Indonesian Journal of Educational Innovation (IJEI)

P-ISSN: 3109-0176 — E-ISSN: 3109-0168

https://journals.widhatulfaeha.id/index.php/jpkjl/index

The Effectiveness of the Problem-Based Learning Model on the Critical Thinking Skills of Grade XI Students at MAN 1 Central Lombok

Nisa Hiidayatullah[1], Ziadatul Fatimah[2]

[1]Master of Science Education, Postgraduate, University of Mataram, NTB, Indonesia.

[1]SMA Nahdlatul Wathan Mataram, Mataram, NTB, Indonesia.

Article Info

Article History
Received: October 11, 2025
Revised: October 18, 2025
Accepted: December 1, 2025
Published: December 31, 2025

***Corresponding Author**
Nisa Hiidayatullah,
Master's Program of Science Education, University of Mataram, Indonesia.
e-mail: nisahidayatullah3@gmail.com

DOI: https://doi.org/10.65622/ijei.v1i3.156

Abstract

Critical thinking skills are fundamental cognitive abilities that play a crucial role across many facets of life by enabling people to analyze, assess, and solve problems. The purpose of this study is to examine how students' critical thinking skills are affected by problem-based learning paradigms. A quasi-experimental design with a non-equivalent control group—also referred to as a pretest-posttest untreated control group design—is used in this quantitative investigation. Purposive sampling was used to get the research sample. This study used a 10-item essay test to assess students' critical thinking skills. According to the study's findings, the significance level value was 0.033, which was less than α of 0.050. It suggests that problem-based learning paradigms impact students' critical thinking skills. These findings suggest that, to accommodate different cognitive styles, learning procedures should be flexible and varied.

Keywords: Problem-Based Learning, Critical Thinking Skills, High Order Thinking Skill.

INTRODUCTION

The world of education is entering the era of the Industrial Revolution 5.0, in which students are expected to master 21st-century skills, comprising life skills, thinking skills, and the ability to act, while also developing critical thinking, a key ability to solve problems that influences student success (Marwan et al., 2020; Hardiyanto et al., 2021). Critical thinking also involves self-regulation in decision-making, including analysis, interpretation, evaluation, and presentation, using concepts, evidence, criteria, methodology, and contextual considerations as the basis for decision-making (Facione, 2006). It is closely related to higher-order thinking, as all its components are present in these skills (Suciati, 2022). These skills are logical, reflective, systematic, and productive, enabling individuals to make informed decisions (Sari et al., 2019). As a process, it deliberately assesses the quality of one's thinking through reflective, independent, transparent, and rational reasoning (Rizaldi et al., 2019), thereby developing a capacity that needs to be nurtured within each individual (Rizaldi et al., 2021). Furthermore, it represents an attitude of deeply thinking about problems within one's experience, knowledge of methods, logical reasoning, and the ability to apply these methods effectively (Nasution, 2018; Nugraha et al., 2017; Rahmawati et al., 2009).

Therefore, Students' problem-solving abilities must be improved. The problem-based learning model is one educational strategy that can help students develop their critical thinking abilities. This problem-based learning model has been widely recognised as effective in developing critical thinking skills, as shown by Junaidi et al. (2020), who found that students with critical thinking skills can solve HOTS questions well. This problem-based learning has a syntax that focuses on problems presented by the teacher to students, who solve them using their knowledge and skills from various sources at their disposal (Lidinillah, 2007). Problem-based learning is a learning model that focuses on identifying a problem and developing a solution plan, thereby increasing the potential for thinking when solving problems (Harahap et al., 2021). Problem-based learning is learning designed around comprehensive, real-world, and complex problems that provide opportunities for students to acquire knowledge, understanding, and skills as defined by the curriculum (Valdez et al., 2019). The problem-based learning model is a classroom learning model characterised by real-world problems that students can use as a reference to solve them (Susilawati et al., 2023). Furthermore, the problem-based learning model can motivate students to develop and organise their knowledge (Widiawati et al., 2022) and hone higher-level skills (Hidayatin et al., 2022). This problem-based learning model also offers a learning technique in which students are challenged with actual situations that require in-depth analysis, problem-solving, and critical thinking to achieve a deep understanding.

