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Optimizing Critical Thinking Skills of Fourth Grade Students Through Inquiry-Based Learning: Elementary School Mathematics

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Abstract: Critical thinking is an important aspect of education that encompasses cognitive, metacognitive, and ethical dimensions. This study aims to examine the impact of inquiry-based learning on students' critical thinking skills in fourth-grade mathematics at elementary school. This research employs a quantitative approach with a quasi-experimental design. This research involves fourth-grade students from Lempuyangwangi Public Elementary School, class A as the experimental group and Class B as the control group. The results of the Paired sample t-test for critical thinking skills in Table 4 between the pretest and posttest of the control class are 8.744 > 1.697 (t table N=30), and for the experimental class, it is 29.078 > 1.699 (t table N=29). In each class, the significance value is 0.001. When compared to the threshold value that must be met for a significance level of 0.05, the calculated significance being less than 0.05 indicates that there is a positive effect. The findings indicate a positive and significant influence of inquiry-based learning on enhancing students' critical thinking skills in mathematics. These results suggest that educators need to consider integrating inquiry-based learning into their teaching strategies to enhance the quality of education.

Keywords: critical thinking, inquiry-based learning, mathematic.

▪ INTRODUCTION

The rapid development of the era of globalization has made all fields compete to create and develop science and technology. Including the field of education which utilizes advances in science with various learning methods that can be implemented in a better and optimal learning process. 21st-century learning emphasizes the learning process on four learning components, namely high-level skills, critical thinking skills, collaboration skills, and skills in communicating ideas (Mu'minah, 2021). Critical thinking is one of the skills that every student must master (Saputra et al., 2019). According to Utaminingsih et al., (2024) Critical thinking skills are essential in facing global challenges as students can solve problems and make decisions based on valid information. In line with this, Lombardi et al., (2024) explain that inquiry-based learning can enhance students' critical thinking skills and encourage them to explore, analyze, and synthesize information.

Critical thinking skills are important in education (Rombout et al., 2021). Critical thinking skills are a combination of three dimensions, the first is the cognitive dimension which plays a role in logical reasoning skills, the second dimension is metacognitive which focuses on self-reflection, criticism, and high-level thinking, and the third dimension is the ethical dimension which concerns morals, ethics, and values (Fernando et al., 2019). The learning process must be based on critical thinking skills which include the three previous dimensions, it is expected that the learning process will take place actively (Kim & Wilkinson, 2019). In addition, learning based on critical thinking skills involves students actively, and collaboratively, in the learning process (Howe et al., 2019).

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The low critical thinking skills among Indonesian students, as highlighted by (Zubaidah et al., 2018), are seen in international assessments such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment), where Indonesia was ranked 73 out of 79 participating countries in 2018 (OECD, 2019). This low performance emphasizes the need to improve the quality of education so that Indonesia can be more competitive globally. Although inquiry-based learning has the potential to motivate active participation in discussions and collaborative problem-solving (Anjarwani et al., 2020), in reality, students' critical thinking skills remain low. The low critical thinking skills in mathematics are caused by the lack of variation in the choice of learning models, the absence of adjustments to the characteristics of student learning in the classroom (Hudha et al., 2018). The learning process in many schools in Indonesia is still traditional, namely the lecture method that emphasizes the process of conveying knowledge from teachers to students (Kai et al., 2021). This causes students to rely solely on the teacher's explanations given so students tend to be passive in the learning process and do not involve many critical thinking skills (Ramadhani et al., 2019). This lack of involvement in critical thinking highlights a significant problem in the current educational approach, so it is necessary to explore more effective teaching methods such as inquiry-based learning to create a more active and critical learning environment. One effort that can be made to improve student's critical thinking skills is to use inquiry-based learning methods (Yustiqvar et al., 2021).

Inquiry-based learning trains students' ability to find solutions to open-ended problems that require more than one solution and answer. Inquiry-based learning is a process that involves students in asking, examining, or investigating something to find answers to problems systematically, critically, logically, and analytically (Lailiah & Wardani, 2021). Inquiry-based learning provides space for students to actively participate in building their ideas (Mashudi, 2021). This method is very effective, especially in mathematics subjects, where the complexity of the material requires students to apply critical thinking skills to solve complex mathematical problems (Davidi et al., 2021). The advantages of inquiry learning in the learning process have a positive impact on developing students' critical thinking skills. This is supported by the results of research conducted by Kartika & Rakhmawati, (2022) which revealed that the application of inquiry learning can increase students' self-confidence, scientific curiosity, and critical thinking skills.

