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Profile of College Students' Critical Thinking Skills Assisted by Problem-Based Learning Models on Electromagnetic Material

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ABSTRACT
Objective: This research aims to analyze the profile of students' critical thinking abilities in physics learning, especially electromagnetic material, with the help of a problem-based learning model implemented at a university in Surabaya, Indonesia. **Method:** The research method used was included in preliminary research with a sample of 19 students. Data collection techniques use critical thinking skills tests, student response questionnaires, and lecturer interviews. Then, the data was analyzed using qualitative descriptions to represent the research results. **Results:** Analysis shows students' critical thinking skills are still relatively low. Critical thinking indicators that get an average score from high to low are interpretation, analysis, inference, and evaluation. An alternative that can be done to increase students' interest and critical thinking skills is to apply the PBL model in physics learning. **Novelty:** The novelty of this research lies in its new contribution to mapping students' initial abilities regarding their critical thinking skills with the help of the PBL model. This mapping helps lecturers evaluate physics learning, especially electromagnetic material, and determine what future steps can be taken to improve students' critical thinking skills.

INTRODUCTION

During the COVID-19 pandemic, which occurred from 2020 to mid-2022, learning was carried out online from home. Online learning is learning without face-to-face using platforms or media in the form of mobile learning, which utilizes various applications such as Google Classroom, Zoom, WhatsApp, and Instagram (Husna, 2020; Rozi, 2021). It is not easy to do online learning. Lecturers and students need more time to learn online (Herliandry et al., 2020) because they must prepare devices that support accessing available platforms and create appropriate class designs and delivery methods to achieve learning objectives (Sari et al., 2021). Additionally, several obstacles felt by both lecturers and students during the online learning process, namely network problems and high internet quota requirements, decrease students' response and understanding of the material presented by lecturers (Loviana et al., 2021). Nadeak et al. (2020) explain that these consequences are also influenced by the demands placed on students, namely that they must be able to use their critical thinking skills well to adapt and survive in online learning, where they must be critical and skilled in using various online learning support media that they have never used before.

Good critical thinking skills can help students become independent and proficient in problem-solving the various problems they face. Critical thinking is a high-level thinking skill that focuses on logic is reflective and allows someone to make decisions and take appropriate actions (Ennis, 2013). Reflective Questioning is an active process of carefully considering all alternatives before deciding. Critical thinking skills are essential and valuable to develop (Fitriani et al., 2020), considering that this ability is a significant part of 21st-century skills. Through critical thinking, students can develop other 21st-century skills, such as problem-solving and creative thinking (Thornhill-Miller et al., 2023). Not only that, but the ability to think critically is also one of the ultimate goals of education, namely producing critical thinkers who can work effectively in society (Alkharusi et al., 2019) and one of the competencies that students must have as future teacher candidates. Students as future teacher candidates are required to master the ability to organize and control their thinking processes, where they use thinking strategies in analyzing arguments and assumptions, provide interpretations based on correct and rational perceptions, and form logical arguments and interpretations; this ability is critical thinking (Febriana, 2019).

Considering the importance of critical thinking skills for students as future teacher candidates, there is a need to map how and to what extent their critical thinking skills are to help lecturers determine what future steps can be taken to improve student's critical thinking skills (Syahfitri et al., 2019). The mapping that will be carried out is assisted by applying the problem-based learning model in physics learning. This model conditions students to learn to interact with other people in groups, relate learning to other material, and train them to make inquiries to find the right way to solve problems, think critically, and learn independently (Arends, 2012). This model was chosen because it has been proven from various studies to be able to improve student's critical thinking skills (Afdareza et al., 2020; Aripin et al., 2021; Cahyono & Dwikoranto, 2021; Mike & Maria, 2020; Rosmasari & Supardi, 2021; Windari & Yanti, 2021). Based on this description, researchers conducted research to analyze the profile of students' critical thinking abilities in physics learning, especially electromagnetic material, with the help of the problem-based learning model.

RESEARCH METHOD

The research design is pre-experimental, and the data analysis technique is qualitative descriptive analysis (Tiswarni, 2019). This preliminary research was conducted to describe the conditions and problems on campus in detail (Shorey et al., 2020). Research like this does not test hypotheses (Saphira & Prahani, 2022). The research results are considered in perfecting models and learning tools to improve student's critical thinking skills in the electricity and magnetism course. The participants in this study were 19 students majoring in natural sciences in their third semester at a university in Surabaya, Indonesia. Data collection in this study used several instruments, namely 1) CTS test questionnaire sheets consisting of five indicators on electromagnetic material, 2) Educator interview sheets, and 3) Student response questionnaire sheets.