Based on an interview with a Physics teacher at a school in Central Lombok Regency, students' ability to analyse physics problems remained low. This affected the average score of students' learning outcomes in Physics for grade XI IPA. The results showed that five classes exceeded the Minimum Completion Criteria (KKM), while four classes fell below the KKM. Students still struggle to address issues raised by instructors, whether in the form of assignments or inquiries. Thus, the purpose of this study is to assess the impact of a project-based learning approach on critical thinking abilities at XI MAN 1 Central Lombok. The study's findings are anticipated to serve as a guide for educational institutions using successful learning models to enhance students' abilities.

MATERIALS AND METHODS

Time and Place

This study was conducted over six weeks, from September to October of 2025. MAN 1 Central Lombok, situated in Praya, Central Lombok, West Nusa Tenggara, served as the research site.

Research Design

This quantitative study used a quasi-experimental design with a pretest and posttest and a non-equivalent control group, sometimes referred to as an untreated control group. In this approach, research participants were not randomly assigned to experimental and control groups. Prior to the learning activities, a pretest was administered to both groups to evaluate students' preliminary critical thinking abilities and prepare them for the lessons. The experimental group then received treatment through a problem-based learning approach, whereas the control group followed standard learning methods. Students in both groups took a posttest at the end to gauge their critical thinking skills in physics.

Population and Sample

The study's population consisted of all 195 students from five classes in class XI IPA during the odd semester of the 2025–2026 academic year at MAN 1 Lombok Tengah. Purposive sampling was the method employed. Purposive sampling is a sampling strategy that considers the specific characteristics of the sample to be selected (Setyosari, 2015). Two classes made up the research sample: thirty-four students from class XI IPA 1 served as the control group, and thirty-two students from class XI IPA 2 served as the experimental group. The exam employed in this study was a critical thinking assessment for students. A descriptive exam based on critical thinking indicators, that is, (1) interpretation, (2) analysis, (3) evaluation, (4) inference, and (5) explanation, was employed in the study. (Facione, 2011).

Research Procedure

The samples were first divided into experimental and control groups as part of the research process. The experimental class was XI IPA 3, while the control class was XI IPA 2. Before receiving therapy, both student groups that made up the research sample took a pretest. Following the pretest, the experimental class engaged in learning activities utilizing a problem-based learning approach, whereas the control class was instructed via lecture. This learning model's steps are as follows: (1) assigning students to the problem; (2) assigning students to learn; (3) directing both individual and group research; (4) creating and presenting findings; and (5) analyzing and assessing the students' approach to problem-solving. Although the classes used different learning methods, the research in both classes was conducted with the same number of meetings and the same learning materials. The next step was to administer a posttest to both groups of students to measure their critical thinking skills after treatment.

Data Analysis Techniques

Afterward, a hypothesis test was conducted on the collected data. However, before conducting the hypothesis tests, data homogeneity and normality were assessed.

Homogeneity Test

The data from the first (pretest) student exam are used for the homogeneity test. To ascertain if the two classes—the experimental and control classes—were homogeneous, the variance test, also known as the F-test, was employed in this investigation. According to Sugiyono (2013), the formulation is as follows: $F = \frac{\text{The largest variance}}{\text{Smallest variance}}$. There are two criteria used for testing:

a. If $F_{count} \leq F_{table}$, the data is homogeneous
b. If $F_{count} > F_{table}$, the data is not homogeneous

Data Normality Test

To assess whether the pretest and posttest data are normally distributed, a normality test is performed. The Chi-Square Equation can be used to perform a normality test. (Sugiyono, 2013)

$$x^2 = \sum_{t=1}^{k} \frac{(f_0 - f_h)^2}{f_h}$$

To determine whether the data is normally distributed, the calculated value of x^2_{hitung} is compared with the calculated value of x^2_{tabel}. The data is normally distributed at a 5% significance level with a db independence of k-1, where k represents the interval class. The comparison criteria used are as follows:

a. If $x^2_{hitung} \leq x^2_{tabel}$, The data is normal.
b. If $x^2_{hitung} > x^2_{tabel}$, The data is not normal

