JoSSEd
Journal of Science and Science Education
ISSN: 2774-1869 eISSN: 2774-2105

The Influence of Problem-Based Learning Models on Students' Critical Thinking Skills Reviewed from Cognitive Style

Nisa Hidayatullah[1*], I Wayan Gunada[1], Susilawati[1], Muhammad Zuhdi[1]

[1] Physics Education, Faculty of Teacher Training and Education, University of Mataram, Lombok, NTB, Indonesia

Received: November 6, 2024
Revised: March 21, 2025
Accepted: April 26, 2025
Published: April 30, 2025

Corresponding Author:
Nisa Hidayatullah
nisahidayatullah3@gmail.com

DOI: 10.29303/jossed.v6i1.9644

Abstract: This study aims to analyze the effect of problem-based learning models on students' critical thinking skills in terms of cognitive style, analyze the effect of cognitive style on students' critical thinking skills, and analyze the interaction between problem-based learning models and cognitive styles on students' critical thinking skills. The type of research used is quasi-experimental with a factorial design research design. The population in this study were all students of class XI IPA at MAN 1 Central Lombok. The research sample was taken using a purposive sampling technique. The data collection technique in this study was taken using an instrument for students' critical thinking skills: a descriptive test of 10 questions and data collection of cognitive styles using the Group Embedded Figure Test (GEFT) instrument. The research hypothesis was tested using a two-way ANOVA test. The study results showed that: 1) there is an influence on students' critical thinking skills based on the problem-based learning model with a significant level of 0.000 <0.050. 2) cognitive style influences students' critical thinking skills with a significant level value of 0.001 <0.050. 3) there is no interaction between cognitive style and problem-based learning model on students' critical thinking ability with a significance level of 0.097>0.050. Thus, it means that the problem-based learning model influences students' critical thinking ability, cognitive style influences students' critical thinking ability, and there is no interaction between cognitive style and learning model on students' critical thinking ability.

Keywords: Cognitive Style; Critical Thinking Skills; Field Dependent; Field Independent; Problem Based Learning

Introduction

The world of education is facing the era of industrial revolution 5.0. In this era of revolution, students are expected to be able to master the skills found in the 21st century, which consist of life skills, thinking skills, and acting skills (Marwan et al., 2020). Education in this era also emphasizes the importance of developing critical thinking skills in students. Critical thinking solves problems that affect students' success (Hardiyanto et al., 2021). Critical thinking is also an effort in self-regulation to decide something that results in analysis, interpretation, evaluation, and presentation using a concept, evidence, criteria, methodology, and contextual considerations that are the basis for making a decision (Facione, 2006). Critical thinking is closely related to high-level thinking because all components of high-level thinking are found in critical thinking skills (Suciati, 2022). Critical thinking skills are logical, reflective, systematic, and productive thinking skills used to make the right decisions (Sari et al., 2019). Critical thinking is a process that deliberately assesses the quality of one's thinking by using reflective, independent, transparent, and rational thinking (Rizaldi et al., 2019). This process is a form of critical thinking that needs to be developed in a person (Rizaldi et al., 2021). Critical thinking is an attitude to thinking deeply about problems and things that are within the scope of a person's knowledge experience of methods and logical reasoning and the ability to apply these methods (Nasution, 2018; Nugraha et al., 2017; Rahmawati et al., 2009). Therefore, students can hone their thinking skills through high-level learning or High Order Thinking skills (HOTS). High-level thinking skills or High Order Thinking Skills (HOTS) are the abilities possessed by students in processing information or ideas critically and creatively in order to be able to solve a problem that involves the process of analysis, interpretation, evaluation, and