The sampling technique in this study was purposive sampling. Data analysis techniques are based on the results of responses from test questionnaires and student response questionnaires (Rizki et al., 2021; Syamsu, 2020), which were made using Google Forms (Mashurin et al., 2021). The results of the data analysis are used to describe the actual conditions and circumstances in tertiary institutions for CTS students. The research phase was carried out as shown in Figure 1.

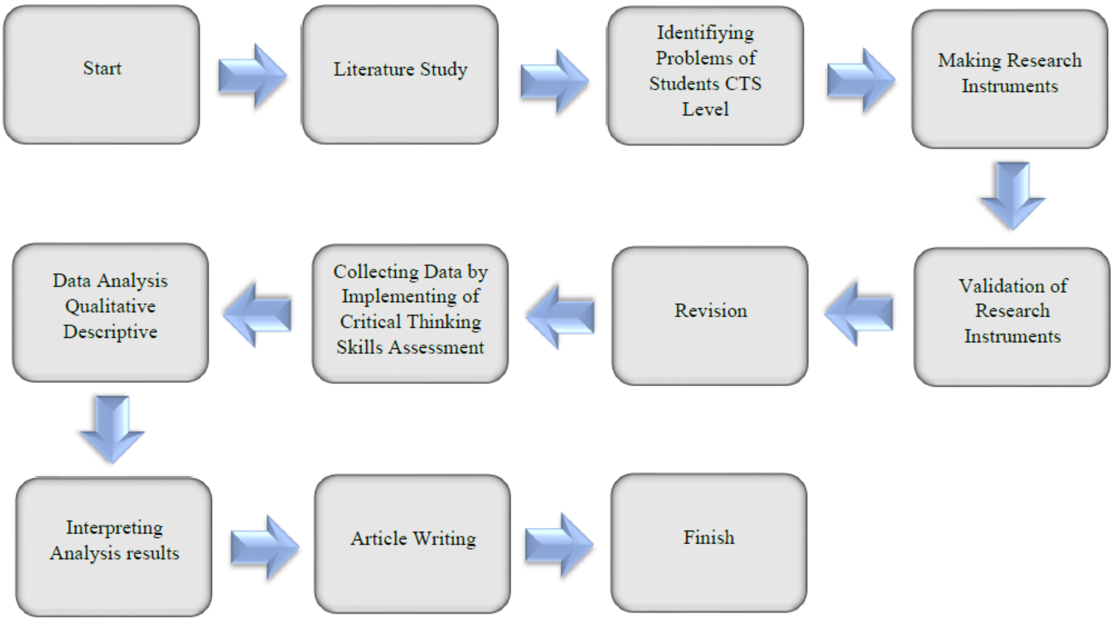

Figure 1. Research stages.

The research stage began with a literature study on critical thinking skills, problem-based learning models, and the relationship between the two. After obtaining the required information, identify problems regarding students' critical thinking abilities through observation. Create, validate, and revise the research instrument based on the identification results. After the instrument is suitable for use, the next step is to collect and analyze the data and draw conclusions from the results of the analysis. The final stage is compiling an article for publication.

The test questionnaire consists of 8 essay questions from the four leading CTS indicators: inference, interpretation, analysis, and evaluation (Dita et al., 2021). The problems raised in essay form are intended to present more complex answers than answers in the multiple-choice form (Maryani et al., 2021). The response questionnaire consists of 8 questions. The responses obtained were then analyzed at the student's CTS level. If the answers are logical, complete, and systematic, then the points obtained are 5; if the answer only has two components (logical and complete or logical and systematic), then the points obtained are 3; if the answer only gets one compliment, then the point obtained is only 1; And if the student's answer is wrong, the points obtained are 0. So, the maximum number of points obtained is 40 (Saphira & Prahani, 2022). Furthermore, the final value of each student is determined mathematically as follows:

$$\textbf{Final Value} = \frac{\textit{Points Earned}}{\textit{Maximum Points}}$$

The categories used are as follows:

Table 1. Range of categories.