Hypothesis Testing

The independent samples t-test was the hypothesis test employed in this investigation. A method for determining the significance of variations in the means of two uncorrelated (related) samples is the independent samples t-test. With homogeneous variance, normally distributed data, and $n1 \neq n2$ (the number of students in the experimental class is different from the number of students in the control class), the pooled variance t-test was selected as the kind of independent samples t-test. The polled variance t-test Equation is as follows (Sugiyono, 2010).

$$t_{hitung} = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{(n_1 - n_2)S_1^{\,2} + (n_2 - 1)S_2^{\,2}}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

The t_{hitung} value is then compared with the t_{tabel} value at a significance level of 5%. If $t_{count} > t_{table}$, then H_o is rejected and H_a is accepted and if $t_{count} \leq t_{table}$, then H_o is accepted and H_a is rejected.

RESULT AND DISCUSSION

Result

Critical Thinking Skills Pretest Results

The results of an essay-style pretest with 10 questions provided the initial data on students' critical thinking abilities in the experimental and control groups. Table 1 below displays the findings of the normalcy test for the original test data. Table 3: Normality Test Results for the Critical Thinking Skills Pretest

Table 1. Students' Physics Critical Thinking Skills Pretest Scores

Class	N	Lowest Value	Highest Value	Mean	Critical thinking category
Experimental	25	30	50	38,90	Very low
control	24	20	60	37,60	Very low

According to Table 1 above, the experimental class's lowest score was 30, whereas the control class's lowest score was 20. The experimental class's highest score was 50, whereas the control group's was 60. Both the experimental and control groups' average pretest results remained in the extremely low range. Figure 1 displays the results of the critical thinking skills pretest graphically.

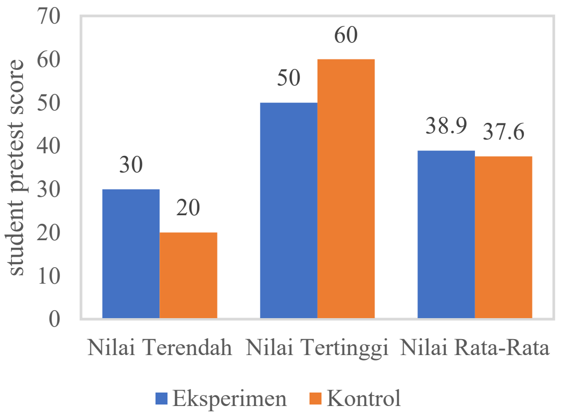

Figure 1. Students' Physics Critical Thinking Skills Pretest Scores

Homogeneity and Normality Test for Pretest

The initial abilities of the experimental and control groups were evaluated using the homogeneity test on pretest data. Table 2 below displays the findings of the homogeneity test for the pretest data for students in both classes.

Table 2. Results of the Homogeneity Test for Critical Thinking Skills Pretest Scores

Class	F_{hitung}	F_{tabel} ($\alpha = 0,05$)	Homogeneity test results
Experimental control	1,27	2,00	Homogen

Table 2 shows $F_{hitung} < F_{tabel}$ (1,27 < 2,00). This indicates that both classes are homogeneous (have the same initial abilities) at the 5% significance level.

To ascertain whether the initial data from both groups were normally distributed and whether the follow-up statistical tests used to evaluate the hypotheses were valid, a normality test was performed on the pretest data from the experimental and control classes. Table 4.7 below displays the findings of the normalcy test for the original test data.

Table 3: Results of the Normality Test for the Critical Thinking Skills Pretest

Class	χ^2_{hitung}	χ^2_{tabel} ($\alpha = 0,05$)	Normality test results
Experimental	5,3975	11,070	Normal
control	7,7378	11,070	Normal

Table 3 shows that the calculated x^2_{hitung} for both classes is smaller than the x^2_{table}. This indicates that the critical thinking ability data for both classes is normally distributed.

Critical Thinking Ability Posttest Results

The final exam results, given in essay format and comprising 10 questions, provided the final critical thinking ability test data for the experimental and control courses. The highest and lowest data models were obtained. Table 4 below shows the experimental and control classes' posttest critical thinking ability results.