How to Cite:
Hidayatullah, N., Gunada, I. W., Susilawati, S., & Zuhdi, M. (2025). The Influence of Problem-Based Learning Models on Students' Critical Thinking Skills Reviewed from Cognitive Style. *Journal of Science and Science Education*, *6*(1), 37–45. https://doi.org/10.29303/jossed.v6i1.9644

creation (Juniadi et al., 2020). Problem-solving is the highest component in HOTS questions that can be solved with critical thinking skills (Andriyani et al., 2022). In other words, high-level thinking skills (HOTS) possessed by students can help them solve problems by involving critical and creative thinking skills to produce solutions to the problem. This high-level thinking ability can also be developed through interactive classroom learning because it can build students' critical thinking skills. The learning method that can be used as a tool to develop students' high-level thinking skills is the problem-based learning model. Based on the results of an interview conducted with a Physics teacher at a school in Central Lombok Regency, it was found that students' ability to analyze physics problems still needed to improve. This affects the average value of students' learning outcomes in the Physics subject of class XI IPA. The results show that 1 out of 5 classes scored above the Minimum Completion Criteria, and four scored below the KKM. Students still need help solving problems given by teachers, both in the form of questions and projects. Therefore, efforts are needed to improve students' abilities to solve problems teachers give. One of the learning approaches that can encourage the development of student's critical thinking skills is a problem-based learning model.

This problem-based learning model has been widely recognized as a model that can develop critical thinking skills, such as research conducted by Junaidi et al. (2020), which shows that students with critical thinking skills can solve HOTS questions well. This problem-based learning has a syntax that focuses on the problems presented by the teacher to students by solving the problems with the knowledge and skills they have and from various sources they have (Lidinillah, 2007). Problem-based learning is a learning model that focuses on identifying a problem and developing a solution plan. This learning model is designed to increase the potential for thinking and solving problems (Harahap et al., 2021). Problem-based learning is learning designed around comprehensive, accurate, and complex problems that provide opportunities for students to acquire knowledge, understanding, and skills that the curriculum has determined (Valdez et al., 2019). The problem-based learning model is one of the classroom learning models with the characteristics that in classroom learning activities, there are real problems that can be used as a reference for students to solve these problems (Susilawati et al., 2023). In addition, the problem-based learning model can also motivate students to develop and organize their knowledge (Widiawati et al., 2022) and hone high-level skills (Hidayatin et al., 2022). This problem-based learning model also offers a learning concept where students face authentic problems requiring in-depth analysis, problem-solving, and critical thinking to achieve deep understanding. However, in its application, the effectiveness of problem-based learning can vary depending on individual characteristics, including cognitive style.

Cognitive style also refers to how a person processes information, solves problems, and faces intellectual tasks. Felder-Silverman's learning theories identify variations in students' cognitive learning styles, such as visual-verbal, active-reflective, and sensitive-intuitive learning styles; these three learning styles can influence how students respond to and process information. Students with a field-independent cognitive style generally process the information they receive in learning. In contrast, students with a field-dependent cognitive style generally accept the information available (Wijaya, 2020). Students with a field-independent cognitive style are generally more independent in learning and are curious about a field and the problems they like. They like learning, which involves their activities in finding knowledge. The knowledge they acquire will be understood more quickly and stored in their memory longer. Students with a field-dependent learning style generally need help from others in understanding learning information. They prefer to learn something specific, do not like independent tasks, and have good imagination skills.

This study aims to test the effect of using problem-based models on students' critical thinking skills as viewed from cognitive style. Hopefully, this study can add more profound insight into problem-based learning models, as viewed from the cognitive style perspective, in improving students' critical thinking skills. The benefits of this study are expected to provide a better understanding to educators and students in improving the quality and learning outcomes in the classroom. In addition, this study is also expected to be a guide in implementing problem-based learning strategies as viewed from a cognitive style.

Method

This study used a quasi-experimental method without conducting random subject selection. The subjects in this study were in the form of predetermined groups. This study used a factorial design. Two groups of classes: the experimental class and the control class. Both classes were given field-independent and field-dependent cognitive style interventions with conventional learning models in the control class and problem-based learning models in the experimental class. Before being given adaptation, students were given a cognitive style test instrument to obtain data on cognitive power tendencies and an initial test to determine the level of critical thinking skills. After being given adaptation by applying a problem-based learning model in the experimental class and conventional learning in the control class, students were given a final test to determine their level of critical thinking skills. The population in this study is described in Table 1. The population of this study was all students of class XI MAN 1 Lombok Tengah. The selected sample consisted of students from class XI IPA 1 as the control class and class XI IPA 2 as the experimental class. This study uses a critical thinking ability test as a post-test and pre-test. It conducts a cognitive style test as a Group Embedded Figure Test (GEFT) instrument for the experimental and control groups. Furthermore, they provided experimental class treatment in the form of learning activities using a problem-based model and provided treatment to the control class using a conventional model.. The research flow can be seen in Figure 1.

