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The Effectiveness of e-LKPD Sience Based on *Project Based Learning* in Improving Critical Thinking Skills of Junior High School Students

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Abstract

This study aimed to examine the effectiveness of an electronic student worksheet (e-LKPD) based on Project Based Learning (PjBL) on temperature and heat material in improving junior high school students' critical thinking skills. The study employed a research and development approach using the ADDIE model, which consists of the stages of Analyze, Design, Develop, Implement, and Evaluate. The e-LKPD was validated by three experts to determine its validity, practicality, and feasibility before implementation. The implementation was conducted in class VII-F of SMPN 2 Jember. Data were collected through expert validation sheets, student response questionnaires, and critical thinking skill tests administered in the form of pretests and posttests. The results showed a significant improvement in students' critical thinking skills after the implementation of the PjBL-based e-LKPD. The average pretest score increased from 55 to 88.75 in the posttest, with an N-Gain value of 0.75, categorized as high. Indicator-based analysis revealed that all critical thinking indicators improved, with the evaluation indicator achieving the highest N-Gain value of 0.87. These findings indicate that the PjBL-based e-LKPD is effective in enhancing students' critical thinking skills and supporting active, meaningful science learning. Therefore, the PjBL-based e-LKPD can be used as an effective alternative learning material for teaching temperature and heat in junior high schools

Keywords: *e-LKPD, Project Based Learning, Critical Thinking Skills*

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INTRODUCTION

Natural Science (IPA) is a field of science that studies natural phenomena based on scientifically tested facts, concepts, principles, and laws. As a core subject at the junior high school level, science plays an essential role in developing students' understanding of natural phenomena while also fostering critical thinking and problem-solving skills (Lubis et al., 2023). Science learning is not limited to mastering theoretical knowledge but also involves applying scientific concepts in daily life through observation, experimentation, and analysis (Setiyawan et al., 2022). However, in practice, science instruction in many junior high schools is still dominated by traditional, teacher-centered approaches. Literature studies on cience learning in public junior high schools in Mojokerto reveal that such methods tend to make students passive, limit their critical thinking abilities, and cause them to rely solely on teacher explanations without gaining deep conceptual understanding (Indrawati et al., 2021).

Critical thinking skills in the context of science learning refer to students' ability to analyze, evaluate, and draw logical and rational conclusions from scientific information. These skills are crucial in science education because they help students understand scientific concepts more deeply and apply them to real-world situations (Setiawan et al., 2022). Furthermore, critical thinking enables students to identify scientific problems, collect and analyze experimental data, and draw valid conclusions based on empirical evidence (Riyanto et al., 2024). This ability also includes reflective thinking, allowing students to evaluate their own scientific reasoning processes and consider alternative perspectives or theories. By developing critical thinking skills in science learning, students are better prepared to face academic challenges and make informed decisions in everyday life (Marunung et al., 2023).

In the 21st century, critical thinking has become one of the essential competencies required to support students in analyzing information, solving problems, and making rational decisions (Azka et al., 2024). Nevertheless, various reports indicate that Indonesian students' critical thinking skills remain relatively low. The Programme for International Student Assessment (PISA) 2022 results show that Indonesia's average scores were 366 in mathematics, 359 in reading, and 383 in science, which are significantly below the OECD average. The proportion of students reaching basic proficiency (Level 2) is still limited, while almost no students reach the highest proficiency levels (Levels 5–6), which reflect advanced critical thinking and complex problem-solving abilities (OECD, 2023). These findings indicate that improving students' critical thinking skills remains a major challenge in the Indonesian education system. One contributing factor is the continued emphasis on memorization and teacher-centered instruction, rather than conceptual understanding and reflective thinking. In addition, internal factors such as low learning autonomy, anxiety in facing challenges, and passive learning styles further hinder the development of students' critical thinking skills (Fitria et al., 2024).

Learning burnout has also been shown to significantly affect students' critical thinking abilities and academic achievement. A study conducted in public junior high schools in Central Java revealed that learning burnout had a negative correlation of –0.526 with eighth-grade students' mathematics achievement, contributing 27.67% to learning outcomes (Putri & Marlina, 2022). This finding highlights the need for innovative learning approaches that actively engage students. One such solution is the use of electronic student worksheets (e-LKPD), which can increase students' active participation in learning. However, the implementation of e-LKPD in schools remains limited, as many teachers still rely on printed worksheets, preventing the full utilization of educational technology. Previous research has shown that e-LKPD based on Problem-Based Learning effectively improves students' collaboration and communication skills (Aulia & Widyatmoko, 2024).

One instructional model considered effective in enhancing junior high school students' critical thinking skills in science is Project Based Learning (PjBL). This model emphasizes students' active involvement in completing real-world projects that are relevant to daily life (Mumiarti, 2021). Through PjBL, students are not passive recipients of information but are actively engaged in designing,

managing, and completing projects through stages such as planning, data collection, analysis, and presentation of results. Project Based Learning promotes meaningful, collaborative, and contextual learning and has been proven to significantly improve students' critical thinking skills (Winarti et al., 2022). Similar findings were reported by Asih et al. (2024), who found increased student learning engagement in junior high school science classes.