Meanwhile, the results of research from Anjarwani et al., (2020) revealed that the inquiry learning process carried out in the classroom stimulates students to be more involved in solving the problems faced, more effective in developing cognitive skills and critical thinking. Furthermore, the results of research from Ilhamdi et al., (2020), Zain et al., (2022) also stated that the application of inquiry learning can improve students' critical thinking skills and have open questions. Therefore, the integration of inquiry-based learning in the curriculum can significantly improve students' critical thinking skills, preparing them for more complex challenges in everyday life. The results of research from Wale & Bishaw, (2020) inquiry learning can improve students' critical thinking. Therefore, inquiry learning is recommended to improve students' critical thinking skills because this method can improve the skills of understanding, analyzing, evaluating, decision-making, and self-regulation, which are the core of critical thinking skills.

Although the potential of inquiry-based learning to improve critical thinking skills has been recognized, there is still a significant gap in its application to mathematics learning in Indonesia. Research consistently shows low critical thinking skills among Indonesian students, especially in international assessments such as TIMSS and PISA (Zubaidah et al., 2018). This problem is exacerbated by the continued reliance on traditional lecture teaching methods in many schools in Indonesia, which fail to actively engage students or encourage critical thinking (Munib, 2022). While inquiry-based learning is effective in a variety of contexts, including improving cognitive and critical thinking skills (Makmur et al., 2019), there is a lack of research specifically exploring its impact on mathematics subjects in Indonesia.

Inquiry-based learning is very necessary in the learning process to provide challenges to students to encourage critical thinking skills (Paidi et al., 2024). Inquiry learning encourages increased critical thinking skills because they are related to activities in everyday life (Henriksen et al., 2017). Therefore, critical thinking skills are very important in education and must be developed in students. To encourage good critical thinking skills, the learning process needs to be designed with a process that can promote students' critical thinking skills. One of them is inquiry-based learning because it triggers students' ideas, seeks their knowledge, and identifies each factor related to the problem (Sari et al., 2022). Therefore, this study aims to fill this gap with research on optimizing critical thinking skills in mathematics of grade IV students with inquiry learning: an effective solution for quality learning.

▪ METHOD

Participants

The sample in this study consists of 59 fourth-grade students at SD Negeri Lempuyangwangi. Purposive sampling is a technique that selects samples for a specific purpose or because they are closest to the information or problem being researched. In addition, this technique is used to select respondents who are most likely to provide relevant results and information (Campbell et al., 2020). This sampling technique has specific considerations, including the qualification of students' critical thinking skills as one of the factors in the sampling process.

Research Design and Procedures

The type of research used in this study is a quantitative approach with a quasi-experimental research method, employing a non-equivalent control group design. They aim to understand the difference in the influence of the inquiry learning method on the critical thinking skills in mathematics of fourth-grade students at Lempuyangwangi Elementary School before and after being given treatment in the form of a pretest and posttest. The procedure in this research begins with administering a pretest to both the experimental and the control groups, followed by the treatment stage, which consists of four meetings for the experimental group. In the final stage, both groups, the experimental group, and the control class, are given a posttest.

Instrument

The instrument used is a test of mathematical critical thinking skills on fractions, including pretest and posttest questions totaling 14 items. The indicators of critical thinking skills that are evaluated include (Supit & Winardi, 2024): identifying problems,

comparing and categorizing information, analyzing relationships between concepts, drawing conclusions from the problem-solving process, evaluating the solutions provided, independently formulating problem-solving strategies, and using evidence to support arguments. To determine validity, the Pearson product-moment correlation formula is used with a table value of 0.355 (at a significance level of 5%), and the instrument's reliability is assessed using Cronbach's alpha formula, yielding a value of 0.792. The outline of the critical thinking skills test questions is presented in Table 1.

