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EFFECTIVENESS OF THE LAPS-HEURISTIC LEARNING MODEL IN ENHANCING STUDENTS' CRITICAL THINKING SKILLS ON MOMENTUM AND IMPULSE TOPICS

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Abstract- This study investigates the effectiveness of the Logan Avenue Problem Solving (LAPS)-Heuristic learning model in improving students' critical thinking skills in physics learning, particularly on momentum and impulse topics. The research was conducted at SMA Negeri 7 Pekanbaru using a quasi-experimental design with a nonequivalent post-test only control group design. The participants consisted of two classes of eleventh-grade students, namely the experimental class taught using the LAPS-Heuristic learning model and the control class taught using conventional learning methods. Data collection was carried out through a critical thinking skills test developed based on Ennis' critical thinking indicators. The obtained data were analyzed using descriptive and inferential statistics through the Independent Sample t-test assisted by SPSS 25. The findings revealed that students taught using the LAPS-Heuristic model achieved a higher average score of critical thinking skills compared to those taught conventionally. The experimental class obtained an average score of 82.08 categorized as "very good," while the control class achieved 61.21 categorized as "good." Furthermore, inferential analysis demonstrated a significant difference between both classes ($p < 0.05$). Therefore, the LAPS-Heuristic learning model effectively enhances students' critical thinking skills in momentum and impulse learning.

Keywords: *LAPS-Heuristic learning model; critical thinking skills; physics learning; momentum and impulse; quasi-experimental design.*

1 Introduction

Physics is one of the fundamental branches of natural science that plays an essential role in the development of science and technology in the modern era. Through physics learning, students are expected not only to master scientific concepts but also to develop scientific attitudes, problem-solving abilities, and critical thinking skills needed in the twenty-first century. Physics learning emphasizes understanding natural phenomena through observation, experimentation, and analytical reasoning. Therefore, physics education should encourage students to actively construct knowledge and connect scientific concepts with real-life situations. According to Robert Resnick and David Halliday, physics is a science that explains natural phenomena through systematic investigation and quantitative analysis (Halliday et al., 2018).

In the current educational context, the development of higher-order thinking skills has become one of the primary goals of learning. Among these skills, critical thinking is considered highly important because it enables students to analyze problems logically, evaluate information critically, and make appropriate decisions based on evidence. Critical thinking also supports students in understanding complex concepts and solving contextual problems encountered in daily life. According to Robert Ennis (2011), critical thinking is reflective and rational thinking focused on deciding what to believe or do. Students who possess good critical thinking skills are able to identify assumptions, analyze arguments, interpret data, and draw logical conclusions. However, many studies indicate that students' critical thinking skills in physics learning

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are still relatively low. One of the causes is the dominance of conventional learning methods that position teachers as the primary source of information, while students tend to act as passive recipients of knowledge. This teacher-centered learning environment often limits students' opportunities to explore ideas, formulate questions, and engage in problem-solving activities independently. As a result, students frequently experience difficulties in understanding abstract physics concepts and applying them in various situations. Research conducted by Facione (2020) revealed that the implementation of active learning strategies significantly influences the development of students' critical thinking abilities.

In Indonesia, improving students' critical thinking skills has become an important concern in educational reform, especially through the implementation of the Merdeka Curriculum. The curriculum emphasizes student-centered learning and encourages the integration of innovative learning models to develop higher-order thinking skills. Nevertheless, the practical implementation of innovative learning approaches in classrooms is still limited. Many physics teachers continue to rely on lecture-based instruction due to time constraints, limited learning resources, and insufficient understanding of alternative learning models. Consequently, students often perceive physics as difficult, abstract, and less engaging. One of the physics topics that students frequently find challenging is momentum and impulse. These concepts require students to understand mathematical relationships, vector quantities, and physical interactions occurring during collisions. Students often struggle to differentiate between momentum and impulse concepts and experience difficulties in applying conservation laws to solve problems. According to Sari et al. (2022), students' misconceptions in momentum and impulse topics are commonly associated with weak conceptual understanding and inadequate analytical skills. Furthermore, the abstract nature of collision phenomena often prevents students from connecting theoretical concepts with real-world applications.