RESEARCH METHOD

This study employed the ADDIE development model, which consists of five systematic stages: Analyze, Design, Develop, Implement, and Evaluate. In the Analyze stage, a needs analysis was conducted to identify students' characteristics, learning problems, curriculum requirements, and learning objectives related to temperature and heat material, particularly in relation to students' critical thinking skills. The Design stage involved designing the structure of the e-LKPD, formulating learning objectives, preparing Project Based Learning (PjBL) activities, and developing assessment instruments such as critical thinking tests and validation sheets. During the Develop stage, the e-LKPD was developed and validated by experts to ensure its content validity, instructional quality, and media feasibility. Revisions were made based on expert feedback. The Implement stage involved applying the validated e-LKPD in science learning for Grade VII students to examine its practicality and effectiveness. Finally, the Evaluate stage was conducted through formative and summative evaluations, including analysis of pretest and posttest results and student responses, to determine the effectiveness of the PjBL-based e-LKPD in improving students' critical thinking skills.

RESULTS AND DISCUSSION

The researcher successfully developed an innovative instructional media product in the form of an electronic Student Worksheet (E-LKPD) for science learning based on the Project Based Learning (PjBL) model. This product focuses on the topic of temperature and heat for seventh-grade students of class VII F at SMP Negeri 2 Jember, aiming to significantly enhance their critical thinking skills. The researcher applied the systematic ADDIE development model, which consists of the stages *of Analysis*, *Design*, *Development*, *Implementation*, and *Evaluation.* During the analysis stage, it was found that the school had implemented the Merdeka Curriculum; however, teachers still faced limitations in providing technology-based interactive learning media.

Therefore, the E-LKPD was designed to meet the need for digital teaching materials that can facilitate students' project-based learning activities in the era of educational digitalization. The analysis stage provided a strong foundation regarding student profiles, curriculum needs, and the relevance of the temperature and heat topic. The researcher observed that students in class VII F demonstrated active participation during group discussions, yet often experienced difficulties in connecting theoretical concepts with real-world phenomena. This condition encouraged the researcher to design the E-LKPD using the Canva and Topworksheet platforms, which offer attractive visualizations and interactive features such as instructional videos. The researcher integrated the six core steps of PjBL into the digital media, ranging from the formulation of essential questions to

the evaluation of learning experiences. After completing the initial design, the researcher conducted an expert validation process to ensure the academic quality of both the product and the research instruments.

In terms of effectiveness, the developed science E-LKPD based on Project Based Learning (PjBL) was proven to significantly improve students' critical thinking skills. This was demonstrated by a comparison of pretest and posttest results, which showed an increase in critical thinking scores after the implementation of the E-LKPD in the learning process. Furthermore, students' active involvement in each stage of the project—from problem formulation and project planning to the presentation of results—indicates that the E-LKPD is effective in facilitating meaningful and contextual learning. The media also helps students relate the concepts of temperature and heat to real-life phenomena in their surrounding environment, making learning not only theoretical but also practical and relevant to everyday life. Therefore, the developed E-LKPD is not only valid and practical, but also effective as a learning medium to support the implementation of the Merdeka Curriculum and the strengthening of students' critical thinking skills.

Improvement of Critical Thinking Skills

The effectiveness of the developed PjBL-based science E-LKPD was examined through its implementation with 35 students of class VII-F. The results show a significant improvement in students' critical thinking skills, indicating that the E-LKPD effectively supports learning activities that promote higher-order thinking.

Table 1. Analysis of the Improvement in Students' Critical Thinking Skills

Component	**Class VII-F**			***N-Gain***	**Criteria**
	Highest	**Lowest**	**Mean**		
Pre-test	72,5	37,5	55	0,75	High
Post-test	95	80	88,75		

The data analysis in Table 1 shows an N-Gain value of 0.75, which falls into the high improvement category**.** The increase in the students' average score from 55.0 to 88.75 demonstrates that the researcher's intervention through the interactive E-LKPD was highly effective in transforming students' thinking patterns. Students no longer merely memorized definitions but were able to analyze problems and design solutions in the form of functional physical products. This effectiveness indicates that the features embedded in the E-LKPD successfully accommodated the structure of Project Based Learning (PjBL), which emphasizes learner autonomy and collaborative investigation. Therefore, the researcher concludes that this learning media is statistically effective as a powerful tool in achieving the objectives of science education.

N-Gain of Students' Critical Thinking Skills for Each Indicator

The improvement of students' critical thinking skills was analyzed across six indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The results show an overall increase in all indicators after the implementation of the PjBL-based science E-LKPD, indicating that the developed learning media effectively supports the development of higher-order thinking skills.