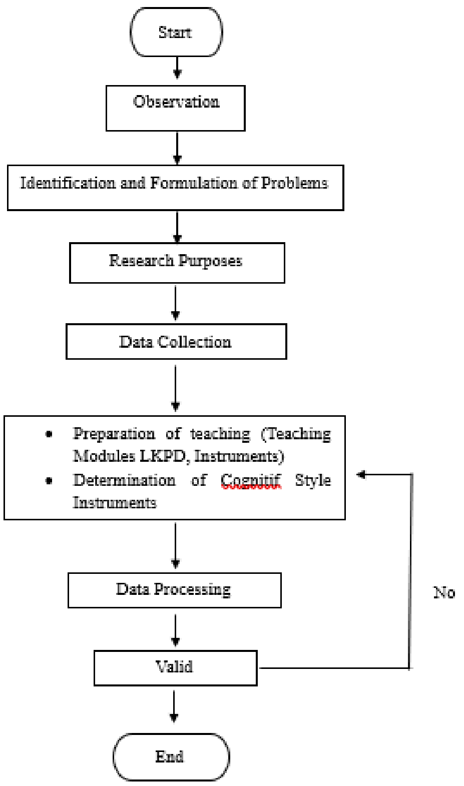


Figure 1. Research Flow

Table 1 *Non-equivalent Control Group Design*

Class	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

Information:

- O_1 : Experimental and control classes before being given treatment
- O_2 : Experimental and control classes after being given treatment
- X_1 : PBL model assisted by physics learning videos on static fluid material
- X_2 : Conventional learning model

$$r_{xy} = \frac{N\,\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\{(N\,\Sigma X^2) - (\Sigma X)^2\}\{(N\,\Sigma Y^2) - (\Sigma Y)^2\}}} \quad (1)$$

Information:

- r_{xy} : Correlation coefficient between variables X and Y
- N : Number of students
- ΣX : Number of values of variable X
- ΣY : Number of variables Y
- ΣXY : Number of values of multiplication of X and Y
- $(\Sigma X)^2$: Number of variables X squared
- ΣX^2 : Number of squares of variables X
- $(\Sigma Y)^2$: Number of variables Y squared
- ΣY^2 : Number of squares of variables Y

The validity test can be found using the Pearson product-moment formula (Sundayana, 2016) as Equation 1. The r_xy value is then consulted with the "r" Product moment table with a significance level of 5%. 2 criteria occur. If r_xy ≥ r_table, then the question is said to be valid; if r_xy <r_table, then the question is said to be invalid.

Question reliability test: A Reliability test is usually used to find out how precise the measuring instrument will be used to measure. A test is reliable if the measurement results from the tested group show consistency. This means the ability of an instrument or test to produce scores that are close to the same for each individual if repeated testing is carried out on the same or different individuals (Sundayana, 2016). Reliability refers to an understanding that an instrument can be trusted to be used as a data collection tool. Reliable means trustworthy, meaning it can be relied on (Arikunto, 2013). The reliability test used Cronbac's Alpha formula or Alpha Coefficient as Equation 2 (Sundayana, 2016). The r_11 value obtained was then compared with the r-product moment table with a significance level of 5%. There are two criteria for the results obtained: if r_11 ≥ r_table, then the question is said to be reliable, and if r_11 < r_table, then the question is said to be unreliable.

Level of difficulty of questions The instrument questions used are relatively straightforward. Each question item's difficulty level must be evenly divided into easy, medium, and complex. This aims to ensure that the instrument is easy for students to complete. The equation used to determine the difficulty of essay-type questions 3 (Sundayana, 2016).