Table 1. Grid of critical thinking skills questions

Indicator	Question form	Cognitive level	Question number
Identifying the problem			
Students can identify and understand problems related to fraction operations (addition, subtraction, multiplication, or division of fractions)	Essay questions	C4 - Analysis	1 and 2
Comparing and grouping information			
Students can compare various types of fractions (such as equivalent fractions) and group fractions that have the same or different values.	Essay questions	C4 - Analysis	3 and 4
Analyzing the relationship between concepts			
Students can analyze the relationship between fractions and whole numbers or decimals, as well as the relationship between fractions (for example, equivalent fractions or larger or smaller fractions).	Essay questions	C4 - Analysis	5 and 6
Summarize the results of the problem-solving process			
Students can conclude the results of fraction operations and explain the reasons or steps taken in solving the problem.	Essay questions	C4 - Analysis	7 and 8
Evaluate the solutions provided			
Students can evaluate the solutions that have been given (for example, the results of fraction operations) and determine whether the solution is correct or not.	Essay questions	C4 - Analysis	9 and 10
Develop problem-solving strategies independently			
Students can develop appropriate strategies to solve fraction problems independently and creatively.	Essay questions	C4 - Analysis	11 and 12
Using evidence to support arguments			
Students can provide evidence or logical reasons to support the answers or solutions they have found in fraction operations.	Essay questions	C4 - Analysis	13 and 14

Data Analysis

The data collection techniques used in this study are pretest and posttest. The data analysis technique used is parametric statistics with a T-test. The researcher wants to determine the differences in the two conditions of subjects before and after the treatment is given to fourth-grade students using an inquiry-based learning approach. The data analysis technique used is the T-test to examine the results of the pretest and posttest, as

well as to determine if there is a difference between students who have not received treatment and those who have. Other data analysis techniques include validity testing, reliability testing, normality testing, and homogeneity testing. To test the data analysis, the SPSS 27 application will be used. Quantitative data is an instrument for critical thinking skills in the form of pretest and posttest questions. After obtaining the pretest and posttest data, the next step is to interpret it. Then, it is explained to determine whether inquiry-based learning has a significant effect on students' critical thinking skills.

This test determines the effectiveness of the learning methods used, to provide empirical evidence of significant changes in the research variables (van Rijn et al., 2024). The use of the t-test in experimental research can provide strong validation for the differences found when involving two groups that are given different treatments (Agbangba et al., 2024). In addition, this test also helps minimize errors in concluding, making the research results more accurate and reliable (Kaplan-Rakowski & Gruber, 2024).

▪ RESULT AND DISSCUSSION

Statistical Analysis

The data obtained will be followed by a validity test using the Pearson product-moment correlation formula in SPSS version 27. Based on the results of the validity analysis of the questions, all test items have validity values ranging from 0.421 to 0.632, indicating that each test item is considered valid. According to the results of the validity test, all items of the critical thinking ability instrument are declared valid. The statement can be seen from the Pearson product-moment correlation value compared to the table value, which is 0.355 (with a significance level of 5%). This indicates that the calculated correlation value exceeds the correlation value in the table, thus it can be concluded that the fourteen items can be accepted as research instruments.

The normality test was conducted to determine whether the pretest and posttest data on critical thinking skills are normally distributed or not. The normality test was performed using SPSS version 27 with a significance level of 0.05. The decision-making criterion is that if the significance value is greater than 0.05, then the data is declared to be normally distributed. For the control class, the significant value of critical thinking ability is 0.418, and for the experimental class, it is 0.115. These values indicate that the two classes do not have a significant difference in terms of critical thinking skills at the pretest stage. As shown by the results of the normality test of the pretest data, the data used has a normal distribution, as the significance value is greater than 0.05. Thus, the assumption of normality is met, allowing for the use of parametric statistical tests such as the Paired Sample t-test for further analysis. Based on the significance values for critical thinking skills in the control class with the conventional learning model, it is 0.268, while the significance value in the experimental class with the inquiry learning model is 0.167. The normality of the data afterward indicates that the data used has a normal distribution because the significance value is greater than the significance level of 0.05.

The homogeneity test determines whether the samples selected from the population have the same or comparable variance by using pretest and posttest data. To conduct this analysis, SPSS 27 is required with a significance level (α) of 0.05. If the results of the pretest and posttest are greater than 0.05, the homogeneity test for decision-making will be used. For the experimental class, we are using the inquiry learning model. The results

of the homogeneity test for critical thinking skills show a significant value greater than 0.05, with a pretest value of 0.916 and a posttest value of 0.654. Based on these results, it can be concluded that the critical thinking skills in the pretest and posttest of the experiment are homogeneous.

Critical Thinking Skills Of Fourth-Grade Students

Results of the Paired Sample T-Test

To determine the significance of the test results, if the significance value is > 0.05, then Ho is accepted; however, if the significance value is < 0.05, then Ho is rejected. The results of the paired sample t-test analysis can be seen in the table below.