Table 4. Posttest Critical Thinking Ability Scores for Students in Physics

Class	N	Lowest Value	Highest Value	Mean	Critical thinking category
Experimental	25	55	75	68,70	medium
control	24	52,5	72,5	61,56	low

According to Table 4 above, the experimental class's lowest score was 55, whereas the control class's lowest score was 52.5. The control class's highest score was 72.5, whereas the experimental class's best score was 75. The experimental and control groups received average scores of 68.70 and 61.56, respectively. Figure 2 displays the posttest results for the experimental and control groups on the critical thinking abilities test.

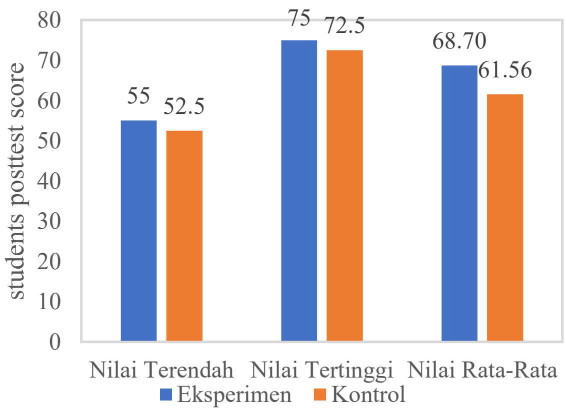

Figure 2. Posttest Score of Students' Physics Critical Thinking Ability

Posttest Data Homogeneity and Normality Test

The follow-up hypothesis testing was determined using the posttest data homogeneity test. Table 4.9 below displays the findings of the posttest homogeneity test for students' critical thinking abilities.

Table 5. Results of the Posttest Homogeneity Test for Critical Thinking Skills Scores

Class	F_{hitung}	F_{tabel} ($\alpha = 0,05$)	Homogeneity test results
Eksperimental Control	1,25	2,00	Homogen

Table 5 shows $F_{hitung} < F_{tabel}$ (1,25 < 2,00). This indicates that both classes are homogeneous (have the same initial abilities) at the 5% significance level.

Posttest Data Normality

The posttest results from the experimental and control groups were subjected to a normality test to determine whether they were normally distributed and to identify the appropriate statistical tests to test the hypotheses. Table 6 below displays the posttest data's normalcy test findings.

Table 6. Results of the Posttest Normality Test for Critical Thinking Skills

Class	χ^2_{hitung}	χ^2_{tabel} ($\alpha = 0,05$)	Normality test results	Hasil Uji Normalitas
Eksperimental	4,7621	11,070	Normal	Normal
Control	6,7029	11,070	Normal	Normal

Table 6 shows x^2_{hitung} for both classes is smaller than the table x^2_{tabel}. This suggests that both classes' critical thinking skill data are distributed regularly.

Furthermore, the average posttest scores for each indicator of critical thinking ability for both classes are shown in Table 7 and Figure 3.

Table 7: Posttest Average for Each Critical Thinking Ability Indicator

Indicator	Eksperimental class	Control Class
Interpretation	2.62	2,20
Analysis	3,10	2,41
Evaluation	2,56	2,29
Inferensi	2,78	2,35
Eksplanation	2,74	2,52

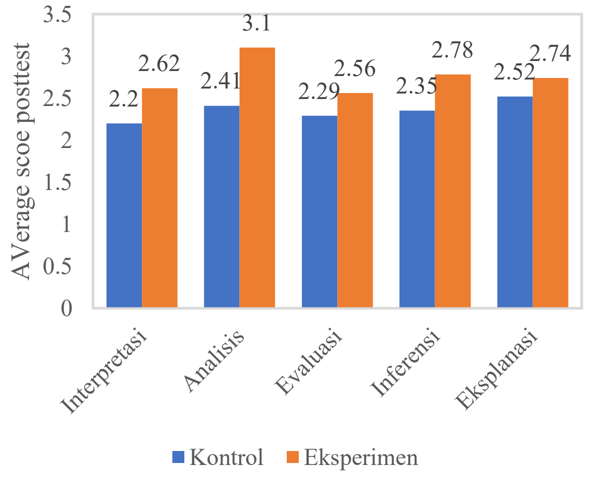

Figure 4.3 Average Posttest Critical Thinking Ability of Physics Students for Each Indicator