Range of Score	Categories
75.00 < Score ≤ 100.00	High
45.00 < Score ≤ 75.00	Medium
Score ≤ 45.00	Low

(Rohmah & Prahani, 2021)

RESULTS AND DISCUSSION

Results

Based on these criteria, the value of students' CTS can be seen. This research was conducted by providing a CTS test questionnaire with eight essay questions. Every two questions represent one indicator in critical thinking: analysis, interpretation, inference, and evaluation (Facione, 2015; Dita et al., 2021). Students are expected to be able to answer based on the problems given by analyzing, interpreting, and concluding data and information, then evaluating solutions in the form of statements and explaining clearly the solutions they have made based on the problems they face (Sunarti et al., 2021). Through these answers, researchers can assess their CTS. Student CTS results obtained on electromagnetic material using the Facione indicator are presented in Figure 2.

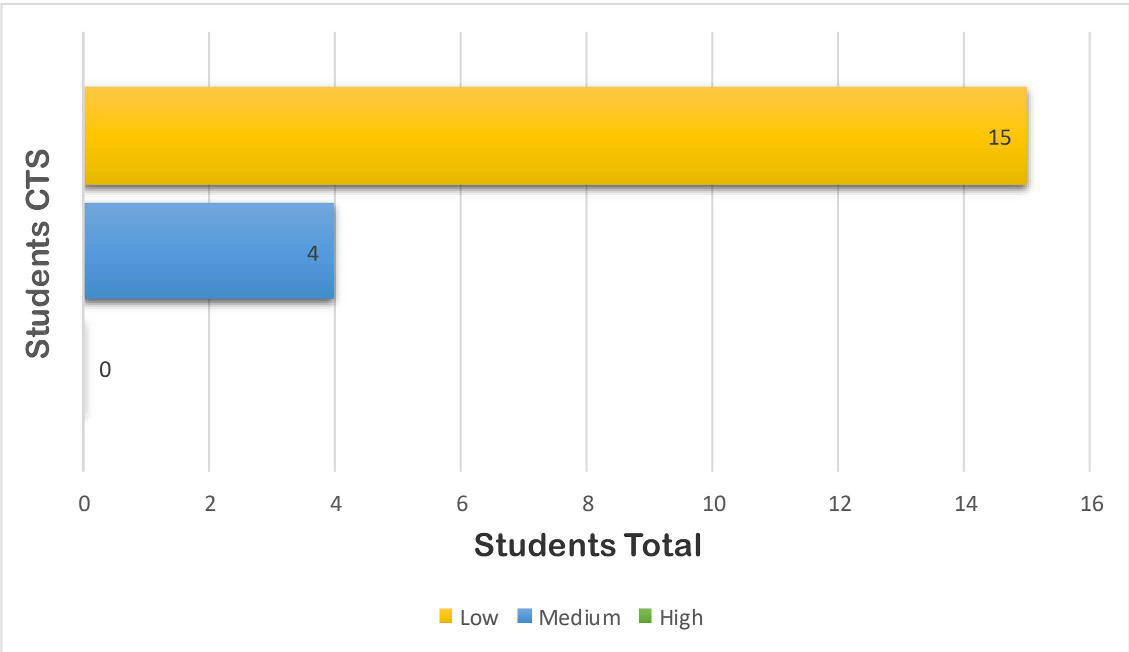

Figure 2. The results of students' CTS assessment.

Figure 2 shows that as many as 15 students get a low category, four students get the medium category, and none get the high category. These results indicate that the CTS level of students, especially in electromagnetic material, is still low.