Table 5. Results of the paired sample t-test

Critical thinking skills	Pretest	Posttest	t_{count}	Sig.	Information
Control class	26.47	29.83	8.744	0.001	Ho was rejected
Experimental class	24, 21	45.45	29.078	0.001	Ho was rejected

The results of the Paired sample t-test for critical thinking skills in Table 5 between the pretest and posttest of the control class are 8.744 > 1.697 (t table N=30), and for the experimental class, it is 29.078 > 1.699 (t table N=29). In each class, the significance value is 0.001. When compared to the threshold value that must be met for a significance level of 0.05, the calculated significance is less than 0.05, indicating that there is a positive effect. Based on the results of the Paired sample t-test and the conclusions drawn, this aligns with Mawarni & Hidayat, 2022; Yustitia et al., 2023, which indicates that inquiry-based learning effectively enhances students' critical thinking skills, leading to a substantial increase in critical thinking scores.

Supported by several studies that state inquiry-based learning influences critical thinking skills, as this method actively involves students in the learning process through active exploration of concepts, problem-solving, and decision-making based on empirical evidence logically and critically (Duran & Dökme, 2016; Rahmi, Alberida, & Astuti, 2019; Wale & Bishaw, 2020b). Based on the results, it can be concluded that the null hypothesis is rejected and the alternative hypothesis is accepted, indicating a positive influence of the inquiry learning model on critical thinking skills in the control class. The improvement in critical thinking skills in the control class before and after using the inquiry learning model was from 26.47 to 29.83, with a score range of 3.36. Meanwhile, the critical thinking skills before and after in the experimental class using the conventional learning model increased from 24.21 to 45.45, with a score range of 21.24.

Independent Sample T-Test Results

The independent sample t-test is conducted to determine the significance of the test results; if the significance value is greater than 0.05, then the null hypothesis (Ho) is accepted, but if the significance value is less than 0.05, then Ho is rejected. The results of the independent sample t-test analysis can be seen in the table below.

Based on the results of the independent sample t-test in table 6, the significance score for critical thinking ability is 21.899 > 1.699 (t-table N=29) and the significance value is 0.001 < 0.05, thus Ho is rejected and Ha is accepted. It can be concluded that there is a positive and significant difference in the effect of using the inquiry learning

Table 6. Results of the independent sample t-test

Class	Condition	T count	Sig.	Findings	Information
Experiment	After	21. 899	0.001	Ho was rejected	There is a difference
Control					

model compared to the conventional learning model on the critical thinking skills of fourth-grade elementary school students. These results indicate that both treatments experienced improvement; however, the use of the inquiry learning model had a positive and significant impact compared to the use of the conventional learning model (Martatis, 2023). In line with (Ali et al., 2023; Armia, 2021; Ghaemi & Mirsaeed, 2017), it is stated that the inquiry model has consistently been shown to have a significant impact on improving students' critical thinking skills. In addition, Azzam (2020) in his research findings states that students' critical thinking skills can significantly improve after the implementation of inquiry-based learning. This research shows a stronger ability to analyze information and make evidence-based decisions compared to conventional learning methods.

The inquiry learning model has been theoretically and empirically proven to be more effective in enhancing students' critical thinking abilities (Antonio & Prudente, 2023; Jia & Tu, 2024; Lee et al., 2024). Inquiry-based learning encourages students to actively engage in the processes of exploration, analysis, and problem-solving, which directly enhances critical thinking skills (Charles et al., 2024; Singha & Singha, 2024; Suryono et al., 2023). Furthermore, research by (Bogador et al., 2024; Maharani et al., 2023; Yonwong et al., 2024) emphasizes that inquiry-based learning not only enhances critical thinking skills but also boosts students' motivation to learn. Students who are actively engaged through inquiry-based learning are more enthusiastic and motivated to learn, which significantly contributes to better learning outcomes. Recent research also supports this finding, indicating that an inquiry-based approach provides students with more opportunities to ask questions, make observations, and draw conclusions from their own experiences, which are essential components of critical thinking (Antonio & Prudente, 2024; Kurniawati, 2021; Presnillo & Aliazas, n.d.; Safkolam et al., 2024).

This finding is in line with the research conducted by (Bako et al., 2024; Darmawati & Mustadi, 2023), which states that inquiry-based learning has a significant impact on students' critical thinking skills compared to conventional methods. Additionally, the study by (Kamal & Suyanta, 2021; Sichangi et al., 2024; Singha & Singha, 2024) also emphasizes that inquiry-based learning is more capable of facilitating the development of analytical and evaluative skills, which are key elements of critical thinking. Another finding reveals that active student involvement in the learning process is key to achieving optimal results in the development of critical thinking skills (Li et al., 2024; Lombardi et al., 2024; van der Zanden et al., 2020). In addition, research from van der Graafet al., (2020) It is expressed that the use of technology in inquiry-based learning can further enhance students' critical thinking skills. They found that the integration of digital tools in inquiry learning not only increases student engagement but also assists students in accessing a broader and more diverse range of information sources, which is essential for the development of analytical and evaluative skills.

