

Effectiveness of Laps-Heuristic Learning With An Open-Ended Approach on Critical Thinking Ability

Baiduri^{1*}, Oktavia Kurniawati Putri¹, & Alfiani Athma Putri Rosyadi¹

¹Department of Mathematics Education, Universitas Muhammadiyah Malang, Indonesia

*Corresponding email: baiduriumm@gmail.com

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Abstract: The objective of this study is to assess the efficacy of LAPS-Heuristic learning, coupled with an Open-Ended instructional approach, in enhancing the critical thinking skills of seventh-grade students in a middle school setting. The research employs an experimental methodology with a quantitative framework, specifically utilizing a posttest-only control group design. The study participants consist of seventh-grade students from classes VII A and VII C at SMP MTs Muhammadiyah 1 Malang during the 2022/2023 academic year. Data collection is achieved through a written critical thinking skills assessment. Analysis of the critical thinking ability test results is conducted using the Independent Sample T-test. The findings reveal significant disparities in the critical thinking abilities of seventh-grade students between the experimental group utilizing LAPS-Heuristic learning with an Open-Ended approach and the control group employing conventional teaching methods. Thus, it can be concluded that LAPS-Heuristic learning, when combined with an Open-Ended approach, proves to be an effective strategy for enhancing students' critical thinking skills.

Keywords: critical thinking, open-ended, laps-heuristic

Abstrak: Tujuan dari penelitian ini adalah untuk mengevaluasi efektivitas pembelajaran LAPS-Heuristic dengan pendekatan Open-Ended dalam meningkatkan kemampuan berpikir kritis siswa kelas VII SMP. Metode penelitian ini menggunakan pendekatan eksperimental dengan pendekatan kuantitatif dan desain yang digunakan adalah posttest-only control group. Subjek penelitian terdiri dari siswa kelas VII A dan VII C di SMP MTs Muhammadiyah 1 Kota Malang selama tahun akademik 2022/2023. Pengumpulan data dilakukan melalui tes tertulis kemampuan berpikir kritis. Analisis data dari tes kemampuan berpikir kritis menggunakan uji Independent Sample T-test. Hasil penelitian menunjukkan perbedaan yang signifikan dalam kemampuan berpikir kritis siswa kelas VII antara kelompok eksperimen yang menggunakan pembelajaran LAPS-Heuristic dengan pendekatan Open-Ended dan kelompok kontrol yang menggunakan metode pembelajaran konvensional. Oleh karena itu, dapat disimpulkan bahwa pembelajaran LAPS-Heuristic dengan pendekatan Open-Ended terbukti efektif dalam meningkatkan kemampuan berpikir kritis siswa.

Kata kunci: berpikir kritis, open-ended, laps-heuristic.

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■ INTRODUCTION

In the era of the Fourth Industrial Revolution (Revolution 4.0), it is imperative for students to possess a range of 21st-century skills, including critical thinking, problem-solving, creativity, innovation, and collaboration (Chasanah, 2019). Educators and prospective teachers in the 21st century are expected to possess the skills necessary to nurture and support students' readiness, curiosity, problem-solving capabilities, and critical thinking (Kuloglu & Karabekmez, 2022). Indeed, aligning with current research trends, contemporary education places a significant emphasis on fostering 21st-century skills, with a primary focus on the cultivation and enhancement of critical thinking abilities (Sarwanto et al., 2021; Setiana & Purwoko, 2020; J. Zhou et al., 2015). Critical thinking skills play a pivotal role in enabling students to think logically and are thus of paramount importance within the realm of education (Fitriani et al., 2020). The definition of critical thinking itself refers to a cognitive process adopted by individuals, characterized by a propensity to seek out information, evidence, and facts (Ouhibu & Nawel, 2022).

The observations conducted by researchers at MTs Muhammadiyah 1 Malang City during the learning process have revealed that students often promptly apply the mathematical formulas they've learned when solving problems. However, when presented with different or novel questions, many students encounter confusion in problem-solving. These findings underscore the existence of students who lack adequate critical thinking skills, a common challenge encountered in mathematics education. In the context of mathematics education, students often struggle to comprehend and solve problems due to their limited critical thinking skills (Lestari, 2021). In accordance with the findings of (Nofriansyah et al., 2018), the contemporary education landscape faces various challenges in the learning process,

one of which is the continued use of traditional lecture-based teaching methods and the existence of inappropriate curricula. Consequently, the development of critical thinking skills has gained substantial attention both domestically and internationally, becoming a prominent of concern among experts and scholars (Z. Zhou, 2018).