Table 2. N-Gain of Students' Critical Thinking Skills for Each Indicator

Critikal Thinking Indicators	**Activity**	**N**	***Mean***	***N-Gain***	**Category**
Interprestation	*Pretest*	36	2,65	0,56	Moderate
	Posttest		3,47		
Analysis	*Pretest*		1,94	0,76	High
	Posttest		3,5		
Evaluation	*Pretest*		2,17	0,87	High
	Posttest		3,75		
Inference	*Pretest*		2,33	0,53	Moderate
	Posttest		3,22		
Explanation	*Pretest*		2,79	0,73	High
	Postest		3,68		
Self-regulation	*Pretest*		2,53	0,74	High
	Postest		3,62		
Average				0,70	High

The researcher also conducted an in-depth analysis of the improvement in each critical thinking indicator to examine the distribution of the product's impact. The evaluation indicator recorded the highest N-Gain value, as the researcher designed monitoring stages that required students to continuously validate data and revise their work. On the other hand, the interpretation and inference indicators fell into the moderate category, indicating that students still require greater guidance in scientific literacy skills. Despite these variations, the overall average improvement demonstrates a positive and consistent trend across all aspects of critical thinking. This finding confirms that the developed PjBL-based E-LKPD effectively addresses all dimensions of higher-order thinking skills.

As supporting data, the researcher also collected students' responses to the use of the E-LKPD through a questionnaire. This instrument captured students' perceptions of ease of use, visual attractiveness, language clarity, and the usefulness of the media. The results showed a very high level of satisfaction, with students perceiving science learning through the E-LKPD as far more engaging than conventional lecture-based methods. Students' enthusiasm played a significant role in maintaining their engagement throughout the project cycle, which spanned several learning sessions. These positive responses complement the quantitative test data and indicate that the target users received the developed product very well.

Table 3. Students' Questionnaire Response Results

Aspect	**Percentage**	**Criteria**
Isi	85,6%	Good
Penyajian	84,9%	Good
Bahasa	84,2%	Good
Rata-rata	84,9%	Good

DISCUSSION

The effectiveness of Project-Based Learning (PjBL)–based e-LKPD was analyzed through the improvement of students' critical thinking skills after the implementation of the learning media in science instructions. The analysis was conducted by comparing students' pretest and posttest results as indicators of learning objective attainment. The results of the study in class VII-F of SMPN 2 Jember showed a significant improvement in students' critical thinking skills after the use of PjBL-based e-LKPD.

The average pretest score of students was 55, which increased to 88.75 in the posttest. The calculated N-gain score of 0.75 falls into the high category, indicating that the PjBL-based e-LKPD is effective in improving students' critical thinking skills. This improvement reflects the success of project-based learning in facilitating students' active engagement in real-world problem-solving processes that require higher-order thinking skills.

Further analysis based on critical thinking indicators revealed that all indicators improved after the learning process. The evaluation indicator achieved the highest N-gain score of 0.87 in the high category, indicating that project-based learning effectively encourages students to assess, reflect on, and evaluate learning outcomes independently. The analysis and explanation indicators also showed high-category improvements, while the interpretation and inference indicators were in the moderate category. Nevertheless, all indicators demonstrated a positive improvement trend.

These findings are consistent with the theory proposed by Sudjana (2009), which emphasizes that learning oriented toward contextual problem solving can optimize students' cognitive processes. Through activities of designing, implementing, and evaluating temperature and heat projects, students were trained to conduct data analysis, information verification, and systematic idea synthesis. Therefore, the PjBL-based e-LKPD has proven to be effective in creating a challenging and meaningful learning environment that significantly enhances students' critical thinking skills.

CONCLUSION

The effectiveness of the *Project Based Learning* (PjBL)-based e-LKPD was examined through improvements in students' critical thinking skills using pretest and posttest assessments on temperature and heat material. The results of the study conducted in class VII-F at SMPN 2 Jember revealed a significant improvement in students' learning outcomes after the implementation of the PjBL-based e-LKPD. The average pretest score of 55 increased substantially to 88.75 on the posttest, with an N-Gain value of 0.75, which falls into the high category. These findings indicate that the PjBL-based e-LKPD is effective in enhancing students' critical thinking skills. Further analysis based on critical thinking indicators showed improvements across all indicators after the learning process. The evaluation indicator achieved the highest N-Gain value of 0.87 (high category), demonstrating that project-based learning effectively encourages students to independently evaluate information and learning outcomes. The analysis and explanation indicators also showed high improvement, while interpretation and inference indicators were categorized as moderate.

Overall, the average N-Gain value of 0.70 confirms that the use of the PjBL-based e-LKPD is effective in training and improving students' critical thinking skills in science learning. In addition, the integration of project-oriented activities and digital worksheets actively engaged students in exploring real-life phenomena related to temperature and heat, such as heat transfer and temperature changes in daily life. This approach supported students in problem identification, data collection, analysis, and presentation, thereby fostering deeper conceptual understanding, independent learning, collaboration, and increased learning motivation.

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