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\Sigma s_i^2}{s_t^2}\right) \quad (2)$$

Information:

- r_{11} : Instrument reliability
- n : Number of questions
- Σs_i^2 : Number of item variants

s_t^2 : Total variance

$$TK = \frac{SA+SB}{IA+IB} \quad (3)$$

Tabel 2. Classification of Question Difficulty Level

Question items	Difficulty Level	Category
1	TK = 0.00	Too difficul
2	0.00 < TK ≤ 0.30	Difficult
3	0.30 < TK ≤ 0.70	Medium
4	0.70 < TK ≤ 1.00	Easy
5	TK = 1.00	Too easy

(Sundayana, 2016)

Discriminatory power is the ability of questions to differentiate between high-ability and low-ability students. The equation for determining the discriminatory power of essay-type questions is shown by Equation 4 (Sundayana, 2016).

$$DP = \frac{SA-SB}{IA} \quad (4)$$

Information:
TK : Difficulty level
DP : Differential power
SA : Total score of upper groups
SB : Total score of lower groups
IA : Total ideal score of upper groups
IB : Total ideal score of lower groups

Tabel 3. Classification of Differential Power of Question Items

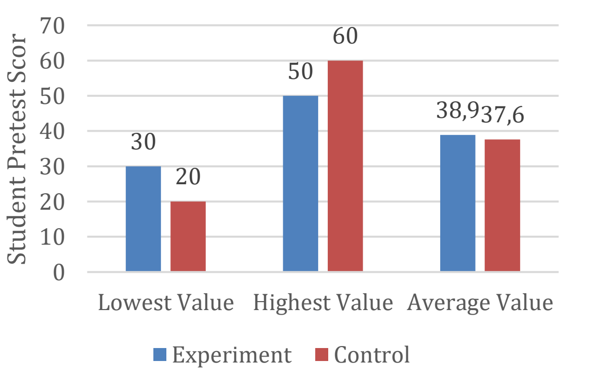
Question items	Difficulty Level	Category
1	DP = 0.00	Very low
2	0.00 < DP ≤ 0.20	low
3	0.20 < DP ≤ 0.40	middle
4	0.40 < DP ≤ 0.70	high
5	0.70 < DP ≤ 1.00	Very high

Results and Discussion

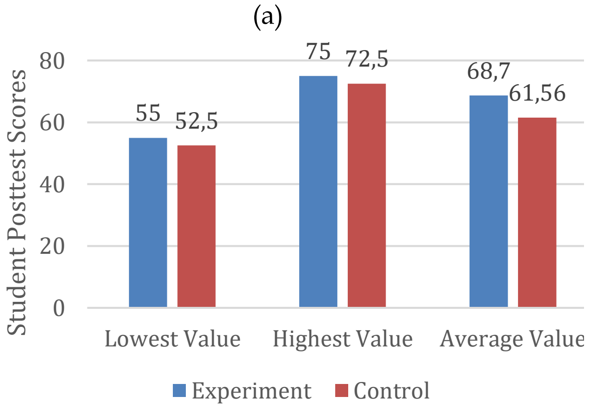
Result

This study evaluates students' critical thinking skills through problem-based learning models compared to conventional ones. The instrument trial conducted in class X E-4 MAN 1 Lombok Tengah showed that all ten questions were valid and reliable. Analysis of the level of difficulty of the questions showed 4 questions in the difficult category and six questions in the medium category. In contrast, the discriminant power test showed 1 question in the high category, seven in the medium category, and two in the low category. This study was conducted in class XI MIPA 1 as the experimental class and XI MIPA 2 as the control class, each for five meetings. At the beginning of the study, a pretest was conducted to measure students' initial critical thinking skills. The pretest results showed that both classes had deficient initial skills, with an average score of 38.90 for the experimental and 37.60 for the control classes. After being given different treatments, a posttest was conducted to measure the increase in students' critical thinking skills. The results showed a significant increase in the experimental class with an average score of 68.70, while the control class obtained an average score of 61.56. Overall, the experimental class showed higher improvements in all indicators of critical thinking skills compared to the control class (Figure 3).