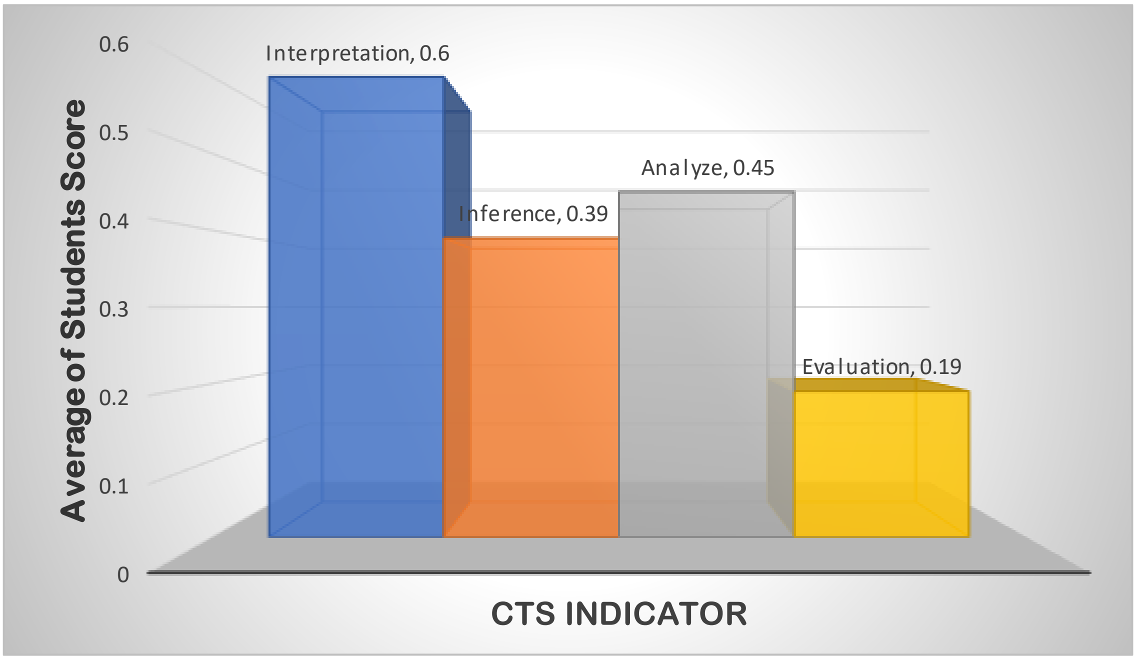

Figure 3. Average of students' CTS of each indicator.

Figure 3 is an interpretation of the results of the essay test, which includes CTS indicators; the average value of each indicator obtained by students is obtained. Based on the picture, interpretation, analysis, inference, and evaluation are the indicators that get the average value from high to low. Examples of student answers to the CTS essay test on each indicator, namely interpretation, inference, analysis, and evaluation, are in Figure 4.

1. In Bar magnet, the poles are at the ends, the right end (red) is the north pole while the left end (blue) is the south pole
2. In cylindrical magnets, the poles are at the ends, the right end (red) is the north pole while the left end (blue) is the south pole
3. In needle magnet, the poles are at the ends, the right end (red) is the north pole while the left end (blue) is the south pole
4. In the Horseshoe magnet, the pole on the north is on the right (red) while the south pole is on the left (blue)
5. Ring magnet, the poles are at the front and back of the ring

Figure 4. Student answers to interpretation.

Figure 4 shows the interpretation indicators; students are asked to interpret the type of magnet based on its shape and mention the polar information. A few student answers focused on the type of magnet based on its shape and should have specifically mentioned the polar information.

Because the electricity needed by each house is different

Due to the influence of the cables used to make the electrical circuit

Figure 5. Student answers to inference.

Figure 5 shows an inference indicator; students are asked to make conclusions from three illustrations regarding the difference in the amount of voltage in each house, even though the input voltage is the same. Most students need help understanding the implementation of transformers in power transmission. The answers given are not related to the working principle of the transformer, power, or electrical energy, which affects the voltage of each house. This shows that students still need help understanding what to do with the problems presented.

The temperature in the outer layer of the sun ranges from thousands of degrees Celsius. At temperatures this hot, collisions or collisions between gas molecules often occur and cause explosions. The electrons freed by the impact are thrown from the sun's atmosphere when the sun rotates. These electrons come out of the holes in the sun's force field. Then it is blown by the solar wind to Earth. These electrically charged particles are deflected by the earth's force field. At the north and south poles, the strength of the earth's force field is very weak, because the reflected electrically charged particles penetrate the earth's atmosphere and collide with the earth's gas particles. This collision produces light that dances in the sky above the north and south poles. So auroras can't occur in Indonesia.

Figure 6. Student answers to analytical indicators.

Figure 6 shows students' answers to the results of their analysis regarding the possibility or not of an aurora occurring in Indonesia. The answer shown is the best because it is very complex and comprehensive; a small number of students only answer no by giving a less in-depth explanation, such as the aurora occurs at the poles of the earth, namely at the south pole and north pole due to the influence of the magnetic field. This indicator is higher than inference; it can be concluded that the analysis carried out by students is good, but it is difficult to conclude the analysis results.

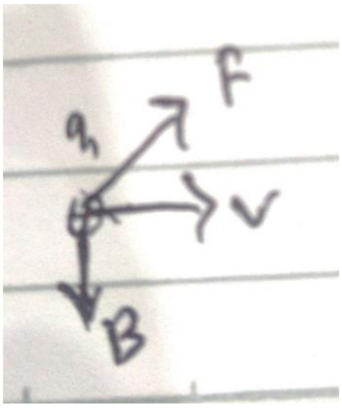

Figure 7. Student answers to evaluation indicators.