The use of conventional learning still focuses on the teacher when explaining the material being taught. Teachers can use a learning style that focuses on students so that they can involve students in solving problems and finding solutions that will be used (Kaitera & Harmoinen, 2022). Certainly, the selection of a learning method plays a significant role in shaping and influencing the process of unlocking and maximizing students' learning potential (Pho et al., 2021). Various teaching methods, including LAPS-Heuristic learning, have been recognized as effective tools in enhancing students' critical thinking abilities (Kamid et al., 2021; Selvia et al., 2017).

LAPS-Heuristic learning is an instructional approach that centers around students and their active engagement in problem-solving tasks. It specifically targets problems that have multiple potential solutions. This approach utilizes heuristic questions, which can be posed verbally or in written form, to guide students through the process of solving the presented problems. According to (Tambunan, 2018) heuristics in mathematics learning use 4 stages: understanding the problem, students are directed to understand concepts in mathematical language, finding a solution, students are able to make a solution plan, implementing a solution plan, students are able to make conclusions, and re-checking, students check the step-by-step conclusions from the results obtained. LAPS-Heuristic learning is an educational model derived from the Problem Solving learning model, further emphasizing its problem-solving focus and heuristic-based approach (Nofiyanti & Mohammad Zaky Tatsar, 2023)

LAPS-Heuristic learning has objectives in the learning process, one of which is to train students to get used to thinking critically and analyzing a problem that occurs, being able to train students' courage and sense of responsibility in facing problems that occur, and 3) being able to know students in mastering the material that has been learned (Suparlan, 2022). The advantages of implementing LAPS-Heuristic learning are: it can increase curiosity, it can apply the knowledge gained, it invites students to have procedures for solving problems (Purba & Sirait, 2017). The disadvantage of implementing LAPS learning is that students need time to complete it, students who do not have interest do not try to solve problems.

Traditional teaching approaches generally focus on learning mathematical facts and procedures. Teachers who can develop innovative and innovative learning require a learning approach that is in accordance with LAPS-Heuristic learning in improving students' critical thinking, one of which is the Open-Ended approach (Bayarcal & Tan, 2023). Open-Ended approach where students work individually or in groups are expected to be able to solve the problems given with a unique method (Munroe, 2015). The problems used have the possibility of more than one correct answer or the possibility of more than one way of solving (Kwon et al., 2006). The application of LAPS-Heuristic learning with an Open-Ended approach can be used as a new innovation in the open problem learning style which is expected to improve students' critical thinking (Ridha, 2017).

Previous research that has implemented LAPS-Heuristic learning is related to learning outcomes in problem solving abilities, mathematical creative abilities, and improving critical thinking skills (Anggrianto et al., 2016; Dewi Astuti, 2020; Kamid et al., 2021). Several studies have conducted research using an Open-Ended approach, one of which is related to

developing student proficiency in geometric material, to evaluate mathematical thinking methods, constructing knowledge in Open-Ended learning (Dugay & Pasia, 2023; Pott & Nortjé, 2021; Ueda et al., 2014)

From the research that has been carried out in the application of learning models and approaches, several researchers have conducted research to improve students' critical thinking skills, one of which is related to the influence of idea discussion activities in Design Thinking; mathematics learning achievement; medium and high influence on gender, choice of subjects and type of management (Buphate & Esteban, 2022; Devika & Soumya, 2016; Merma-Molina et al., 2022). Several studies that have been conducted have not explicitly linked the LAPS-Heuristic learning model with the Open-Ended approach to students' critical thinking abilities. Indeed, the primary focus of this research is to investigate and determine the effectiveness of LAPS-Heuristic learning when combined with an Open-Ended approach in enhancing the critical thinking abilities of seventh-grade junior high school students.

■ METHODS

Types and Research Approaches

This research employs an experimental research design, specifically utilizing a quantitative approach. The research design used is True Experimental Design, which is characterized by the random assignment of subjects to both the experimental and control groups (Cohen et al., 2017), allowing for a rigorous comparison between the two groups to assess the impact of LAPS-Heuristic learning with an Open-Ended approach on critical thinking abilities

The choice of a Posttest Only Control Group design is appropriate for your research since it involves conducting the study with the experimental group and the control group in two

separate sessions, each comprising two meetings. This design allows for efficient data collection and is particularly suited for studying the impact of an intervention, such as LAPS-Heuristic learning with an Open-Ended approach, on critical thinking abilities by comparing the outcomes between the two groups after the intervention has taken place (Usman & Faradina, 2023).

