investigations systematically and logically, thereby developing critical thinking skills. Inquiry-based student worksheets (LKPD) are able to guide students to discover knowledge independently through investigation. This study used the ADDIE model, and the results showed that LKPD is very practical and effective in improving student learning outcomes and thinking skills(Damanik et al., 2022). Based on initial observations at Azizi Islamic Elementary School in Medan, science instruction on changes in the state of matter is still dominated by lectures and textbooks. Teachers have not yet used teaching materials that encourage students to actively discover concepts independently, resulting in students tending to be passive and less engaged in the learning process.

In addition, the developed LKPD is expected to be an interesting, systematic teaching material that suits the characteristics of elementary school students(Pramesti et al., 2024). Based on the description, this study aims to develop an inquiry-based science worksheet (LKPD) on the topic of changes in the state of matter to improve the critical thinking skills of fifth-grade students at SDS Islam Azizi Medan. The development of an educational game-based LKPD to improve the critical thinking skills of elementary school students. In this study, it is explained that the developed LKPD has gone through a validation stage by material, design, language, and practitioner experts so that it is declared valid and suitable for use in science learning.

Game-based LKPD can make the learning process more interesting, interactive, and help students understand concepts more easily. In addition, the use of educational games is considered to be able to reduce learning boredom and increase student motivation and engagement in learning (Aufa, 2024). Mediation services are part of guidance and counseling services aimed at resolving conflicts between students, thereby creating a conducive learning environment. Research shows that mediation services can enhance student creativity through a more orderly, comfortable, and supportive learning environment(Hasibuan et al., 2023). Although not directly addressing student worksheets (LKPD), this study remains relevant as a supporting tool because it explains that a conducive learning environment significantly influences the development of students' thinking skills. In the context of this research, the use of inquiry-based LKPD will be more effective in improving critical thinking skills if supported by a comfortable and active learning environment(Hasibuan et al., 2023).

Various previous studies have developed inquiry-based worksheets (LKPD) to improve students' learning outcomes and thinking skills. (Damanik et al., 2022) developed an inquiry-based worksheet to increase the activeness and conceptual understanding of elementary school students.(Damanik et al., 2022)developed a guided inquiry-based worksheet on the human respiratory system and proved effective in developing students' critical thinking skills. (Pramesti et al., 2024)also developed an inquiry-based science worksheet and demonstrated effective results in improving critical thinking skills. However, most of these studies focused on improving learning outcomes and did not specifically develop an inquiry-based worksheet on the topic of changes in the state of matter in elementary schools with structured and systematically measurable critical thinking skill indicators. Furthermore, there are not many studies that explicitly integrate critical thinking indicators based on aspects of interpretation, analysis, evaluation, and inference into the worksheet design. Based on this analysis, there is a research gap in the form of suboptimal development of inquiry-based worksheets specifically designed to improve critical thinking skills on the topic of changes in the state of matter in fifth grade elementary school. The novelty in this research lies in:

1. Development of inquiry-based science worksheets specifically designed for material on changes in the state of matter.
2. Integration of critical thinking ability indicators referring to Facione (interpretation, analysis, evaluation, inference) into every LKPD activity.

3. Preparation of simple experimental activities that are contextual and appropriate to the characteristics of fifth grade students.
4. Testing the effectiveness of LKPD is not only on learning outcomes, but specifically on improving students' critical thinking skills.

Thus, this research not only develops LKPD products, but also offers a systematic learning design to train critical thinking skills in a structured manner in elementary school science learning.

RESEARCH METHOD

The research method used is Research and Development (R&D) According to (Sugiyono, 2019),namely a research method that aims to produce a certain product and test its effectiveness. In this study, the R&D method was used to develop a product in the form of an inquiry-based Science Student Worksheet (LKPD) on the topic of changes in the state of matter. Product development began with an analysis of student and teacher needs, then continued with the process of designing, developing, and testing the product. Testing was conducted to determine the level of feasibility, practicality, and effectiveness of LKPD in improving the critical thinking skills of fifth-grade elementary school students, so that the resulting product can be used optimally in the learning process. Quantitative data analysis was conducted by calculating the percentage of eligibility from expert validators using a Likert scale. The practicality of the worksheet was analyzed through the percentage of student responses. The effectiveness of the worksheet was analyzed using a comparison of pretest and posttest critical thinking ability scores by calculating the increase (N-Gain). Qualitative data from observations and validator suggestions were analyzed descriptively for product improvement(John W. Creswell & J. David Creswell, 2018).