Hypothesis testing

The results of the hypothesis test can be seen in Figure 4.4

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai	Equal variances assumed	5.482	.024	2.195	47	.033	172.554	78.609	14.413	330.695
	Equal variances not assumed			2.189	45.610	.034	172.554	78.828	13.846	331.263

Discussion

According to the research findings, students in the experimental class had very low average pretest scores on critical thinking, whereas students in the control group also had very low scores. Both classes have incredibly low levels of critical thinking abilities. This indicates that the current learning process has not improved critical thinking skills because the cognitive aspect emphasises outcomes rather than the process aspect, resulting in low critical thinking skills. Furthermore, another factor is that both sample groups have not received material on the global warming phenomenon appropriate to their level, but only introductory material at the junior high school level. This average pretest score for critical thinking serves as a benchmark for measuring improvement in students' critical thinking.

Students are guided to actively participate in their education by the phases of the problem-based learning approach. Students are assisted in resolving issues that arise in daily life. Students' critical thinking abilities will be stimulated by engaging them in active thinking during the learning process. Every phase of the problem-based learning paradigm allows for the development of students' critical thinking abilities. Organizing students to learn is the first step. At this point, the instructor provides examples, asks questions, and collects students' answers. Giving kids questions and demonstrations will help them develop their critical thinking abilities as they consider the solutions. Interpretation is a sign of critical thinking abilities that can be developed during the learning organization phase., because at this stage students are given a question about the material on global warming symptoms that requires students to express their initial knowledge or initial opinions about the relationship between the symptoms of global warming in the given LKPD, and are given questions related to everyday life related to the material on global warming symptoms. In this initial stage, students have trained their critical thinking skills in answering questions from the teacher.

The second stage organizes students' learning. In this stage, since the teacher serves as a facilitator, students must actively investigate their own knowledge to motivate themselves. Students receive LKPD in this second phase, which is intended to hone their critical thinking abilities. Because students are granted LKPD about the content of global warming symptoms, analysis is the indicator with the highest average score based on the final exam results., students' analysis is trained by being able to analyze based on the problems that exist in each LKPD given.

The third phase directs both individual and group research. At this point, students clarify their explanations and use their own language to illustrate the concepts. Students are trained to conduct experiments and observations relevant to the sub-material provided in the LKPD, which helps them develop two critical thinking skills: inference and analysis. Students are required to notice the surrounding environment in relation to the idea of global warming symptoms during the observation stage, after which they are requested to describe and evaluate why it is included in the concept, Students are asked to provide clarification in the form of pertinent facts and data based on the outcomes of the experiments that have been conducted in order to explain the findings of observations regarding the material on global warming symptoms that they have understood through the LKPD that has been completed with the group.

Developing and assessing the outcomes is the fourth step. Students now present the findings from their observations. Explanation indicators are among the critical-thinking abilities that can be developed in this fourth stage, when pupils are taught to solve and explain the issues they encounter. The process of creating and assessing the outcomes develops students' capacity to communicate their ideas and explain reasons, based on evidence, methodological concepts, criteria, and context, through the Student Worksheet (LKPD) completed on the material on global warming symptoms. To develop their critical thinking abilities, pupils have begun to build their own understanding and reflect on the information they have received.

Examining every experience from every phase of the problem-based learning model is the fifth step in the analysis and evaluation of the problem-solving process. At this point, the instructor allows each group to share their conclusions from the material they have studied, specifically regarding the symptoms of global warming. Additionally, the instructor supports the viewpoints that each group has voiced. Critical thinking abilities, specifically evaluation, can be developed at this fifth level. The conclusion regarding the information developed by the teacher and pupils is the evaluation indicator that appears. According to Snyder & Snyder (2008), training, practice, and patience are necessary for the development of critical thinking skills, which is demonstrated by the series of lessons used in the experimental class. Critical thinking abilities must be taught in order to prepare children to think critically; they do not develop naturally (Rahma, 2012).