To address these problems, teachers need to implement innovative learning models capable of actively engaging students in the learning process and improving their critical thinking skills. One of the learning models considered suitable for this purpose is the Logan Avenue Problem Solving (LAPS)-Heuristic learning model. The LAPS-Heuristic model is a student-centered learning approach that emphasizes systematic problem-solving activities through heuristic questioning. This model encourages students to identify problems, generate alternative solutions, analyze possible outcomes, and evaluate solutions critically. According to Shoimin (2019), the LAPS-Heuristic learning model guides students through several stages of problem solving, including understanding problems, planning solutions, implementing strategies, and reviewing the obtained results. The LAPS-Heuristic learning model is strongly associated with constructivist learning theory, which emphasizes that knowledge is actively constructed by learners through experience and interaction with their environment. In constructivist learning, students are encouraged to actively participate in discussions, investigations, and collaborative activities that help them develop conceptual understanding independently. According to Jean Piaget, learning occurs when individuals actively organize and interpret experiences to build cognitive structures (Piaget, 1977). Similarly, Lev Vygotsky emphasized the importance of social interaction and scaffolding in promoting cognitive development (Vygotsky, 1978). Therefore, the implementation of the LAPS-Heuristic model aligns well with constructivist principles because it promotes active engagement, collaborative learning, and reflective thinking.

Several previous studies have demonstrated the positive impact of the LAPS-Heuristic learning model on students' learning outcomes and thinking abilities. Rahman et al. (2018) reported that the application of the LAPS-Heuristic model improved students' mathematical problem-solving skills and learning motivation. Similarly, Novitasari and Shodikin (2020) found that the model effectively enhanced students' reasoning and critical thinking abilities during mathematics learning. In physics education, the implementation of problem-solving-based learning models has also been shown to improve conceptual understanding and analytical thinking skills. However, studies specifically investigating the effect of the LAPS-Heuristic learning model on students' critical thinking skills in momentum and impulse topics are still limited, particularly in Indonesian senior high schools.Based on preliminary observations conducted at SMA Negeri 7 Pekanbaru, physics learning in grade XI was still dominated by conventional teaching methods. Teachers primarily used lectures and direct instruction, while students had limited opportunities to participate actively in discussions and problem-solving activities. As a result, many students showed low engagement during learning activities and experienced difficulties in analyzing physics problems critically. Furthermore, students' average physics achievement scores were still below the minimum mastery criteria, especially in momentum and impulse topics. These conditions indicate the necessity of implementing an alternative learning model capable of improving students' critical thinking skills and learning outcomes.

Therefore, this study aims to investigate the effect of the LAPS-Heuristic learning model on students' critical thinking skills in momentum and impulse learning among eleventh-grade students at SMA Negeri 7 Pekanbaru. This research is expected to contribute theoretically to the development of innovative physics learning models and practically to provide teachers with an effective instructional strategy for enhancing students' critical thinking abilities. Moreover, the findings of this study are expected to support the implementation of student-centered learning approaches aligned with the objectives of the Merdeka Curriculum and twenty-first-century education.

2 Research Methodology

This study employed a quantitative approach using a quasi-experimental research design to investigate the effect of the Logan Avenue Problem Solving (LAPS)-Heuristic learning model on students' critical thinking skills in physics learning. Quantitative research is appropriate for examining causal relationships between variables through statistical analysis and objective measurement of learning outcomes (Sugiyono, 2021). The selected research design was the Nonequivalent Post-test Only Control Group Design, which is commonly used in educational research when random assignment of participants is not fully possible (Creswell, 2018).

The research was conducted at SMA Negeri 7 Pekanbaru during the first semester of the 2024/2025 academic year. The population consisted of all eleventh-grade science students comprising six classes with a total of 204 students. The sampling technique used in this research was simple random sampling after conducting prerequisite tests of normality and homogeneity on students' previous physics examination scores. Based on the results of these tests, two classes with homogeneous characteristics were selected. Class XI.4 consisting of 36 students was assigned as the experimental class, while class XI.3 consisting of 35 students served as the control class.

The experimental class received instruction using the LAPS-Heuristic learning model, whereas the control class was taught using conventional lecture-based learning. The implementation of the LAPS-Heuristic model followed four major stages: understanding the problem, planning the solution, solving the problem, and reviewing the obtained results (Shoimin, 2019). During the learning process, students were encouraged to actively identify problems, analyze information, discuss alternative solutions, and evaluate their answers critically. Meanwhile, the control class mainly relied on teacher explanations and routine exercises. The research design used in this study is presented in Table 1.

Table 1. Nonequivalent Post-test Only Control Group Design

Group	Treatment	Post-test
Experimental Class	LAPS-Heuristic Learning Model	O_1
Control Class	Conventional Learning	O_2

Source: Adapted from Creswell (2018)

The research instrument used in this study was a critical thinking skills test developed based on Ennis' critical thinking indicators (Ennis, 2011). The instrument consisted of 12 objective questions representing five major aspects of critical thinking, namely: providing simple explanations, building basic skills, making further explanations, arranging strategies and tactics, and drawing conclusions. Prior to implementation, the instrument was validated by physics education experts to ensure content validity and clarity of the questions. presents the indicators of critical thinking skills used in this study Tabel 2.