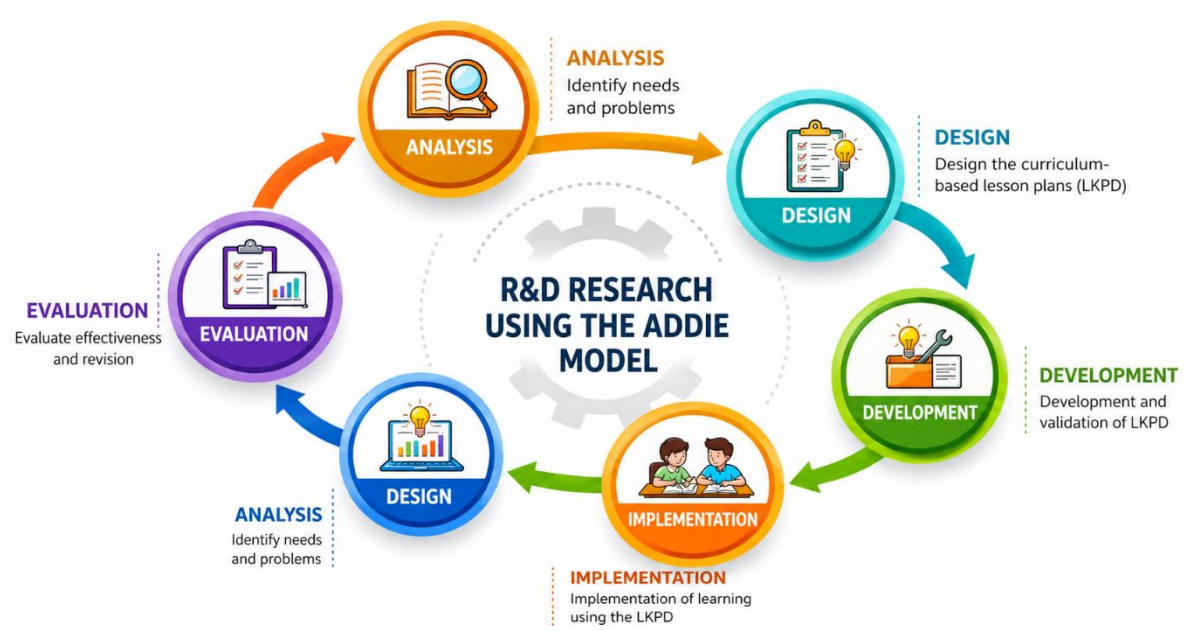

Figure 1. Research and Development (R&D) Procedure Using the ADDIE Model

The first stage is Analysis. At this stage, an analysis of learning needs was conducted at SDS Islam Azizi, specifically for fifth-grade science learning. The analysis included analysis of student characteristics, curriculum analysis, and analysis of material on changes in state of matter. The needs analysis was conducted to determine the learning problems faced, the conditions of students, and the limitations of teaching materials used by teachers. The results of this analysis became the basis for developing LKPD to suit the needs of students and learning objectives. The second stage is Design. At this stage, the design of inquiry-based science LKPD products was carried out.

Activities carried out included preparing the LKPD structure, formulating learning objectives, compiling critical thinking ability indicators, and designing inquiry-based learning activities. In addition, at this stage, research instruments were also designed to measure the feasibility, practicality, and effectiveness of LKPD, such as expert validation sheets, student response questionnaires, and critical thinking ability tests. The third stage is Development. At this stage, the preparation of inquiry-based science LKPD was carried out in accordance with the planned design. The developed student worksheets were then validated by subject matter experts, media experts, and learning experts. Validation was conducted to assess the appropriateness of the content, language, presentation, and appearance of the student worksheets. The validation results were used as a basis for revisions to ensure the developed student worksheets were suitable for use in the learning process.

The fourth stage is Implementation. At this stage, the revised and feasible LKPD was trialed on a limited basis with fifth-grade students at SDS Islam Azizi. The trial was conducted to determine the practicality of using LKPD in science learning and to observe students' responses to the developed LKPD. In addition, at this stage, data collection was also carried out through observation, questionnaires, and critical thinking skills tests. The fifth stage is Evaluation. At this stage, an evaluation was carried out on the entire development process and the results of using LKPD. The evaluation aims to assess the feasibility, practicality, and effectiveness of the inquiry-based science LKPD. The effectiveness of LKPD is seen from the increase in students' critical thinking skills after using LKPD. The evaluation results were used as material for improving and perfecting the final product. The subjects in this study were fifth-grade students at SDS Islam Azizi and expert validators consisting of material experts, media experts, and learning experts. The object of the study was the inquiry-based science LKPD on the topic of changes in state of matter. Data collection techniques used in this study include observation, questionnaires, and critical thinking ability tests.