As a moderator variable, students' cognitive style was measured using the GEFT test. The distribution of cognitive style in the experimental class was 52% field-independent and 48% field-dependent, while in the control class, it was 46% field-independent and 54% field-dependent. Critical thinking skills based on cognitive style showed that students with field-independent cognitive style in the experimental class had an average score of 75.45, higher than those in the control class with an average score of 66.73. Students with a dependent cognitive style in the experimental class had an average score of 70.83, also higher than those in the control class, with an average score of 58.64



(a)



(b)

Figure 2. Graph of Pretest (a) and Post Test (b) Results in the experimental class and control class

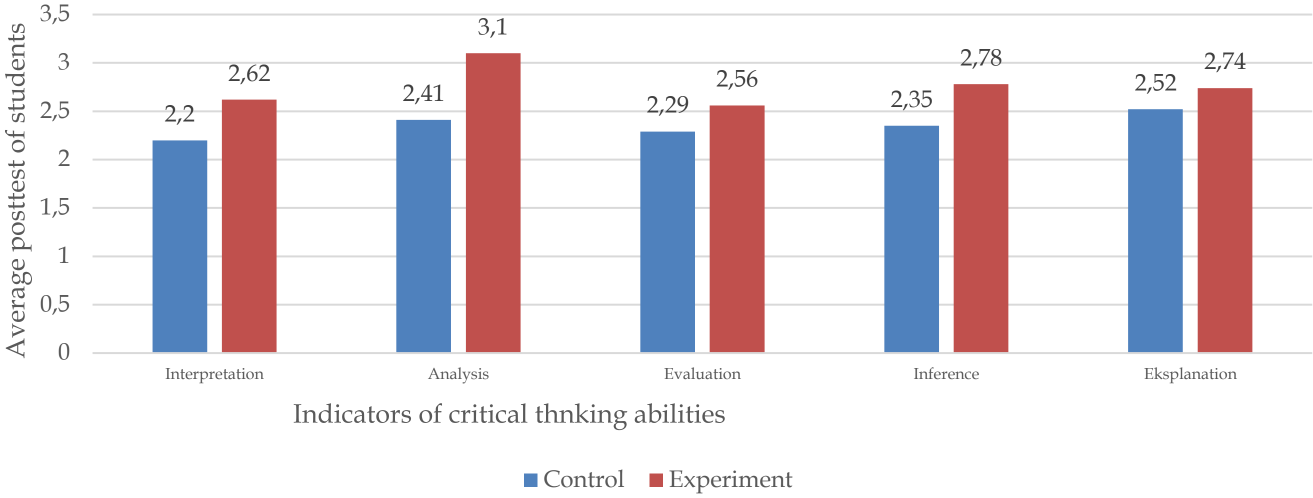


Figure 3. Average Posttest Critical Thinking Ability of Physics Students for Each Indicator

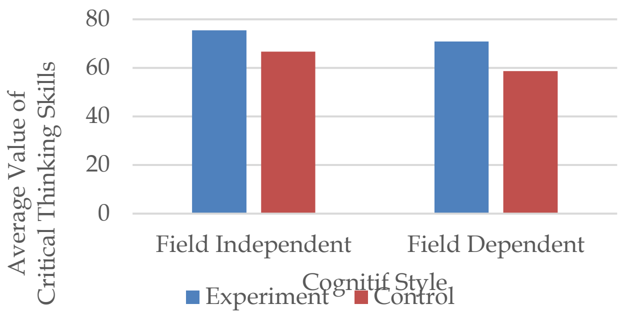


Figure 4. Comparison of critical thinking skills based on students' cognitive styles

Hypothesis test analysis using a two-way ANOVA parametric statistical test shows that the problem-based learning model significantly affects student's critical thinking skills ($p < 0.05$). In addition, cognitive style also has a significant effect on students' critical thinking skills ($p < 0.05$). However, there is no significant correlation between the problem-based learning model and cognitive style in terms of students' critical thinking skills ($p > 0.05$). The results of the hypothesis test can be seen in Table 4.