Compared with direct learning methods, problem-based learning models enable students to develop critical thinking more effectively. This is consistent with the experimental class's average critical thinking skill score being higher than that of the control group. The experimental class's average posttest score falls into the medium range, whereas the control group's falls into the low range. According to the collected data, the average score in the experimental class increased statistically significantly. This rise in the mean score suggests that the use of problem-based learning methods impacts critical thinking abilities. According to the hypothesis test results, the critical thinking abilities of MAN 1 Central Lombok class XI students are affected by problem-based learning models. This is possible because this approach maximizes student participation in the learning process, transforming them into active learners through a sequence of exercises that teach them to find their own knowledge. This exercise develops critical thinking abilities. This is consistent with what Udayani et al. (2014) stated: if kids encounter problems regularly, their critical thinking abilities will grow. Critical thinking abilities can be enhanced by learning that requires maximum participation in the learning process. The study's findings are consistent with those of Aryawati et al. (2020), who found that students who learn using a problem-based learning model and those who learn using a direct instruction approach exhibit different levels of critical thinking. This is because the stage of directing individual and group investigations will involve student abilities, including the capacity to concentrate in accordance with the goals of the experiment or investigation being conducted, the capacity to gather information or the investigation's results, the capacity to organize the results of observations, the capacity to analyze the investigation's results, the capacity to analyze after organizing, and the capacity to generalize. After all, psychology claims that critical thinking emphasizes procedural and process skills.

Because the control group employed a traditional learning approach, their average final exam scores were substantially lower than those of the experimental group. Students' learning time is poorly controlled since this learning model contains fewer, less dense learning stages than the problem-based learning model. Because of this, many students do other things while they are learning, such as chatting with friends, daydreaming, and feeling drowsy. The teacher serves as the focal point of knowledge in the control class. The conventional learning model also includes lecture and discussion stages, during which students are instructed to engage in discussion activities. Students engage in discussions only to reinforce concepts presented by the teacher in class; in other words, they verify concepts they have learned, so their critical thinking skills are categorized as low. According to Sulistyowati et al. (2014), the conventional model applied in learning forces students to remain concentrated using limited listening. The conventional model makes it difficult for students to identify the teacher's analytical, synthetic, critical, and evaluative ideas. The conventional model creates a monotonous learning environment, quickly leading to student boredom. The discussion method used by subject teachers also does not encourage active participation. Students work in groups to answer questions in worksheets (LKS) and discuss the material without teacher guidance, simply submitting written reports. The learning method used in the control class does not encourage students to develop their critical thinking skills.

CONCLUSION

This study shows how the problem-based learning approach affects students' capacity for critical thought. Through a methodical approach, this learning style gives students the chance to solve problems, engage in active learning, and hone their critical thinking skills. The study's findings corroborate earlier research and offer instructors helpful suggestions for creating learning models that enhance students' critical thinking abilities.

ACKNOWLEDGEMENT

The University of Mataram, MAN 1 Central Lombok, the students at MAN 1 Central Lombok, and everyone else who helped with this research are all appreciated by the author.

REFERENCES

Andriyani, R., & Saputra, N. N. (2020). Optimalisasi kemampuan higher order thinking skills mahasiswa semester awal melalui penggunaan bahan ajar berbasis berpikir kritis. *Al-Khwarizmi: Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam, 8*(1). https://doi.org/10.24256/jpmipa.v8i1.948

Arifin, S., Setyosari, P., Sa'dijah, C., & Kuswandi, D. (2020). The effect of problem-based learning by cognitive style on critical thinking skills and student retention. *Journal of Technology and Science Education, 10*, 271-281. https://doi.org/10.3926/jotse.790

Arikunto, S. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta.

Aryawati, N. P. A., Pujani, N. M., & Widyanti, N. L. (2020). Pengaruh model problem-based learning terhadap keterampilan berpikir kritis dalam pembelajaran biologi ditinjau dari gaya kognitif siswa kelas X SMA. *Jurnal Matematika, Sains, dan Pembelajarannya, 14*(2), 105-124. https://doi.org/10.23887/wms.v14i2.24141

Ennis, R. H. (2011). The nature of critical thinking: An outline of critical thinking dispositions and abilities. *Presentation at the Sixth International Conference on Thinking at MIT,* Cambridge, MA, July, 1994. Faculty of Education, Illinois. Retrieved from https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking_51711_000.pdf