RESULT AND DISCUSSION

Result

Results of Student Work on LKPD

Based on the results of the inquiry-based Student Worksheet (LKPD) on the material of changes in the state of matter (referring to the data in the PDF file), it is clear that students are able to follow the flow of learning activities that have been systematically designed. The LKPD developed contains inquiry stages that include observing, asking questions, collecting data, associating (analyzing), and communicating results. These stages have been proven to be able to direct students to not only receive information, but also actively build their own understanding through learning experiences. In the observation stage, most students were able to identify the phenomena of changes in the state of matter presented, both through pictures and illustrations of everyday events. Students were able to write down the results of their observations in their own words, although there were still some simple answers. This indicates that students' initial abilities in understanding concepts have begun to develop, especially in recognizing events of changes in the state of matter such as melting, freezing, and evaporation.

During the questioning stage, students begin to demonstrate curiosity by attempting to answer the questions provided in the worksheet. Although most of the questions are still structured (guided), students are already accustomed to thinking about the cause and effect of an event. This is an early indicator of the development of critical thinking skills, particularly in understanding the relationship between concepts and phenomena. Furthermore, during the data collection stage, students are able to connect everyday experiences with the material being studied. For example, students can explain that ice left at room temperature will melt or that water heated will evaporate. This indicates that learning is becoming more contextual and meaningful. However, some students still have difficulty explaining the process coherently.

During the analysis stage, students' ability to connect the information obtained with scientific concepts began to emerge. Some students were able to explain the relationship between temperature changes and changes in the state of matter. However, their answers were still incomplete and unsystematic. This indicates that students' analytical skills still need to be further developed through ongoing practice. During the conclusion-drawing stage, some students still had difficulty formulating comprehensive conclusions. Many students simply copied previous answers without summarizing the main points of the lesson. This indicates that inference (conclusion-drawing) skills have not yet developed optimally. Therefore, further guidance from teachers is needed to train students to draw good and correct conclusions.

Table 1. Results of Validation by Material Experts

Assessment Aspects	Score	Percentage	Criteria
Material Suitability	18	90%	Very Valid
Linguistics	17	85%	Valid
Presentation of Material	19	95%	Very Valid
Conformity to Inquiry	18	90%	Very Valid
Average	72	90%	Very Valid

Based on the table above, the validation results from the material experts obtained an average percentage of 90%, categorized as very valid. This indicates that the material in the LKPD aligns with the learning objectives and student characteristics.

Table 2. Media Expert Validation Results

Assessment Aspects	Score	Percentage	Criteria
LKPD display	19	95%	Very Valid
Design and Color	18	90%	Very Valid
Readability of Writing	17	85%	Valid
Layout	18	90%	Very Valid
Average	72	90%	Very Valid

The results of media expert validation show that LKPD has an attractive appearance and is easy to use by elementary school students.

Improving Students' Critical Thinking Skills

The use of inquiry-based student worksheets (LKPD) in science learning has shown an increase in students' critical thinking skills. This can be seen from changes in students' answer patterns before and after using LKPD. Students who previously tended to answer briefly and directly, after using LKPD, began to provide more detailed explanations and provide reasons. Critical thinking skills in this study refer to the indicators proposed by Facione, namely interpretation, analysis, evaluation, and inference. In the interpretation indicator, students are able to understand the information provided and explain it again in their own words. This is evident in students' ability to explain the types of changes in the state of matter and provide real-life examples.

In the analysis indicator, students are beginning to be able to connect various pieces of information and discover cause-and-effect relationships. For example, students can explain that increasing temperature causes a substance to change from a solid to a liquid or from a liquid to a gas. This indicates development in logical thinking skills. However, in the evaluation indicator, students' abilities are still relatively low. Students are not yet fully able to assess the truth of a statement or compare several concepts critically. Meanwhile, in the inference indicator, students still have difficulty drawing accurate and comprehensive conclusions. This indicates that higher-order thinking skills still need to be continuously trained. Overall, the use of inquiry-based student worksheets has a positive impact on improving students' critical thinking skills, although not evenly distributed across all indicators. This indicates that inquiry-based learning is an effective approach, but requires sufficient time and practice to achieve optimal results.

Table 3. Results of Learning Expert Validation

Assessment Aspects	Score	Percentage	Criteria
Learning Suitability	18	90%	Very Valid
Inquiry Activities	19	95%	Very Valid
Critical Thinking Skills	18	90%	Very Valid
Instructions for use	17	85%	Valid
Average	72	90%	Very Valid

The results of the validation by learning experts show that inquiry-based LKPD is suitable for use in science learning because it is able to train students' critical thinking skills.