Table 1. Research design

| No. | Aspect | Score |
|-------|--------|-------|
| R_1 | X | O_1 |
| R_2 | | O_2 |

Informasi:

R_1 : The Experimental group was taken randomly

R_2 : The Control group was taken randomly

X : Treatment (LAPS-Heuristic Learning with Open-Ended approach)

O_1 : Test for Experimental Group

O_2 : Test for Control Group

Research Subjects

The study used class VII students at MTs Muhammadiyah 1 Malang City in the 2022/2023

school year. Then using 2 classes, namely the experimental class (VIIC) which will be given treatment, namely LAPS-Heuristic learning with an Open-Ended approach, while the control class (VIA) uses conventional learning. The number of subjects used in this research was 40 students. LAPS-Heuristic learning with an Open-Ended approach is learning that will use LAPS-Heuristic learning steps in which there are elements of the Open-Ended approach. The subjects in both the experimental and control classes possessed the same level of initial mathematical proficiency. This is evident from the homogeneity test results presented in Table 2, based on the mathematics scores from the end-of-semester examination for the second semester of the academic year 2022/2023.

Based on the information provided, it seems that the significance level (Sig.) in Table 2 for both the experimental class and the control class is 0.051, which is slightly higher than the conventional significance level of 0.05. This suggests that there may not be a statistically significant difference between the two classes in terms of their initial data for end-of-semester test

Table 2. Test of homogeneity of variance

| | Levene Statistics | df1 | df2 | Sig. |
|--------------------------------------|-------------------|-----|--------|------|
| Based on Means | 4.072 | 1 | 38 | .051 |
| Based on Median | 1.145 | 1 | 38 | .291 |
| Based on Median and with adjusted df | 1.145 | 1 | 37.863 | .291 |
| Based on trimmed mean | 3.497 | 1 | 38 | .069 |

grades. Consequently, it can be concluded that the initial data for the end-of-semester test grades for class VII in both the experimental and control classes originated from homogeneous conditions, meaning that the two groups had similar starting points or characteristics regarding their test grades.

Data and Its Collections

The data in this study encompass both students' mathematical abilities and their critical thinking skills. Mathematical abilities were gathered from the results of the end-of-semester examination for the second semester of the academic year 2022/2023 and were employed

to assess the homogeneity between the two classes, namely the control and experimental groups. Critical thinking skill data were essential to evaluate the effectiveness of LAPS-Heuristic learning with an Open-Ended approach and were collected through written tests. These assessments were conducted once, upon completion of the taught material.

Research Instrument

The instrument employed in this research consists of a test comprised of 5 test items. This test was developed by the researchers and is designed based on critical thinking indicators. The specific test indicators include: Problem Formulation: Assessing students' ability to translate problems into mathematical concepts. Strategy and Tactic Development: Evaluating students' capacity to identify relevant concepts related to the problem, enabling them to devise problem-solving strategies. Argument Analysis: Measuring students' proficiency in critically assessing the validity of arguments. 4) Conclusion Drawing: Examining students' ability to draw meaningful conclusions from the results obtained. The test instrument underwent validation by Mathematics Education Lecturers and Middle School Mathematics Teachers, with the results confirming its validity for use in this study.

Certainly, here's an example of a test question. *Problem*: Mr. Agus is tasked with installing a roof for a rectangular swimming pool with a perimeter of 80 meters. The swimming pool roof has a maximum length of 35 meters and a minimum length of 25 meters, along with a maximum width of 20 meters and a minimum width of 5 meters. The height and width of the pool roof must both be integers. Determine the dimensions of the swimming pool roof that Mr. Agus should install, and calculate the area of the swimming pool roof. Please provide a clear explanation for your choices.

Data Analysis

The data utilized for this study consisted of scores from a critical thinking ability test. These scores were subsequently subjected to analysis using the Independent Sample t-test to determine whether the experimental class exhibited superior performance compared to the control class. Before conducting the Independent Sample T-test, certain prerequisites needed to be met. The requirement was that the data should exhibit a normal distribution. The normality of the data was assessed using the Shapiro-Wilk Normality test. Additionally, data normality if the probability sig > 0.05 . All analysis was carried out using SPSS 22 Software. The decision-making process based on the t-test involved the following criteria:

H_0 (null hypothesis) is accepted if the probability sig (2-tailed) ≥ 0.05 .