Based on numerous recent studies, findings support that inquiry-based learning has a significant positive impact on students' critical thinking skills. This approach not only

enhances critical thinking abilities but also encourages student engagement and motivation in the learning process. Therefore, educators need to implement inquiry-based learning models in the curriculum, particularly in mathematics instruction for fourth-grade students in elementary schools.

▪ CONCLUSION

Based on the discussion results, it can be concluded that the use of the inquiry learning model has a positive and significant impact on improving students' critical thinking skills. The results of the paired sample t-test show a significant increase in both groups, both the control class and the experimental class, with the experimental class using the inquiry learning model experiencing a greater improvement in critical thinking skills. This finding aligns with various recent studies, which affirm that inquiry-based learning encourages active student engagement in the processes of analysis and problem-solving, thereby significantly strengthening critical thinking skills. The inquiry model has proven to be more effective than the conventional model, leading to a substantial increase in students' analytical and evaluative skills, especially in the context of fourth-grade mathematics learning in elementary schools.

▪ REFERENCES

Agbangba, C. E., Aide, E. S., Honfo, H., & Kakai, R. G. (2024). On the use of post-hoc tests in environmental and biological sciences: A critical review. Heliyon.

Ali, A., Rafiqa, R., Palliwi, E. D., Nuraini, N., & Rahmadiani, R. (2023). Implementing guided inquiry-based biology learning tools to enhance students' critical thinking skills. Jurnal Penelitian Pendidikan IPA, 9(6), 4856–4862. https://doi.org/10.29303/jppipa.v9i6.4541

Anjarwani, R., Doyin, M., & Indiatmoko, B. (2020). Guided inquiry learning with outdoor activities setting to improve critical thinking ability and science process skills of elementary school students. 9(2), 129–135.

Antonio, R. P., & Prudente, M. S. (2023). Effects of inquiry-based approaches on students' higher-order thinking skills in science: a meta-analysis. International Journal of Education in Mathematics, Science and Technology, 12(1), 251–281. https://doi.org/10.46328/ijemst.3216

Antonio, R. P., & Prudente, M. S. (2024). Effects of inquiry-based approaches on students' higher-order thinking skills in science: A meta-analysis. International Journal of Education in Mathematics, Science and Technology, 12(1), 251–281.

Armia, M. S. (2021). Impacts of inquiry learning model on students' cognitive and critical thinking ability. Cypriot Journal of Educational Sciences, 16, 1291–1299.

Azzam, L. A. (2020). The Impact of Inquiry-Based Learning on the Critical Thinking of High School Students. (December), 1–87.

Bako, A., Phang, F. A., Pusppanathan, J., & Nawi, N. D. (2024). Critical thinking and teaching conception of nigerian physics teachers in inquiry-based learning classroom. International Journal of Advanced Research in Future Ready Learning and Education, 34(1), 77–92.

Bogador, C. J., Camarao, M. K. G., Matunding, C. G., & Sombria, K. J. F. (2024). Challenges and benefits of inquiry-based learning in physics. International Journal of Multidisciplinary: Applied Business and Education Research, 5(7), 2716–2732.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., … Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. Journal of Research in Nursing, 25(8), 652–661. https://doi.org/10.1177/1744987120927206

Charles, M., George, K., Kuteesa Mugenyi, D., Muhamadi, K., Lawrence, S., Nabateregga, J., … Taddeo, K. Y. (2024). Experiential and inquiry-based learning approaches; correlated exploration on usage in selected secondary schools in Bugiri District, Eastern Uganda. Interactive Learning Environments, 1–15.

Darmawati, Y., & Mustadi, A. (2023). The effect of problem-based learning on the critical thinking skills of elementary school students. Jurnal Prima Edukasia, 11(2), 142–151. https://doi.org/10.21831/jpe.v11i2.55620

Davidi, E. I. N., Sennen, E., & Supardi, K. (2021). *Integrasi pendekatan STEM (science, technology, enggeenering and mathematic) untuk peningkatan keterampilan berpikir kritis siswa sekolah dasar.* Scholaria: Jurnal Pendidikan Dan Kebudayaan, 11(1), 11–22.