Figure 7 shows a representation of student answers to evaluation indicators. Students are asked to evaluate the state of a positive electric charge (q) in a magnetic field (B), which is related to the magnetic force (F) and the speed of the charge (v) as outlined in the illustration. Most of the students could not describe the state of a positive electric charge (q) in a magnetic field (B), so the results of their answers deviated from the theory, and most of them did not answer or were blank. This indicator is the lowest in obtaining the average value in Figure 3.

Results of Student Response to Electromagnetic Material

Table 2 shows that students agree that electromagnetic material is essential and challenging to learn, and they disagree if it is easy to learn. They often ask if they need help understanding the material presented by the lecturer.

Table 2. Students' response to electromagnetic material and CTS in college.

Statement	Answer (%) (n=19 Students)			
	Strongly Disagree (SD)	Disagree (D)	Agree (A)	Strongly Agree (SA)
Electromagnetic material is important to learn	5.26 (1)	5.26 (1)	78.94 (15)	10.52 (2)
Electromagnetic material is difficult to learn	0 (0)	10.52 (2)	63.15 (12)	26.31 (5)
Electromagnetic material is easy to understand	5.26 (1)	63.15 (12)	26.31 (5)	5.26 (1)
I often ask if I do not understand the material delivered by the teacher	10.52 (2)	26.31 (5)	52.63 (10)	10.52 (2)
CTS is important to teach in school	0 (0)	5.26 (1)	47.36 (9)	47.36 (9)
I have done learning activities to improve CTS	0 (0)	15 (3)	57.89 (11)	26.31 (5)
I have been trained with critical thinking skills tests	5.26 (1)	10.52 (2)	63.15 (12)	21.05 (4)
Critical thinking skills tests are difficult to do	10.52 (2)	5.26 (1)	47.36 (9)	36.84 (7)

Furthermore, students agree that CTS in lectures is necessary. They have carried out activities to improve CTS and have been trained with the CTS test even though it is difficult.

Interview Results of Interviews with Electromagnetic Lecturer

This research looks not only at the student's point of view but also at the lecturer's opinion regarding the learning model and learning outcomes applied on campus. Interviews were conducted to look deeper (Osborne et al., 2018) regarding learning physics, especially in electromagnetic material. The results of interviews conducted with six questions are presented in Table 3.

Table 3. Results of interviews with electromagnetic lecturers regarding the implementation of physics lessons.

Question	Answers
How are the character, motivation, and interest in learning students in studying physics, especially electromagnetic material?	Their character, motivation, and demand still need to be improved due to the length of online learning.
Has the learning method used applied Merdeka Belajar to teach the concept of physics to students, especially on electromagnetic materials?	Not really
Are there any disadvantages or limitations of learning methods used to teach the concept of	There are no significant limitations because learning has started offline; students can study

Question	Answers
physics to students, especially in electromagnetic materials?	in rooms and practicums to improve their understanding and skills.
Has CTS ever been specially trained for students during teaching and learning activities in college?	Ever by integrating material with phenomena or cases that occur in the real world.
According to the Teacher, is CTS important? Could you give me a reason?	It is essential because CTS can assist students in solving a problem to obtain an effective and efficient solution.
According to The Teacher, how should efforts be made to improve CTS in students?	Could you give them a quiz?

Table 3 shows that physics learning in lectures, especially in electromagnetic material, is still conventional; no design, implementation, and assessment reform has yet to be adapted to the latest curriculum. There has yet to be a significant effort by educators to increase student CTS.

Discussion

Reviewing the results obtained, firstly, the electromagnetic material is classified as a material that is difficult to study. This difficulty arises because concepts related to electromagnetics tend to be abstract and complex and contain various calculations requiring students to memorize various formulas. In conventional learning, lecturers usually need help teaching this material even though it has been linked to natural phenomena or events (Kanamugire et al., 2019). This difficulty will trigger students to distort and integrate scientific concepts with intuitive conceptions that conflict. This distortion causes conceptual errors in perception and confusion in relating existing concepts, making them sink into misconceptions. Conventional learning change strategies must involve cognitive conflict to suppress misconceptions so that existing scientific conceptions can be understood, make sense, and are helpful for students (Wahyudi et al., 2019).