H_0 is rejected if the probability sig (2-tailed) < 0.05 .

In essence, accepting implies that there is no significant difference between the experimental class and the control class, while rejecting suggests that there is indeed a significant difference between the two groups.

■ RESULTS AND DISCUSSION

The effectiveness of employing LAPS-Heuristic learning with an Open-Ended approach in enhancing students' critical thinking abilities is evident by examining the average scores on the critical thinking ability tests for both the experimental and control groups, as presented in Table 3.

Based on the data presented in Table 3, it is evident that the mean score for the experimental class is 74.800, while the control class has a mean score of 65.250. Additionally, the median score for the experimental class is 73.800, whereas the control class has a median score of 64.00. These findings lead to the conclusion that, on average, students in the experimental class, who were

Table 3. Descriptive statistic of experimental class and control class

| | Eksperimen | Kontrol |
|--------------------|-------------------|----------------|
| N | Valid | 20 |
| | Missing | 20 |
| Mean | 74.8000 | 65.2500 |
| Std. Error of Mean | 1.56205 | 1.49363 |
| Median | 73.8000 | 64.0000 |
| Mode | 69.00 | 61.00 |
| Std. Deviation | 6.98570 | 6.67970 |
| Variance | 48.800 | 44.618 |
| Range | 25.00 | 22.00 |
| Minimum | 64.00 | 56.00 |
| Maximum | 89.00 | 78.00 |

exposed to LAPS-Heuristic learning with an Open-Ended approach, have achieved higher critical thinking ability scores compared to students in the control class who received conventional teaching methods.

The data collected in this study aligns with the observations made during the learning process in both classes. This consistency is in accordance with the findings of previous research (Ningsih & Husaini, 2020), one of the factors contributing to the development of students' critical thinking skills is their increased level of engagement, as

evidenced by their active participation in explaining their answers, even when those answers differ, and their ability to tackle problems without hesitation. In contrast, within the control class, students often experience boredom and encounter challenges in comprehending the materials presented by the teacher. Consequently, they exhibit a reduced capacity for critical thinking. A visual representation of the comparison of critical thinking skills between the experimental class and the control class for each indicator can be found in Figure 1.

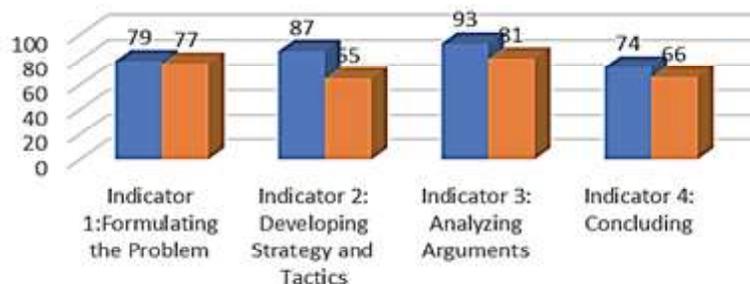


Figure 1. Comparison of critical thinking ability for each indicator in the experimental class and the control class

Based on Figure 1, it can be inferred that the experimental class, which employed the LAPS-Heuristic approach with an Open-Ended

method, yielded the following results: In indicator 1, students are adept at articulating the problem presented and formulating it into a mathematical

model, achieving an average score of 79, and in Indicator 2, students excel at devising appropriate problem-solving strategies based on their knowledge, attaining an average score of 87. Students are able to analyze the truth of an argument based on mathematical principles on indicator 3 with obtaining an impressive score of 93, as well as indicator 4, where students are able to draw conclusions from the steps that have been determined to get a value of 74. Whereas it is known that in the control class that uses conventional learning indicator 1 it gets a result of 77, indicator 2 gets a score of 65, as well as indicator 3 of 81. These findings highlight the notable differences in critical thinking performance between the experimental class, utilizing LAPS-Heuristic learning with an Open-Ended approach, and the control class, which relies on conventional learning methods.

The disparities in outcomes, influenced by the utilization of different learning models, clearly demonstrate that the experimental class outperforms the control class. This disparity can be attributed to the active engagement of students in the learning process, particularly in the

experimental class. Indeed, in the process of learning mathematics, it is imperative to cultivate and encourage reasoning, analysis, evaluation, and interpretation of thoughts among students. These cognitive skills are essential for students to effectively comprehend and solve mathematical problems (Kurniawati & Ekayanti, 2020). The LAPS-Heuristic learning model, coupled with an Open-Ended approach, places students at the center of the learning process. It involves presenting open-ended problems that require students to engage in active thinking and explore multiple alternative solutions. This pedagogical approach is employed to enhance students' critical thinking skills.