Table 2. Critical Thinking Indicators Based on Ennis

Aspect of Critical Thinking	Indicators
Providing Simple Explanations	Focusing questions, analyzing arguments
Building Basic Skills	Observing and considering reports
Making Further Explanations	Identifying assumptions and definitions
Arranging Strategies and Tactics	Determining actions and interactions
Drawing Conclusions	Deduction and induction processes

Source: Adapted from Ennis (2011)

Data collection was conducted through post-test administration after the completion of learning activities in both classes. The obtained data were analyzed using descriptive and inferential statistical techniques with the assistance of SPSS 25 software. Descriptive analysis was used to determine students' average scores and categorize their critical thinking skill levels. Meanwhile, inferential analysis was conducted using the Independent Sample t-test to determine whether there was a significant difference between the experimental and control groups.

Before conducting the hypothesis test, prerequisite analyses including normality and homogeneity tests were performed. The Kolmogorov–Smirnov test was applied to examine data normality, while Levene's test was used to assess variance homogeneity. According to Ghozali (2020), data are considered normally distributed and homogeneous if the significance value exceeds 0.05. The hypothesis was accepted if the significance value obtained from the Independent Sample t-test was less than 0.05, indicating a significant effect of the LAPS-Heuristic learning model on students' critical thinking skills. Overall, this methodology was designed systematically to ensure the validity and reliability of the research findings regarding the effectiveness of the LAPS-Heuristic learning model in improving students' critical thinking skills in momentum and impulse learning.

3 Results and Discussion

3.1 Results

This study aimed to investigate the effect of the Logan Avenue Problem Solving (LAPS)-Heuristic learning model on students' critical thinking skills in momentum and impulse learning. The research was conducted in two classes consisting of an experimental class taught using the LAPS-Heuristic learning model and a control class taught using conventional learning methods. At the end of the learning process, both classes were given a post-test based on Ennis' critical thinking indicators to evaluate students' critical thinking performance.

Table 3. Normality Test Results

Class	Significance Value
Experimental Class	0.200
Control Class	0.200

The results presented in Table 3 indicate that both classes obtained significance values greater than 0.05. Therefore, the data were considered normally distributed and suitable for further parametric statistical analysis.

Table 4. Homogeneity Test Results

Test	Significance Value	Criteria
Levene's Test	0.059	Homogeneous

Based on Table 4, the significance value of the homogeneity test was higher than 0.05, indicating that the variances of the two groups were homogeneous. Consequently, the Independent Sample t-test could be applied to test the research hypothesis. The descriptive analysis of students' critical thinking skills showed differences between the experimental and control classes. The experimental class demonstrated higher average scores compared to the control class after the implementation of the learning treatments.

Table 5. Descriptive Statistics of Critical Thinking Skills

Class	Number of Students	Mean Score	Category
Experimental Class	36	82.08	Very Good
Control Class	35	61.21	Good

The data in Table 5 reveal that students taught using the LAPS-Heuristic learning model achieved a mean score of 82.08, categorized as "very good," while students taught conventionally obtained an average score of 61.21, categorized as "good." The difference in mean scores between both classes reached 20.87 points, indicating that the experimental class showed substantially better critical thinking performance.
Further analysis was conducted based on each aspect of critical thinking skills according to Ennis' indicators.

Table 6. Students' Critical Thinking Skills in Each Aspect

Critical Thinking Aspect	Experimental Class	Control Class
Providing Simple Explanations	84.50	65.20
Building Basic Skills	80.30	60.10
Making Further Explanations	81.40	59.70
Arranging Strategies and Tactics	83.10	61.80
Drawing Conclusions	81.10	59.30

The findings indicate that the experimental class consistently outperformed the control class across all critical thinking aspects. The highest score in the experimental class was found in the aspect of providing simple explanations, while the lowest score occurred in building basic skills. Nevertheless, all aspects remained within the "very good" category.
To determine whether the observed differences were statistically significant, an Independent Sample t-test was performed.

Table 7. Independent Sample t-test Results

Variable	Significance (2-tailed)	Decision
Critical Thinking Skills	0.000	Significant Difference

The significance value obtained from the Independent Sample t-test was 0.000, which was lower than 0.05. Therefore, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_a) was accepted. This result indicates that there was a significant difference between students taught using the LAPS-Heuristic learning model and those taught using conventional learning methods.