Student Activeness and Involvement in Learning

During the learning process using Student Worksheets (LKPD), a significant increase in student activity was observed. Students no longer simply listened to teacher explanations but were directly involved in the learning activities. They actively read the LKPD, completed assignments, discussed with friends, and attempted to answer questions. Student engagement was also evident in group discussions, where students exchanged opinions and collaborated to complete assignments. This demonstrates that LKPD not only improves cognitive abilities but also develops students' social skills. Furthermore, the learning atmosphere became more lively and interactive. Students appeared more enthusiastic and less bored because the learning was packaged in the form of interesting activities. This demonstrates that the use of inquiry-based LKPD can increase student learning motivation.

Table 4. Pretest and Posttest Results

Information	Average value
Pretest	58
Posttest	86

The effectiveness of the student worksheet (LKPD) was determined through the results of the pretest and posttest of students' critical thinking skills. The table shows an increase in student scores after using the inquiry-based LKPD.

Table 5. N-Gain Results

N-Gain Value	Category
0.68	Currently

The N-Gain result of 0.68 shows that inquiry-based LKPD is quite effective in improving students' critical thinking skills.

Discussion

Student responses to the use of student worksheets (LKPD) showed positive results. Based on observations and student responses, LKPD was considered interesting, easy to understand, and helpful in understanding the learning material. Students felt more enjoyable learning because they were directly involved in activities, not just listening to teacher explanations. The language used in the LKPD was also considered appropriate for the developmental level of elementary school students, making it easy to understand. Furthermore, the LKPD's attractive and systematic presentation made students more interested in working on it. This positive response indicates that the developed LKPD has a good level of practicality and can be used effectively in learning.

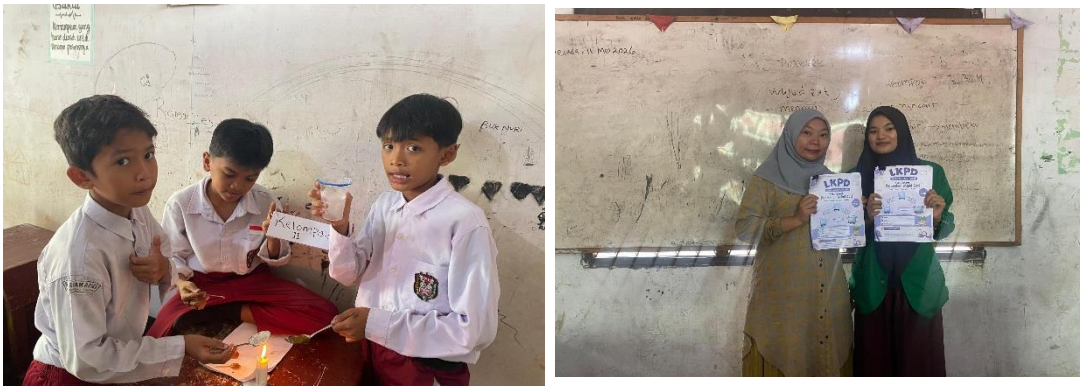

Figure 2. Documentation of Learning Activities with Science Students and Teachers

The student worksheets developed in this study proved to be practical and suitable for use in science learning. This was evident in the ease with which students used the worksheets and the appropriateness of the content to the learning objectives. Clear instructions helped students follow each step of the activity without experiencing significant difficulties. Furthermore, the worksheets were systematically structured from the initial activity to the closing, making it easier for students to understand the learning flow. The appropriateness of the material, learning objectives, and activities presented demonstrated that the worksheets met the eligibility criteria as teaching materials.

Table 6. Product Revisions Based on Validator Suggestions

Before Revision	Validator Suggestion	After Revision
The cover display is less attractive	Add appropriate colors and images	The cover was revised using purple and illustrations of changes in the state of matter.
Instructions for use are not clear	Add steps for using LKPD	Added usage instructions on the home page
The question is still simple	Add critical thinking questions	Questions are revised according to critical thinking indicators
The layout is not neat	Improve the arrangement of images and text	The layout is made more systematic

After the validation process, product revisions were made based on the validator's suggestions to improve the LKPD and make it suitable for use. Revisions were made to make the LKPD more engaging, easier to understand, and more suited to the needs of elementary school students.