Subsequently, an inference analysis was conducted to assess the effectiveness of the critical thinking skills test after implementing LAPS-Heuristic learning with an Open-Ended approach. To perform the t-test, it is essential for the data to conform to a normal distribution, and therefore, a normality test is a necessary prerequisite. The results of the normality test, conducted using the Shapiro-Wilk test and the SPSS 22 application, are presented in Table 4.

Table 4. Test of normality

| | Class | Shapiro-Wilk | | |
|---------------------------|------------------|--------------|----|------|
| | | Statistics | Df | Sig. |
| Critical Thinking Ability | Experiment Class | .951 | 20 | .378 |
| | Control Class | .939 | 20 | .225 |

Based on the information provided in Table 4, it is evident that the significance value for both classes is greater than 0.05. Therefore, it can be concluded that the test scores for students' critical thinking skills in both classes follow a normal distribution.

Subsequently, the mean difference test was performed using an independent sample t-test, facilitated by SPSS Statistics 22 software. The

specific results of the t-test are presented in Table 5.

Based on the information provided in Table 5, it is evident that the test results for the difference in mean critical thinking ability scores, as determined by the t-test for Equality of Means, yielded a t-value of 4.419 with a significance level of 0.000, which is less than the significance threshold of 0.05. This indicates a statistically

Table 5. Independent sample t-test

| | | t-test for Equality of Means | | | | |
|---------------------------|-----------------------------|------------------------------|--------|-----------------|---------------------------|------------------|
| | | t | df | Sig. (2-tailed) | Mean (2-Differencestd. s) | Error Difference |
| Critical Thinking Ability | Equal variances assumed | 4.419 | 38 | .000 | 9.55000 | 2.16123 |
| | Equal variances not assumed | 4.419 | 37.924 | .000 | 9.55000 | 2.16123 |

significant difference between the experimental and control classes. Consequently, it can be concluded that the implementation of LAPS-Heuristic learning with an Open-Ended approach effectively enhanced the critical thinking skills of seventh-grade junior high school students.

The results of this study indicate that the student's critical thinking skills in the experimental class are better than the control class. The results of the test in the experimental class used LAPS-Heuristic learning with an average of 74.800, while in the control class with conventional learning, it was 65.2500. The findings of the t-test calculation, which reveal a significant difference between the experimental class and the control class, align with the outcomes of prior research conducted in this area (Azis & Fadillah, 2022), LAPS-Heuristic learning which is greater than students taught with conventional learning. These results provide further support for the effectiveness of the LAPS-Heuristic learning with an Open-Ended approach in enhancing students' critical thinking skills (Sadat & Harisuddin, 2023; Anggrianto et al., 2016; Laksono, 2020), so that students are able to formulate problems, develop strategies and tactics, analyze arguments, and draw conclusions correctly in learning mathematics.

Utilizing the Open-Ended approach in mathematics education has been shown to encourage critical thinking, collaborative teamwork, and effective logical and argumentative

communication (Mustamiroh et al., 2019; Ninomiya & Pusri, 2015). Supporting this research, a study found that mathematics learning using the LAPS-Heuristic approach with an Open-Ended approach yielded superior results compared to conventional teaching methods (Ridha, 2017).

In the experimental class, students demonstrated their critical thinking abilities through problem-solving. Some students exhibited well-structured critical thinking, aligning with predetermined indicators, while others showed commendable proficiency. In contrast, the control class exhibited discrepancies in the critical thinking abilities of certain students concerning the strategies employed and their ability to draw conclusions. The learning approach emphasized guiding students in formulating problems, devising strategies and tactics for analyzing predetermined arguments, and subsequently reaching informed conclusions. These findings align with the research which suggests that implementing LAPS-Heuristics in education simplifies problem-solving and nurtures the critical thinking skills of students (Ningsih & Husaini, 2020).