Duran, M., & Dökme, I. (2016). The effect of the inquiry-based learning approach on student's critical-thinking skills. Eurasia Journal of Mathematics Science and Technology Education, 12(12).

Fernando, L., Meneses, S., Fernando, L., & Meneses, S. (2019). Jo ur of. thinking skills and creativity, 100610. https://doi.org/10.1016/j.tsc.2019.100610

Ghaemi, F., & Mirsaeed, S. J. G. (2017). The impact of inquiry-based learning approach on critical thinking skill of EFL students. Efl Journal, 2(2), 89–102.

Henriksen, D., Richardson, C., & Mehta, R. (2017). Design thinking : A creative approach to educational problems of practice. Thinking Skills and Creativity, 26(October), 140–153. https://doi.org/10.1016/j.tsc.2017.10.001

Howe, C., Hennessy, S., Mercer, N., Vrikki, M., Wheatley, L., Howe, C., … Wheatley, L. (2019). Teacher – student dialogue during classroom teaching : does it really impact on student outcomes ? teacher – student dialogue during classroom teaching : does it really impact on student outcomes ? Journal of the Learning Sciences, 0(0), 1–51. https://doi.org/10.1080/10508406.2019.1573730

Hudha, M. N., Aji, S. D., & Huda, C. (2018). E-Rubric: Scientific work based on android for experimental physic. IOP Conference Series: Materials Science and Engineering, 288(1). https://doi.org/10.1088/1757-899X/288/1/012100

Ilhamdi, M. L., Novita, D., & Rosyidah, A. N. K. (2020). *Pengaruh model pembelajaran inkuiri terbimbing terhadap kemampuan berpikir kritis IPA SD.* Jurnal Ilmiah KONTEKSTUAL, 1(02), 49–57.

Jia, X.-H., & Tu, J.-C. (2024). Towards a new conceptual model of ai-enhanced learning for college students: the roles of artificial intelligence capabilities, general self-efficacy, learning motivation, and critical thinking awareness. Systems, 12(3), 74.

Kai, S., Chu, W., Reynolds, R. B., Tavares, N. J., & Notari, M. (2021). 21st Century Learning. https://doi.org/10.4018/978-1-7998-4102-9.ch002

Kamal, N. A., & Suyanta. (2021). The effect of inquiry based learning models on students' critical thinking ability and self-efficacy in reaction rate material. Journal of Physics: Conference Series, 1806(1). https://doi.org/10.1088/1742-6596/1806/1/012179

Kaplan-Rakowski, R., & Gruber, A. (2024). An experimental study on reading in high-immersion virtual reality. British Journal of Educational Technology, 55(2), 541–559.

Kartika, Y. K., & Rakhmawati, F. (2022). Peningkatan Kemampuan Berpikir Kritis Matematis Siswa Menggunakan Model Inquiry Learning. Jurnal Cendekia : Jurnal Pendidikan Matematika, 6(3), 2515–2525. https://doi.org/10.31004/cendekia.v6i3.1627

Kim, M., & Wilkinson, I. A. G. (2019). Learning, culture and social interaction what is dialogic teaching ? constructing , deconstructing , and reconstructing a pedagogy of classroom talk. Learning, Culture and Social Interaction, 21(July 2018), 70–86. https://doi.org/10.1016/j.lcsi.2019.02.003

Kurniawati, K. (2021). Utilizing guided inquiry learning model to improve students' science process skills. Primary: Jurnal Pendidikan Guru Sekolah Dasar, 10(2), 433–441. Retrieved from https://primary.ejournal.unri.ac.id/index.php/JPFKIP/article/view/8250

Lailiah, I., & Wardani, S. (2021). *Implementasi guided inquiry berbantuan e-lkpd terhadap hasil belajar kognitif siswa pada materi redoks dan tata.* 15(1), 2792–2801.

Lee, N. Y., Wang, Z., & Lim, B. (2024). The development of critical thinking: What university students have to say. Teaching in Higher Education, 29(1), 286–299.

Li, L., Ismail, S. M., Patra, I., & Lami, D. (2024). Not a passive learner but an active one: a focus on the efficacy of philosophy-based language instruction and its consequences on EFL learners' critical thinking, engagement, and academic achievement. BMC Psychology, 12(1), 148.