Facione, P. A. (2010). *Critical Thinking: What It Is and Why It Counts*. USA: Insight Assessment. Retrieved from https://www.law.uh.edu/blakely/advocacy-survey/Critical%20Thinking%20Skills.pdf

Harahap, A., Irwan, Musdi, E., & A, A. (2021). Pengembangan Media Pembelajaran Interaktif Berbasis Problem Based Learning (PBL) Berbantuan Android Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Peserta Didik Kelas VII SMP Negeri 1 Sosopan. *JEMS: Jurnal Edukasi Matematika Dan Sains*, 9(2), 371–383.

Hardiyanto, H., Failasofah, F., Armiwati, A., Abrar, M., & Thabran, Y. (2021). Students' practices of 21st-century skills between conventional learning and blended learning. *Journal of University Teaching and Learning Practice, 18*(3). https://doi.org/10.53761/1.18.3.7

Hidayatin, S., Verawati, N. N. S. P., Susilawati, S., & A, S. (2022). Pengembangan Perangkat Pembelajaran Berbasis Problem based learning untuk Meningkatkan Penguasaan Konsep Fisika Materi Momentum dan Impuls Class X. *Jurnal Ilmiah Profesi Pendidikan*, 7(2b), 663–671. https://doi.org/10.29303/jipp.v7i2b.623

Junaidi, J., Roza, Y., & Maimunah, M. (2020). Kemampuan berpikir siswa dalam menyelesaikan soal HOTS pada materi pola dan barisan bilangan. *E-Saintika: Jurnal Penelitian dan Pengkajian Ilmu Pendidikan, 4*(2), 173. https://doi.org/10.36312/e-saintika.v4i2.220

Lefrida, R., Siswono, T. Y. E., & Lukito, A. (2021). Process-oriented routines of students in heterogeneous field dependent-independent groups: A commognitive perspective on solving derivative tasks. *European Journal of Educational Research, 10*(4), 2017-2032. https://doi.org/10.12973/eu-jer.10.4.2017

Malanog, S., & Aliazas, J. (2021). Active learning strategies and higher-order thinking skills of grade 10 students. *International Multidisciplinary Research Journal,* 3(3), 241-249. https://doi.org/10.54476/iimrj255

Marwan, M., Khaeruddin, K., & Amin, B. D. (2020). Pengembangan instrumen asesmen higher order thinking skills (HOTS) pada bidang studi fisika. *Prosiding Seminar Nasional Fisika PPs UNM, 02*, 116–119. Retrieved from https://ojs.unm.ac.id/semnasfisika/article/view/14365

Nasution, S. W. R. (2018). Penerapan model inkuiri terbimbing (guided inquiry) dalam meningkatkan kemampuan berpikir kritis pada pembelajaran fisika. *Jurnal Education and Development*, 3(1), 1-1. DOI: https://doi.org/10.37081/ed.v3i1.85

Nugraha, A., Suyitno, H., & Susilaningsih, E. (2017). Analisis Kemampuan Berpikir Kritis Ditinjau dari Keterampilan Proses Sains dan Motivasi Belajar melalui Model PBL. *Journal of Primary Education*, 6(1), 35-43. DOI: https://doi.org/10.15294/jpe.v6i1.14511.

Oktaviani, L., Dantes, N., & Sadia, W. (2014). Pengaruh model problem-based learning berbasis asesmen kinerja terhadap hasil belajar IPA ditinjau dari gaya kognitif. *Jurnal Ilmiah Pendidikan dan Pembelajaran Ganesha, 4*(1), 1-11. Retrieved from https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ep/article/view/1117

Pepo, A. R. R., Arjaya, I. B. A., & Paraniti, A. A. I. (2019). Penerapan model pembelajaran problem-based learning berbasis Google Classroom terhadap kemampuan berpikir kritis ditinjau dari gaya kognitif siswa. *Jurnal Biologi Kontekstual, 1*(2), 152-163. Retrieved from https://e-journal.unmas.ac.id/index.php/JBK/article/view/628

Persky, A., Medina, M., & Castleberry, A. (2019). Developing critical thinking skills in pharmacy students. *American Journal of Pharmaceutical Education, 83*. https://doi.org/10.5688/AJPE7033

Pritchard, A. (2009). *Ways of Learning: Learning Theories and Learning Styles in the Classroom*. New York: Routledge Taylor & Francis Group.