■ CONCLUSIONS

This study investigated the effectiveness of LAPS-Heuristic learning with an Open-Ended approach in improving the critical thinking skills of seventh-grade junior high school students. The

research employed an experimental design and utilized critical thinking ability tests as the primary data source. The research data demonstrated that students in the experimental class, exposed to LAPS-Heuristic learning with an Open-Ended approach, achieved higher average critical thinking ability scores compared to students in the control class, who received conventional teaching methods. The significant differences in critical thinking ability scores between the two classes were confirmed through statistical analysis, specifically the independent sample t-test, which revealed a statistically significant difference in mean scores. The results of this study support the notion that LAPS-Heuristic learning with an Open-Ended approach is an effective instructional method for enhancing students' critical thinking skills of junior high school students. The findings support the notion that student-centered learning, active problem-solving, and open-ended questioning can have a substantial positive impact on students' ability to think critically.

Indeed, the results of this research highlight the importance of creating an educational environment that actively cultivates and enhances students' critical thinking skills. Such an environment equips students with the necessary abilities to navigate and succeed in today's complex and ever-changing world. By implementing the suggested strategies and recommendations, educational institutions can play a pivotal role in preparing students to think critically, solve problems effectively, and excel in various aspects of their lives, both within and beyond the classroom. These skills are not only essential for academic success but also for their future roles as informed and adaptable individuals in an evolving society and workforce.

■ REFERENCES

- Anggrianto, D., Churiyah, M., & Arief, M. (2016). *Meningkatkan keterampilan berpikir kritis menggunakan model pembelajaran logan avenue problem solving (laps)-heuristic* [improving critical thinking skills using learning model logan avenue problem solving (laps)-heuristic]. *Journal of Education and Practice*, 7(9), 128–136.
- Azis, Z., & Fadillah, J. H. (2022). *Pengaruh penggunaan model pembelajaran avenue logan problem solving (laps)-heuristic terhadap kemampuan pemecahan masalah matematis siswa smp muhammadiyah 1 medan* [the effect of using the avenue logan problem solving (laps)-heuristic learning model on students' mathematic problem-solving ability smp muhammadiyah 1 medan]. *EduMatika: Jurnal MIPA*, 2(3), 46–53. <https://doi.org/10.56495/emju.v2i3.233>
- Bayarcal, G. C., & Tan, D. A. (2023). Students' achievement and problem-solving skills in mathematics through open-ended approach. *American Journal of Educational Research*, 11(4), 183–190. <https://doi.org/10.12691/education-11-4-2>
- Buphate, T., & Esteban, R. H. (2022). Using ideation discussion activities in design thinking to develop efl students' speaking and critical thinking abilities. *LEARN Journal: Language Education and Acquisition Research Network*, 15(1), 682–708.
- Chasanah, A. N. (2019). *Model pembelajaran pertumbuhan kognitif untuk meningkatkan keterampilan berpikir kritis siswa* [cognitive growth learning model to improve the students' critical thinking skills]. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 4(2), 112–123. <https://doi.org/10.23917/jramathedu.v4i2.8127>
- Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education*. In *Research Methods in Education*. <https://doi.org/10.1080/00131801.2017.1381111>