Second, students' CTS still needs to be higher. Referring to the interview results in Tables 2 and 3, this low skill level is because learning is still carried out conventionally. This learning is more lecturer-centered and causes some students to appear still passive when learning (Angelina, 2019). Lecturers tend to use the lecture method and do not familiarize students with how to make the right decisions and solve a problem effectively even though they have linked the material to natural phenomena or events, so they experience difficulty in providing logical arguments. Students are also more often accustomed to learning by prioritizing the process of remembering and understanding rather than accustomed to learning using critical thinking indicators (Ningsih et al., 2022). CTS is essential to be taught, trained as early as possible, and implemented continuously to help students observe various problems that may occur and find solutions to these problems (Rahmadita, 2021), as well as make them critical thinkers who can work effectively in society (Alkharusi et al., 2019; Fitriani, 2020). Considering the importance of this skill for students, lecturers need to improve it through various creative and innovative efforts in learning so that they become more interested in literacy, thinking, conducting investigations, and making conclusions based on the problems given (Dewi et al., 2019). One effort can be used to apply the problem-based learning (PBL) model in learning. The problem-based learning (PBL) model has been proven more effective than conventional classroom learning. It positively impacts students' critical thinking abilities because problem-solving through PBL can help build new knowledge and hone their critical thinking skills.

Table 4. Relevant research.

Author	Research Purposes	Research Result
(Aswan et al., 2018)	Determine the effect of PBL models on students' critical thinking skills and competencies.	PBL models affected the students' critical thinking skills and competencies.
(Hussin et al., 2019)	Examine how the online tools are a medium to increase students' critical thinking skills by PBL strategy.	PBL, with the aid of online tools, is the best teaching strategy to enhance students' critical thinking skills.
(Afdareza et al., 2020)	Produce a learning device based on 21st-century skills with the implementation of problem-based learning to increase students' critical thinking skills on polyhedron for grade 8th junior high school valid, practical, and effective.	The learning device based on 21st-century skills with the implementation of problem-based learning to increase students' critical thinking skills on polyhedron for grade 8th junior high school has been valid, practical, and effective.
(Mike & Maria, 2020)	Producing learning tools using the PBL model, which in the implementation process uses manipulative materials in terms of cognitive abilities and interest in learning material opportunities for class VIII middle school students.	The test scores and the questionnaire scores indicated that problem-based learning using manipulative materials effectively improved learning outcomes and students' interest in learning mathematics.
(Aripin et al., 2021)	Know the effectiveness of PBL teaching materials to improve effective and efficient problem-solving and students' critical thinking skills.	Physics learning tools based on PBL models effectively and efficiently to improve problem-solving skills and critical thinking skills learners.
(Cahyono & Dwikoranto, 2021)	Describe the application of the PBL model and the implications for improving critical thinking skills.	Implementing the PBL model improved students' critical thinking skills according to the experimental class n-gain score of 0.58 and the control class by 0.31.
(Rahmadita et al., 2021)	Determine the students' critical thinking skills and the application of PBL in high school.	Surabaya State High School students' critical thinking abilities are at a medium level. Applying the PBL learning model assisted by PhET can be an alternative learning method to improve students' critical thinking skills.
(Rosmasari & Supardi, 2021)	Improve learners' critical	The PBL learning model on

Author	Research Purposes	Research Result
	thinking skills by applying PBL learning models to business and energy materials.	business, energy, and material physics lessons can improve learners' critical thinking skills.
(Windari & Yanti, 2021)	Improve the ability to think critically in physics learning using PBL models.	This study uses this type of classroom action research. Incorporating aspects of critical thinking skills can improve the critical thinking skills of static fluid principal learners.
(Neswary & Prahani, 2022)	Analyzing the profile of students' critical thinking skills and the application of PBL models based on digital books on physics learning in high school.	Students' critical thinking skills are low; therefore, it is necessary to improve them by implementing digital book-assisted PBL models.
(Darmawati & Mustadi, 2023)	Determine (1) the difference in critical thinking skills between students taught using problem-based learning and expository learning and (2) the influence of implementing problem-based learning on students' critical thinking skills.	The research findings indicate that (1) there is a significant difference in students' critical thinking skills between the group taught using problem-based learning and the group taught using expository learning, with a p-value of 0.004, and (2) the implementation of problem-based learning positively and significantly influences students' critical thinking skills, with a significance value of 0.005.
(Jamilah et al., 2023)	Determine the effect of problem-based learning models on students' critical thinking skills.	The PBL learning model affected the critical thinking skills of fourth-semester students at the Indonesian Language and Literature Education Study Program.
(Siregar & Narpila, 2023)	Determine the effect of the problem-based learning (PBL) model on critical thinking skills and students' motivation to learn mathematics.	Students who get the problem-based learning model are better than students who use conventional learning models.
(Yu & Zin, 2023)	Analyzed how studies have adapted Problem-Based Learning (PBL) to become more Critical Thinking (CT)-oriented, evaluated the effectiveness of these adaptations, and determined	An analysis of all selected studies revealed positive outcomes, indicating that incorporating CT elements into PBL effectively enhanced students' CT. These findings were categorized into nine

Author	Research Purposes	Research Result
	why specific adaptions were successful.	factors contributing to the successful adaptation of PBL to CT-oriented.