Lombardi, L., Thomas, V., Rodeyns, J., Mednick, F. J., De Backer, F., & Lombaerts, K. (2024). Primary school teachers' experiences of teaching strategies that promote pupils' critical thinking. Educational Studies, 50(5), 683–701. https://doi.org/10.1080/03055698.2021.1990017

Maharani, N. I., Dasna, I. W., & Utama, C. (2023). The effectiveness of inquiry-based learning instrument to enhance student's critical thinking skills. Madrasah: Jurnal Pendidikan Dan Pembelajaran Dasar, 15(2), 66–77. https://doi.org/10.18860/mad.v15i2.18682

Makmur, W., Susilo, H., & Indriwati, S. E. (2019). Implementation of guided inquiry learning with scaffolding strategy to increase critical thinking skills of biology students' based on lesson study. Journal of Physics: Conference Series, 1227(1). https://doi.org/10.1088/1742-6596/1227/1/012003

Martatis, M. (2023). *Pengaruh model pembelajaran inkuiri terbimbing terhadap berpikir kritis siswa pada mata pelajaran fisika.* Journal of Educational Research and Humaniora (JERH), 1, 24–33. https://doi.org/10.51178/jerh.v1i2.1367

Mashudi, M. (2021). *Pembelajaran modern: membekali peserta didik keterampilan abad ke-21.* Al-Mudarris (Jurnal Ilmiah Pendidikan Islam), 4(1), 93–114.

Mawarni, D., & Hidayat, H. (2022). Inquiry learning model to improve student's critical thinking in the themes learning technology development in Class III SD IT Bina Insan Batang kuis. Widyagogik : Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar, 10(1), 148–160. https://doi.org/10.21107/widyagogik.v10i1.16868

Mu'minah, I. H. (2021). *Studi literatur: pembelajaran abad-21 melalui pendekatan steam (science, technology, engineering, art, and mathematics) dalam menyongsong era society* 5.0. Prosiding Seminar Nasional Pendidikan, 3, 584–594.

Munib, A. (2022). *Studi komparatif antara pendekatan kontekstual dan metode ceramah terhadap kemampuan ranah kognitif pembelajaran fiqih materi haji dan umrah di MTs Al-Islam Gunungpati.* Jurnal PROGRESS: Wahana Kreativitas Dan Intelektualitas, 10(1).

OECD. (2019). *Pendidikan di Indonesia belajar dari hasil* PISA 2018. Pusat Penilaian Pendidikan Balitbang KEMENDIKBUD, (021), 1–206. Retrieved from http://repositori.kemdikbud.go.id/id/eprint/16742

Paidi, Pratama, A. T., Anazifa, R. D., Suratsih, Ibrahim, H. Bin, & Wahid, N. B. A. (2024). The development of two levels of inquiry-based blended learning model on ecology to improve student's critical thinking skills, creative thinking skills and learning independence skills. AIP Conference Proceedings, 2622(1), 30016. https://doi.org/10.1063/5.0181125

Presnillo, J., & Aliazas, J. V. (n.d.). Inquiry-based learning for an enhanced students' engagement and critical thinking skills in biology.

Rahmi, Y. L., Alberida, H., & Astuti, M. Y. (2019). Enhancing students' critical thinking skills through inquiry-based learning model. Journal of Physics: Conference Series, 1317(1), 12193. IOP Publishing.

Ramadhani, R., Umam, R., Abdurrahman, A., & Syazali, M. (2019). The effect of flipped-problem based learning model integrated with LMS-google classroom for senior high school students. Journal for the Education of Gifted Young Scientists, 7(2), 137–158. https://doi.org/10.17478/jegys.548350

Rombout, F., Schuitema, J. A., & Volman, M. L. L. (2021). Teachers ' implementation and evaluation of design principles for value-loaded critical thinking. International Journal of Educational Research, 106(September 2020), 101731. https://doi.org/10.1016/j.ijer.2021.101731

Safkolam, R., Madahae, S., & Saleah, P. (2024). The effects of inquiry-based learning activities to understand the nature of science of science student teachers. International Journal of Instruction, 17(1), 479–496.

Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing critical-thinking skills through the collaboration of Jigsaw model with problem-based learning model. International Journal of Instruction, 12(1), 1077–1094. https://doi.org/10.29333/iji.2019.12169a

Sari, D. T., Aula, A. W., Nugraheni, V. A., Dina, Z. K., & Romdhoni, W. (2022). *Penerapan pembelajaran berbasis masalah pada siswa sd untuk menumbuhkan kemampuan berpikir kritis.* Prosiding Seminar Nasional Pendidikan Guru Sekolah Dasar, 2(1), 82–96.