- doi.org/10.4324/9781315456539
- Devika, R., & Soumya, P. R. (2016). Research papers critical thinking ability of higher secondary school. *I-Manager's Journal on School Educational Technology*, 12(1), 39–44.
- Dewi Astuti, E. S. (2020). *Pengaruh model pembelajaran laps(logan avenue problem solving) heuristik terhadap kemampuan pemecahan masalah matematis siswa sma negeri 1 air joman* (the influence of the laps (logan avenue problem solving) heuristic learning model on the mathematical problem solving ability of air joman 1 public high school students). *Jurnal Pendidikan*, 4(1), 275.
- Dugay, P. M. V., & Pasia, A. E. (2023). International journal of open-access, interdisciplinary & new educational discoveries of etcor educational research center (ijoined etcor) examining the relationship between job satisfaction and personality traits among professors in a public university. *Educational Research Center Philippines*, 388–398.
- Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). PBLPOE: A learning model to enhance students' critical thinking skills and scientific attitudes. *International Journal of Instruction*, 13(2), 89–106. <https://doi.org/10.29333/iji.2020.1327a>
- Kaitera, S., & Harmoinen, S. (2022). Developing mathematical problem-solving skills in primary school by using visual representations on heuristics. *Lumat*, 10(2), 111–146. <https://doi.org/10.31129/LUMAT.10.2.1696>
- Kamid, K., Marzal, J., Syaiful, S., Remalisa, Y., & Dewi, R. K. (2021). *Pengaruh model pembelajaran laps-heuristic terhadap kemampuan pemecahan masalah siswa* [the effect of the laps-heuristic learning model on students' problem solving abilities]. *Journal of Educational Science and Technology (EST)*, 7(1), 9–17. <https://doi.org/10.26858/est.v7i1.14670>
- Kuloglu, A., & Karabekmez, V. (2022). The relationship between 21st-century teacher skills and critical thinking skills of classroom teacher. *International Journal of Psychology and Educational Studies*, 9(1), 91–101. <https://doi.org/10.52380/ijpes.2022.9.1.551>
- Kurniawati, D., & Ekayanti, A. (2020). *Pentingnya berpikir kritis dalam pembelajaran matematika* (the importance of critical thinking in mathematics learning). *Jurnal Penelitian Tindakan Kelas Dan Pengembangan Pembelajaran*, 3(2), 107–114.
- Kwon, O. N., Park, J. S., & Park, J. H. (2006). Cultivating divergent thinking in mathematics through an open-ended approach. *Asia Pacific Education Review*, 7(1), 51–61. <https://doi.org/10.1007/BF03036784>
- Lestari, E. S. (2021). *Model pembelajaran konstruktivis metakognitif untuk meningkatkan kemampuan berpikir kritis* (metacognitive constructivist learning model to improve critical thinking abilities). *Jurnal Basicedu*, 5(6), 6349_6356.
- Merma-Molina, G., Gavilán-Martín, D., & Urrea-Solano, M. (2022). Actively open-minded thinking, personality and critical thinking in spanish adolescents: a correlational and predictive study. *International Journal of Instruction*, 15(2), 579–600. <https://doi.org/10.29333/iji.2022.15232a>
- Munroe, L. (2015). The open-ended approach framework. *European Journal of Educational Research*, 4(3), 97–104. <https://doi.org/10.12973/eujer.2015.p97>

- Mustamiroh, R., Hidayati, Y., Hadi, W. P., & Muharrami, L. K. (2019). *Penerapan model pembelajaran problem based instruction (pbi) berbasis open ended terhadap keterampilan berpikir kritis siswa* (application of the open ended problem based instruction (pbi) learning model to students' critical thinking skills). *Natural Science Education Research*, *1*(2), 124–137. <https://doi.org/10.21107/nser.v1i2.4244>
- Ningsih, D. M., & Husaini, K. (2020). *Pengembangan kemampuan berfikir kritis melalui model pembelajaran logan avenue problem solving (laps) heuristik pada pembelajaran ips sejarah di smp negeri 1 bandar kabupaten bener meriah* (developing critical thinking abilities through the logan avenue problem solving (laps) Heuristic Learning Model in History Social Studies Learning at SMP Negeri 1 Bandar Bener Meriah Regency). *JIM*, *5*(1), 25–40.
- Ninomiya, H., & Pusri, P. (2015). The study of open-ended approach in mathematics teaching using jigsaw method/: a case study of the water beaker problem. *üW%os'Yf[] %o Ye²€f[è ÿ*, *64*(2), 11–22.
- Nofiyanti, A., & Mohammad Zaky Tatsar. (2023). *Penerapan model pembelajaran (laps) – heuristic berbantuan worksheet untuk meningkatkan hasil belajar kognitif peserta didik sma negeri 3 pasuruan* (Application of the Learning Model (LAPS) - Heuristic Assisted by Worksheets to Improve Cognitive Learning Outcomes of Students at SMA Negeri 3 Pasuruan). *Athena: Journal of Social, Culture and Society*, *1*(1), 1–5. <https://doi.org/10.58905/athena.v1i1.1>
- Nofriansyah, Martiah, A., & Vhalery, R. (2018). The effect of learning model logan avenue problem solving heuristic to the students learning activity. *International Journal of Scientific and Research Publications (IJSRP)*, *8*(10), 279–286. <https://doi.org/10.29322/ijsrp.8.10.2018.p8236>
- Ouhibu, M., & Nawel. (2022). The role of literature in boosting efl university students' critical thinking: case of first-year students in algeria. *Arab World English Journal*, *13*(1), 477–485. <https://doi.org/10.24093/awej/vol13no1.31>
- Pho, D. H., Nguyen, H. T., Nguyen, H. M., & Nguyen, T. T. N. (2021). The use of learning station method according to competency development for elementary students in Vietnam. *Cogent Education*, *8*(1). <https://doi.org/10.1080/2331186X.2020.1870799>
- Pott, R. W. M., & Nortjé, S. (2021). The use of student question-posing in reactor design to encourage an open-ended approach to learning. *European Journal of Engineering Education*, *46*(6), 874–888. <https://doi.org/10.1080/03043797.2021.1923662>
- Purba, O. N., & Sirait, S. (2017). *Peningkatan kemampuan pemecahan masalah dengan model laps-heuristic di sma shafiyatul amaliyah* (increasing problem solving abilities using the laps-heuristic model at shafiyatul amaliyah high school). *Jurnal Mathematic Paedagogic*, *2*(1), 31–39. <https://doi.org/10.36294/jmp.v2i1.119>
- Ridha, M. R. (2017). *Meningkatkan kemampuan pemecahan masalah dan penalaran matematis dengan laps-heuristic dan pendekatan open-ended* (improving problem solving and mathematical reasoning abilities with laps-heuristics and open-ended approaches). *MATHLINE/: Jurnal Matematika Dan Pendidikan Matematika*, *2*(1), 91–108.