Table 7. Practical Results of LKPD

No	Assessment Aspects	Percentage	Criteria
1	Ease of use	88%	Very Practical
2	Attractive LKPD display	92%	Very Practical
3	Easy to understand language	90%	Very Practical
4	Helps understand the material	91%	Very Practical
5	Increase enthusiasm for learning	89%	Very Practical
	Average	90%	Very Practical

The practicality of the student worksheet was assessed through a questionnaire survey of student responses after using the worksheet in their learning. The table above shows that the worksheet achieved an average score of 90%, categorized as very practical. Students found the

worksheet easy to use, engaging, and helpful in understanding the material on changes in state of matter.

The results of this study align with the inquiry-based learning theory, which states that learning will be more effective if students are actively involved in the process of discovering knowledge. Inquiry-based student worksheets (LKPD) provide students with opportunities to learn through direct experience, thus deepening their understanding of concepts. Furthermore, these results also support previous research that found inquiry-based LKPD can improve critical thinking skills and student learning outcomes. This indicates that LKPDis one of the effective teaching materials in science learning in elementary schools.

4. Advantages and Limitations of LKPD

The developed student worksheets (LKPD) have several advantages, including increasing student engagement, aiding conceptual understanding, and fostering critical thinking skills. Furthermore, LKPDs make learning more engaging and less monotonous. However, there are some limitations, such as some students still having difficulty with analysis and drawing conclusions. Furthermore, inquiry-based learning takes longer and requires intensive teacher guidance.

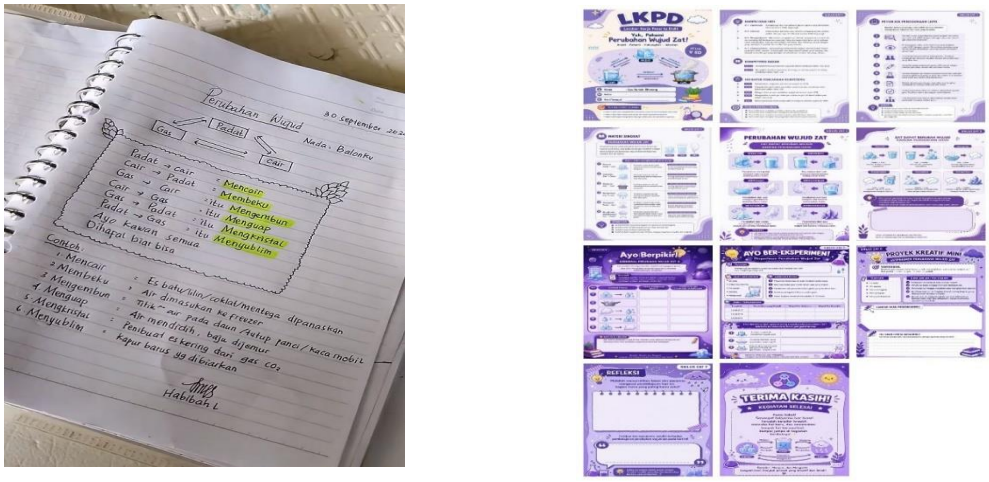

Figure 3. Learning Media Before and After

CONCLUSION

Based on the results of the research and development that has been carried out, it can be concluded that the inquiry-based Science Student Worksheet (LKPD) on the material of changes in the state of matter was successfully developed using the ADDIE model which includes the stages of analysis, design, development, implementation, and evaluation. The developed LKPD was declared valid, practical, and effective for use in science learning for grade V of SDS Islam Azizi Medan. The validation results by material experts, media experts, and learning experts showed that the LKPD obtained an average percentage of 90% with a very valid category. This indicates that the LKPD is appropriate in terms of material content, appearance, language, and suitability with the inquiry approach and indicators of critical thinking skills.

The practicality of the Student Worksheet also showed excellent results with an average percentage of 90% based on student response questionnaires. Students considered the Student Worksheet easy to use, interesting, helpful in understanding the material, and increased enthusiasm for learning. The use of inquiry-based Student Worksheets makes students more active in the learning process through activities such as observing, asking questions, collecting data, analyzing, and drawing conclusions. In addition, the Student Worksheet based on inquiry has proven effective in improving students' critical thinking skills. This is evident from the increase in the average pretest score of 58 to 86 in the posttest, with an N-Gain value of 0.68 which is included

in the moderate category. The increase in critical thinking skills is seen in the indicators of interpretation, analysis, evaluation, and inference, although some students still require guidance in the analysis and conclusion-drawing stages. Thus, the development of inquiry-based Science Student Worksheets on the material of changes in the state of matter can be an effective alternative teaching material to improve the critical thinking skills of elementary school students and create more active, interesting, and meaningful science learning.

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