Sichangi, M. W., Ngaruiya, B., Muriithi, E. M., & Odundo, P. A. (2024). Re-defined learner's role in inquiry-based learning and achievement in mathematics in stem-integrated secondary schools in Kenya. Journal of Pedagogy, Andragogy and Heutagogy in Academic Practice, 5(1), 78–93.

Singha, R., & Singha, S. (2024). Application of experiential, inquiry-based, problem-based, and project-based learning in sustainable education. In Teaching and

Learning for a Sustainable Future: Innovative Strategies and Best Practices (pp. 109–128). IGI Global.

Supit, P. G. Y., & Winardi, Y. (2024). *Pembelajaran berbasis riset (research-based learning) untuk meningkatkan kemampuan berpikir kritis, berpikir kreatif dan berpikir reflektif siswa dalam pembelajaran biologi* [research-based learning to improve students' critical thinking, creative thinking. Polyglot: Jurnal Ilmiah, 20(2), 115. https://doi.org/10.19166/pji.v20i2.8355

Suryono, W., Winiasri, L., Santosa, T. A., Sappaile, B. I., & Solehuddin, M. (2023). Effectiveness of the inquiry training model to improve students' critical thinking skills in learning: systematic literature reviews and meta-analysis. Jurnal Penelitian Pendidikan IPA, 9(10), 947–954. https://doi.org/10.29303/jppipa.v9i10.4804

Utaminingsih, E. S., Irchamni, A., Utami, Y., & Shabrina, M. N. (2024). Enhancing critical thinking skills through group investigating models and "datar" "pakar" media for facing the 21st century. Journal of Educational Development, 12(2), 63–72. Retrieved from https://journal.unnes.ac.id/journals//jed

van der Graaf, J., Segers, E., & de Jong, T. (2020). Fostering integration of informational texts and virtual labs during inquiry-based learning. Contemporary Educational Psychology, 62(June), 101890. https://doi.org/10.1016/j.cedpsych.2020.101890

van der Zanden, P. J. A. C., Denessen, E., Cillessen, A. H. N., & Meijer, P. C. (2020). Fostering critical thinking skills in secondary education to prepare students for university: teacher perceptions and practices. Research in Post-Compulsory Education, 25(4), 394–419. https://doi.org/10.1080/13596748.2020.1846313

van Rijn, M., Raab, J., Roosma, F., & Achterberg, P. (2024). To prove and improve: An empirical study on why social entrepreneurs measure their social impact. Journal of Social Entrepreneurship, 15(2), 494–516.

Wale, B. D., & Bishaw, K. S. (2020a). Effects of using inquiry-based learning on EFL students' critical thinking skills. Asian-Pacific Journal of Second and Foreign Language Education, 5(1). https://doi.org/10.1186/s40862-020-00090-2

Wale, B. D., & Bishaw, K. S. (2020b). Effects of using inquiry-based learning on EFL students' critical thinking skills. Asian-Pacific Journal of Second and Foreign Language Education, 5, 1–14.

Yonwong, P., Thongsuk, T., & Hemtasin, C. (2024). Creativity development of secondary school students using four thinking activities blended inquiry-based learning. International Journal of Instruction, 17(1), 579–598.

Yustiqvar, M., Nisrina, N., & Mataram, U. (2021). Enhancing prospective teachers' creative thinking skills : a study of the transition from structured to open inquiry classes peningkatan keterampilan berpikir kreatif calon guru : 40(3). https://doi.org/10.21831/cp.v40i3.41758

Yustitia, V., Kusmaharti, D., Anggraini, M., Petrus Jacob Pattiasina, & Luluk Faridah. (2023). Process-oriented guided-inquiry learning model and critical thinking ability of elementary school students. Jurnal Pendidikan Dan Pengajaran, 56(1), 217–216. https://doi.org/10.23887/jpp.v56i1.59650

Zain, U. N. I., Affandi, L. H., & Oktaviyanti, I. (2022). *Pengaruh model pembelajaran inkuiri terhadap kemampuan berpikir kritis siswa kelas V pada mata pelajaran IPS.* Journal of Classroom Action Research, 4(2), 71–74.

Zubaidah, S., Corebima, A. D., Mahanal, S., & Mistianah. (2018). Revealing the relationship between reading interest and critical thinking skills through remap GI and remap jigsaw. International Journal of Instruction, 11(2), 41–56. https://doi.org/10.12973/iji.2018.1124a