CONCLUSION

Fundamental Finding: From the results of research using preliminary research methods that have been carried out, it was concluded that the lowest student CTS criteria were found in the evaluation indicators with an average score of 0.19 and the highest criteria were found in the interpretation indicators. These results show that students' CTS is still relatively low. This research also found that universities still apply physics with conventional teaching, and the lecture method dominates learning. An alternative that can be done to increase students' interest and critical thinking skills is to apply the PBL model in physics learning. **Implication:** These findings have significant implications for education. Improving students' critical thinking can encourage their intellectual development. Lecturers and policymakers must consider the importance of learning habits and integrating critical thinking indicators into the curriculum. Positive student feedback highlights the importance of creating a more exciting learning environment, motivating and encouraging interactivity in learning physics, especially electromagnetic, so they can develop themselves to the maximum.

In conclusion, this research highlights that applying the PBL model can increase students' interest and critical thinking skills to prepare themselves to face the future. **Limitation**: This research shows that students' CTS is still relatively low. Critical thinking indicator testing is limited to four indicators: interpretation, analysis, inference, and evaluation, so other indicators must be tested more accurately. **Future Research:** Future research can explore the latest indicators of critical thinking, whether according to Facione or others, to be integrated into physics learning, especially electromagnetic material, and integrate various learning strategies that are creative, innovative, challenging, and accommodate students' needs so that the learning they experience does not seem conventional. If all of this can be realized, students can optimally develop themselves to have an essential societal role.

REFERENCES

Afdareza, M. Y., Yuanita, P., & Maimunah, M. (2020). Development of learning device based on 21st century skill with implementation of problem based learning to increase critical thinking skill of students on polyhedron for grade 8th junior high school. *Journal of Educational Science, 4*(2), 273-284. http://dx.doi.org/10.31258/jes.4.2.p.273-284

Alkharusi, H. A., Sulaimani, H. A., & Neisler, O. (2019). Predicting critical thinking ability of sultan qaboos university students. *International Journal of Instruction, 12*(2), 491-504. https://doi.org/10.29333/iji.2019.12231a

Angelina, N., & Rosdiana, L. (2019). Kelayakan validitas kartu belajar untuk meningkatkan literasi sains pada materi tata surya SMP. *PENSA: E-Jurnal Pendidikan Sains, 7*(2), 161-166.

Arends, R. I. (2012). *Learning to teach ninth edition*. New York: Mc Graw Hill.

Aripin, W. A., Sahidu, H., & Makhrus, M. (2021). Efektivitas perangkat pembelajaran fisika berbasis model problem based learning untuk meningkatkan kemampuan pemecahan masalah dan kemampuan berpikir kritis peserta didik. *Jurnal Penelitian Dan Pembelajaran Fisika Indonesia, 3*(1), 120-134. https://doi.org/10.29303/jppfi.v3i1.120

Aswan, D. M., Lufri, L., & Sumarmin, R. (2018). Influence of problem based learning on critical thinking skills and competence class VIII SMPN 1 gunuang omeh, 2016/2017. *IOP*

Conference Series: Materials Science and Engineering, 335, 1-8. https://doi.org/10.1088/1757-899X/335/1/012128

Cahyono, B. D. T., & Dwikoranto, D. (2021). Implementasi model pembelajaran problem based learning untuk meningkatkan kemampuan berfikir kritis pada siswa. *Inovasi Pendidikan FIsika, 10*(1), 1–7. https://doi.org/10.26740/ipf.v10n1.p1-7

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. http://dx.doi.org/10.21831/jpe.v11i2.55620

Dewi, C., Khery, Y., & Erna, M. (2019). An ethnoscience study in chemistry learning to develop scientific literacy. *Jurnal Pendidikan IPA Indonesia, 8*(2), 279-287. doi:https://doi.org/10.15294/jpii.v8i2.19261

Dita, S. P., Qadar, R., & Komariyah, L. (2021). Asesmen formatif dalam pembelajaran inkuiri model 5 e (engagement, exploration, explanation, elaboration, evaluation) untuk meningkatkan keterampilan berpikir kritis berbasis WEB pada Siswa SMA. *Jurnal Kajian Pendidikan IPA, 1*(2), 76-85. https://doi.org/10.52434/jkpi.v1i2.1317

Ennis, R. H. (2013). *Critical thinking across the curriculum (CTAC).* University of Windsor.