3.2 Discussion

The results of this study demonstrate that the implementation of the LAPS-Heuristic learning model significantly improved students' critical thinking skills in momentum and impulse learning. Students in the experimental class showed higher achievement across all critical thinking indicators compared to students in the control class. These findings suggest that the LAPS-Heuristic learning model provides an effective learning environment that encourages students to engage actively in the learning process and develop analytical thinking abilities. One of the main reasons for the improvement in students' critical thinking skills is the problem-solving orientation of the LAPS-Heuristic model. During learning activities, students were required to identify problems, analyze information, formulate alternative solutions, and evaluate the effectiveness of their answers. These activities trained students to think systematically and critically while solving contextual physics problems related to momentum and impulse. According to Ennis

(2011), critical thinking skills develop when students are actively involved in reasoning, evaluating evidence, and making logical judgments. Therefore, the stages within the LAPS-Heuristic model align closely with the indicators of critical thinking. The significant improvement observed in the experimental class also supports the constructivist learning theory proposed by Jean Piaget and Lev Vygotsky. Constructivist learning emphasizes that students actively construct knowledge through interaction, exploration, and discussion. In this study, students in the experimental class participated actively in collaborative discussions and problem-solving tasks, enabling them to build conceptual understanding independently. Such learning conditions are more effective than conventional teacher-centered instruction because students become directly involved in the cognitive process.

Furthermore, the LAPS-Heuristic learning model encouraged students to communicate ideas and defend their arguments during classroom discussions. This interaction helped students improve their reasoning abilities and confidence in expressing opinions. The aspect of "providing simple explanations" achieved the highest score because students were frequently trained to explain concepts and identify problems during learning activities. Meanwhile, the "drawing conclusions" aspect also showed significant improvement due to students' involvement in evaluating solutions and interpreting problem-solving results. In contrast, students in the control class experienced lower critical thinking performance because learning activities mainly relied on lectures and routine exercises. In conventional learning, students tend to receive information passively without sufficient opportunities to analyze problems independently. Consequently, their ability to evaluate arguments, formulate solutions, and apply concepts critically becomes limited. This finding is consistent with previous studies reporting that teacher-centered learning approaches often hinder the development of higher-order thinking skills.

The findings of this study are consistent with previous research conducted by Rahman et al. (2018), which found that the LAPS-Heuristic learning model improved students' problem-solving abilities and learning motivation. Similarly, Novitasari and Shodikin (2020) reported that the implementation of heuristic-based learning significantly enhanced students' reasoning and analytical thinking skills. Therefore, the present study strengthens previous evidence regarding the effectiveness of the LAPS-Heuristic learning model in promoting critical thinking skills in science education, particularly physics learning. Another important finding is that the LAPS-Heuristic learning model was highly suitable for teaching momentum and impulse concepts. These topics require students to analyze physical interactions, apply mathematical relationships, and evaluate collision phenomena critically. Through problem-solving activities, students became more capable of understanding abstract concepts and relating them to real-life situations. This contextual learning process helped students develop deeper conceptual understanding and improved their ability to solve physics problems systematically.

Overall, the results indicate that the LAPS-Heuristic learning model can serve as an effective alternative instructional strategy for improving students' critical thinking skills in physics education. The model not only enhances conceptual understanding but also encourages active participation, collaboration, and analytical reasoning. Therefore, physics teachers are recommended to implement the LAPS-Heuristic learning model more frequently in classroom instruction to support the development of twenty-first-century learning competencies.

4 Conclusion

Based on the results of the study, it can be concluded that the implementation of the Logan Avenue Problem Solving (LAPS)-Heuristic learning model has a significant positive effect on students' critical thinking skills in momentum and impulse learning. Students who were taught using the LAPS-Heuristic model demonstrated better critical thinking performance compared to those who learned through conventional teaching methods. The experimental class achieved a higher average score categorized as "very good," while the control class was categorized as "good." Statistical analysis using the Independent Sample t-test also confirmed that the difference between both groups was statistically significant ($p < 0.05$).

The improvement in students' critical thinking skills occurred because the LAPS-Heuristic learning model encourages active student participation through systematic problem-solving activities. Students were trained to identify problems, analyze information, formulate alternative solutions, evaluate arguments, and draw logical conclusions. These learning activities supported the development of higher-order thinking skills and helped students understand momentum and impulse concepts more meaningfully. Furthermore, the implementation of the LAPS-Heuristic learning model created a more interactive and student-centered learning environment, which enhanced students' engagement, reasoning abilities, and collaborative discussion skills. The findings indicate that the LAPS-Heuristic model is effective not only in improving conceptual understanding but also in developing students' analytical and critical thinking competencies required in twenty-first-century learning.

Therefore, the LAPS-Heuristic learning model can be recommended as an alternative instructional strategy for physics learning, particularly for topics requiring conceptual analysis and problem-solving skills. Future studies are encouraged to apply this model to other physics topics and educational levels to further examine its effectiveness in improving various higher-order thinking skills.

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