Rahmawati, K. M., Prastowo, S. H. B., & Bektiarso, S. (2019). Pengembangan Bahan Ajar Fisika Berbasis Scientific Approach Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Pada Materi Medan Magnet Di SMA. *Jurnal Pembelajaran Fisika*, 8(2), 80-86. DOI: https://doi.org/10.19184/jpf.v8i2.11663.

Rizaldi, D. R., Doyan, A., Makhrus, M., Fatimah, Z., & Pineda, C. I. S. (2021). The Relationship Between Learning Style and Critical Thinking Skills in Learning Kinetic Theory of Gases. *Journal of Science and Science Education*.2 (2), 72-76. DOI : https://doi.org/10.29303/jossed.v2i2.488.

Rizaldi, D. R., Makhrus, M., & Doyan, A. (2019). Analisis Tingkat Kemampuan Berpikir Kritis dengan Model Perubahan Konseptual ditinjau dari Gaya Belajar Peserta didik. *Jurnal Pendidikan Fisika dan Teknologi*, 5(1), 74-81. DOI: http://dx.doi.org/10.29303/jpft.v5i1.794.

Sari, IP., Sutarto, Mudakir, I., Supeno., & Budiarso, A. S. (2020). Instructional Materials for Optical Mater Based On STEM-CP (Science, Technology, Engineering, Mathematics-Contextual Problem) to Increase Student Critical Thinking Skills in High School. *Journal of Physics: Conference Series*. 1563: 1-7. https://doi.org/10.1088/1742-6596/1563/1/012052

Sarwanto, S., Fajari, L., & Chumdari, C. (2021). Critical thinking skills and their impacts on elementary school students. *Malaysian Journal of Learning and Instruction,* 18(2), 161-188. https://doi.org/10.32890/mjli2021.18.2.6

Son, A., Darhim, D., & Fatimah, S. (2020). Students' mathematical problem-solving ability based on teaching models intervention and cognitive style. *Journal on Mathematics Education, 11*(2). https://doi.org/10.22342/jme.11.2.10744.209-222

Sundayana, R. (2016). *Statistika Penelitian Pendidikan*. Bandung: Alfabeta.

Susilawati, S., & Doyan, A. (2023). The Influence of Problem Based Learning (PBL) Model on Students Learning Outcome. *Jurnal Penelitian Pendidikan IPA*, 9(2), 1004–1008. https://doi.org/10.29303/jppipa.v9i2.4587

Tanjung, Y., Irfandi, I., Sudarma, T., Lufri, L., Asrizal, A., & Hardeli, H. (2023). The effect of constructivism learning on student learning outcomes: A meta-analysis study. *ISER (Indonesian Science Education Research)*, 28-36. https://doi.org/10.24114/iser.v5i1.49409

Valdez, J. E., & Bungihan, M. E. (2019). Problem-based learning approach enhances the problem solving skills in chemistry of high school students. *Journal of Technology and Science Education*, 9(3), 282–294. https://doi.org/10.3926/JOTSE.631

Widiawati, R., Hikmawati, H., & Ardhuha, J. (2022). Pengembangan Perangkat Pembelajaran Berbasis Model Problem based learning untuk Meningkatkan Kemampuan Pemecahan Masalah Fisika Peserta Didik pada Materi Fluida Dinamis. *Jurnal Ilmiah Profesi Pendidikan*, 7(3c), 1803–1810. https://doi.org/10.29303/jipp.v7i3c.857

Wijaya, A. P. (2020). Gaya kognitif field dependent dan tingkat pemahaman konsep matematis antara pembelajaran langsung dan STAD. *Jurnal Derivat: Jurnal Matematika dan Pendidikan Matematika, 3*(2), 1-16. Retrieved from https://journal.upy.ac.id/index.php/derivat/article/view/713

Witkin, H. A., & Goodenough, D. R. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research, 47*(1), 1-64. Retrieved from https://psycnet.apa.org/record/1979-06062-001