- <https://doi.org/10.31943/mathline.v2i1.38>
- Sadat, A., & Harisuddin, M. I. (2023). *Kemampuan berpikir kritis matematis dan kemandirian belajar siswa dengan laps-heuristik* (mathematical critical thinking ability and student learning independence using laps-heuristics). *Aksentuasi: Jurnal Ilmiah Pendidikan Bahasa Dan Sastra Indonesia*, *IV*(1), 1–23.
- Sarwanto, Fajari, S. L. E. W., & Chumdari. (2021). Critical thinking skills and their impacts. *Malaysian Journal of Learning and Instruction*, *2*(2), 161–187.
- Selvia, M. D., Santika, S., & Muzdalipah, I. (2017). *Korelasi kemampuan komunikasi matematik dengan kemampuan pemecahan masalah matematik terhadap peserta didik melalui model pembelajaran logan avenue problem solving (laps)-heuristic* (correlation of mathematical communication skills with students' mathematical problem solving abilities through the logan avenue problem solving (laps)-heuristic learning model). *JP3M (Jurnal Penelitian Pendidikan Dan Pengajaran Matematika)*, *3*(2), 145–150. <https://doi.org/10.37058/jp3m.v3i2.407>
- Setiana, D. S., & Purwoko, R. Y. (2020). *Analisis kemampuan berpikir kritis ditinjau dari gaya belajar matematika siswa* (analysis of critical thinking skills in terms of students' mathematics learning styles). *Jurnal Riset Pendidikan Matematika*, *7*(2), 163–177. <https://doi.org/10.21831/jrpm.v7i2.34290>
- Suparlan, S. (2022). *Penerapan model pembelajaran laps-heuristik di sekolah dasar/madrasah ibtidaiyah* (application of the laps-heuristic learning model in elementary schools/madrasah ibtidaiyah). *As-Sabiqun*, *4*(1), 50–65. <https://doi.org/10.36088/assabiqun.v4i1.1654>
- Tambunan, H. (2018). Impact of heuristic strategy on students' mathematics ability in high order thinking. *International Electronic Journal of Mathematics Education*, *13*(3), 321–328. <https://doi.org/10.12973/iejme/3928>
- Ueda, A., Baba, T., & Matsuura, T. (2014). Takuya baba , phd values in japanese mathematics education from the perspective of open-ended approach. *Teaching Innovation*, *27*(3), 69–82.
- Usman, A. A., & Faradina, F. (2023). *Pengaruh penggunaan metode pembelajaran penemuan terbimbing terhadap keterampilan proses sains belajar fisika peserta didik sma negeri 3 kota ternate* (the effect of using the guided discovery learning method on the physics learning science process skills of students at sma negeri 3 ternate city). *KUANTUM: Jurnal Pembelajaran Dan Sains Fisika*, *4*(1), 1–16. <http://jurnal.stkipkieraha.ac.id/index.php/kuantum/article/view/431>
- Zhou, J., Jiang, Y., & Yao, Y. (2015). The investigation on critical thinking ability in EFL reading class. *English Language Teaching*, *8*(1), 83–94. <https://doi.org/10.5539/elt.v8n1p83>
- Zhou, Z. (2018). An empirical study on the influence of pbl teaching model on college students' critical thinking ability. *English Language Teaching*, *11*(4), 15. <https://doi.org/10.5539/elt.v11n4p15>