Tabel 4. Average Level of Critical Thinking Skills Per Student Indicator

Cognitive Style Class	Cognitive Style Class	Average level of Critical Thinking Ability per Indicator				
		A	B	C	D	E
Field Independent Experiment (13 students)	Field Independent Experiment (13 students)	68	85	69	74	71
Field Dependent (12 students)	Field Dependent (12 students)	63	70	59	65	66
Field Independent Control (13 students)	Field Independent Control (13 students)	62	65	66	64	66
Field Dependent	Field Dependent (11 students)	44	51	44	49	55

Information
A : Interpretation
B : Analysis
C : Evaluation
D : Inference
E : Explanation

Tabel 4. Hypothesis Test Analysis Results

Source	Sum of Squares Type III	Df	Mean Square	F	Sig
Model	1099.537	1	1099.537	54.174	0.000
Cognitive Style	255.381	1	255.381	12.583	0.001
Model×Cognitive Style	58.418	1	58.418	2.8780	0.097

The results of the two-way ANOVA calculation are supported by a plot diagram showing the interaction between cognitive style and learning model. Intersecting lines indicate the interaction between cognitive style and learning model, while parallel lines indicate no interaction. The image for the results of the two-way ANOVA calculation can be seen in Figure 5.

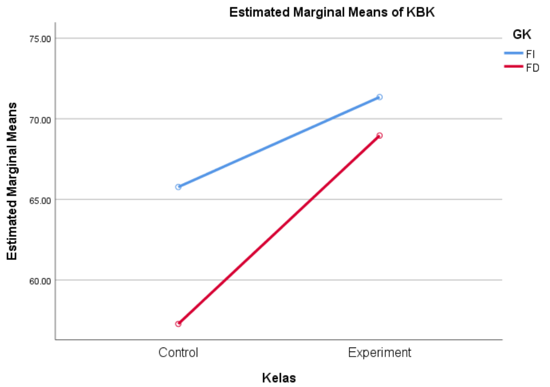


Figure 5. Interaction between problem-based learning models and cognitive styles on students' critical thinking skills

Discussion

This study was conducted in class XI at MAN 1 Lombok Tengah using two sample groups: an experimental class that uses a problem-based learning model, and a control class that applies a conventional learning model. This study aims to evaluate the effect of the problem-based learning model on students' critical thinking skills and to examine the interaction between learning models and cognitive styles on critical thinking skills.

The Influence of Problem-Based Learning Models on Students' Critical Thinking Skills

This study found that the average pretest score of students' critical thinking skills in both classes was meager. This indicates that conventional learning methods have yet to improve students' critical thinking skills. Conventional learning tends to focus on the result without involving the critical thinking process in depth. According to Ennis (2011), critical thinking involves analyzing, evaluating, and synthesizing information logically and systematically, which is not achieved in conventional learning methods.

As applied to the experimental class, the problem-based learning model is designed to stimulate students' critical thinking activities through various systematic stages. In the first stage, namely organizing students to learn, the teacher provides demonstrations and questions that stimulate students to express their prior knowledge. This is in line with the theory of constructivism, which states that knowledge is built by individuals through active interaction with their environment (Tanjung et al., 2023).

The second stage requires students to explore their knowledge with minimal guidance from the teacher, training their analytical skills. The LKPD given at this stage is designed to train indicators of critical thinking skills such as analysis and evaluation. According to Facione (2011), analytical skills involve breaking down problems into smaller parts and identifying relationships between those parts.

In the third stage, students conduct individual or group investigations, practicing their inference and analysis skills. Students are asked to observe the surrounding environment related to global warming symptoms and explain and analyze their findings. This strengthens the statement of Persky et al. (2019) that critical thinking skills can be developed through challenging and relevant learning experiences.

The fourth stage involves presenting the results of observations, which trains students' explanation skills. At this stage, students learn to convey the results of their thinking logically and systematically based on the evidence and facts they have collected. This is important for building higher critical thinking skills such as explanation and synthesis (Sarwanto et al., 2021).

The fifth stage is evaluating the entire learning process, where teachers and students together reflect on the learning that has been done. At this stage, students are trained to evaluate their conclusions based on existing evidence, which is the core of critical thinking (Ennis, 1985).

The study results showed a significant increase in critical thinking skills in the experimental class compared to the control class. The average posttest score in the experimental class showed a moderate category, while the control class was still in the low category. The problem-based learning model effectively improves students' critical thinking skills. This study supports the findings of Malanog and Aliazas (2021), which state that active involvement in learning can improve students' critical thinking skills.

The Influence of Cognitive Style on Students' Critical Thinking Skills

Everyone has different learning characteristics, one of which is cognitive style. This study categorizes students' cognitive styles into field-dependent and field-independent, based on the theory of Witkin et al. (1977). Students with field-independent cognitive styles are more able to process information analytically and independently. In contrast, students with field-dependent cognitive styles depend more on external structures and tend to see information (Pritchard, 2009).

The results of this study indicate that students with field-independent cognitive styles experience a higher increase in critical thinking skills than students with field-dependent cognitive styles. This shows that cognitive style affects students' critical thinking skills. According to research by Onyekuru (2015), students with field-independent cognitive styles can better develop their critical thinking skills because they tend to process information more deeply and analytically.

In the experimental and control classes, the division of heterogeneous groups allows students with field-independent and field-dependent cognitive styles to exchange knowledge. This allows for an optimal exchange of ideas and understanding so that students' critical thinking skills do not differ significantly between the two cognitive styles. This study supports the findings of Aryawati et al. (2020), who stated that interactions between students with different cognitive styles can enrich the learning process and improve critical thinking skills.

Interaction of Problem-Based Learning Model with Cognitive Style on Students' Critical Thinking Skills

The analysis showed no significant interaction between the problem-based learning model and cognitive style on students' critical thinking skills. Although the problem-based learning model effectively improves critical thinking skills, cognitive style only provides a significant interactive effect. This may be due to the division of heterogeneous groups that allow students with different cognitive styles to help each other solve problems (Lefrida et al., 2021).

Another factor that may influence these results is the presence of other variables that researchers cannot control, such as differences in individual abilities and the incompatibility of the learning model with students' cognitive styles. Son et al. (2020) explained that the interaction effect is the joint influence of two or more independent variables on the dependent variable. However, interaction may not occur if independent variables have significant effects separately. This study is in line with the findings of Arifin et al. (2020), which stated that there was no significant interaction between the problem-based learning model and cognitive style on student learning outcomes. The results of this study are also supported by Pepo et al. (2019), who stated that cognitive style did not significantly affect interaction with the problem-based learning model.

Overall, this study shows that the problem-based learning model effectively improves students' critical thinking skills and that cognitive styles affect students' critical thinking skills. Learning that involves in-depth critical thinking activities, analysis, evaluation, and logical and systematic synthesis of information can improve students' critical thinking skills. The results of this study also show the importance of considering students' cognitive styles in designing learning models to achieve optimal learning outcomes.

This study has several practical implications. First, teachers can use problem-based learning models to improve students' critical thinking skills. This learning model provides opportunities for students to actively participate in the learning process, solve problems, and develop critical thinking skills through systematic stages. Second, teachers must consider students' cognitive styles when designing learning models. Students with field-independent cognitive styles tend to have higher critical thinking skills, so teachers can develop learning strategies from students' cognitive styles to achieve optimal learning outcomes. This study also has several limitations. First, this study was conducted in multiple schools, so the results need to be more generalizable to a broader population. Second, this study did not consider other factors affecting students' critical thinking skills, such as learning motivation, interest, and environment. For further research, it is recommended to involve more schools and larger samples to generalize the study results to a broader population. In addition, further research can use more comprehensive measurement methods such as observation, interviews, and portfolios to measure students' critical thinking skills more comprehensively. Further research can also consider other factors influencing students' critical thinking skills, such as learning motivation, interest, and environment.

Conclusion

This study shows that the problem-based learning model improves students' critical thinking skills. This learning model provides opportunities for students to actively participate in the learning process, solve problems, and develop critical thinking skills through systematic stages. Cognitive style also affects students' critical thinking skills, where students with field-independent cognitive styles tend to have higher critical thinking skills than those with field-dependent cognitive styles. However, the interaction between the problem-based learning model and cognitive style did not significantly affect students' critical thinking skills. The results of this study support previous findings and provide practical implications for teachers in designing learning models to improve students' critical thinking skills.

Acknowledgments

The author would like to thank Mr. I Wayan Gunada, S.Si., M.Pd., and Mrs. Prof. Dra. Susilawati, M.Si., Ph.D., as the supervising lecturers who have guided us in completing this article.

Author Contributions

All authors have made a real contribution in completing this manuscript

Funding
The research received no external funding

Conflicts of Interest
The authors declare no conflict of interest

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. 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://ejournal.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. 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