Facione, P. A. (2015). *Critical thinking: What it is and why it counts insight reasoning skills and mindset measures for various professional groups view project critical thinking, decision making, and problem-solving view project.* Measured Reasons LLC.

Febriana, R. (2019). *Kompetensi guru*. Jakarta: Bumi Aksara.

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). PBLPOE: A learning model to enhance students' critical thinking skills and scientific attitudes. *International Journal of Instruction, 13*(2), 89–106. https://doi.org/10.29333/iji.2020.1327a

Herliandry, L. D., Nurhasanah, N., Suban , M. E., & Kuswanto, H. (2020). Pembelajaran pada masa pandemi COVID-19. *JTP - Jurnal Teknologi Pendidikan*, *22*(1), 65-70. https://doi.org/10.21009/jtp.v22i1.15286

Husna, R. (2020). Efektivitas pembelajaran turunan pada masa pandemi covid-19 melalui media mobile learning ditinjau dari hasil belajar mahasiswa. *Jurnal Numeracy, 7*(2), 324–333. https://doi.org/10.29407/jmen.v6i2.14813

Hussin, H., Jiea, P. Y., Rosly, R. N. R., & Omar, S. R. (2019). Integrated 21st century science, technology, engineering, mathematics (stem) education through robotics project based learning. *Humanities & Social Sciences Reviews, 7*(2), 204–211. https://doi.org/10.18510/hssr.2019.7222

Jamilah, F., Wahyuni, P., & Septarianto, T. W. (2023). The effect of the problem-based learning model on students critical thinking ability. *IJLECR (International Journal of Language Education and Cultural Review), 9*(1), 56-63. https://doi.org/10.21009/ijlecr.v9i1.37837

Kanamugire, C., Yadav, L. L., & Mbonyiryivuze, A. (2019). Tutors' perceptions about science curriculum reforms and challenges for their implementation in teacher training colleges in rwanda. *African Journal of Educational Studies in Mathematics and Sciences, 15*(1), 101-116. https://doi.org/10.4314/ajesms.v15i1.9

Loviana, L., Selvi, S., Janah, M., Cahya D. P., & Nisa, C. (2021). Evaluasi pembelajaran daring pada tingkat smp dan sma di masa pandemi COVID-19. *Journal of Mathematics Education, 2*(1), 65-74. https://doi.org/10.32332/linear.v2i1.3207

Maryani, I., Prasetyo, Z. K., Wilujeng, I., Purwanti, S., & Fitrianawati, M. (2021). HOTs multiple choice and essay questions: A validated instrument to measure higher-order thinking skills of prospective teachers. *Journal of Turkish Science Education, 18*(4), 674–690. https://doi.org/10.36681/tused.2021.97.

Mashurin, A. H., Mubarok, H., & Prahani, B. K. (2021). Profile of guided discovery learning implementation assisted by the virtual lab and students' problem-solving skills on gas kinetic theory. *Jurnal Penelitian & Pengembangan Pendidikan Fisika, 7*(2), 131–144. https://doi.org/10.21009/1.07205.

Meke, M., Pareira, M. K., & Wondo, M. T. S. (2020). Pengembangan perangkat pembelajaran model problem based learning melalui penggunaan bahan manipulatif. *Jurnal Kependidikan*, 6(3), 1-10. https://doi.org/10.33394/jk.v6i3.2861

Nadeak, B., Puspa, C. J., & Sormin, E. (2020). Hubungan kemampuan berpikir kritis mahasiswa dengan penggunaan media sosial terhadap capaian pembelajaran pada masa pandemi COVID-19. *Jurnal Konseling dan Pendidikan, 8*(2), 98-104. https://doi.org/10.29210/146600

Neswary, S. B. A., & Prahani, B. K. (2022). Profile of students' physics critical thinking skills and application of problem based learning models assisted by digital books in physics learning in high school. *Jurnal Penelitian Pendidikan IPA, 8*(2), 781–789. https://doi.org/10.29303/jppipa.v8i2.1444

Ningsih, E. M., Efendi, N., & Sartika, S. B. (2022). Pengaruh model pembelajaran berbasis masalah terhadap keterampilan berpikir kritis siswa dalam mata pelajaran IPA. *DIKSAINS : Jurnal Ilmiah Pendidikan Sains, 3*(1), 1–6. https://doi.org/10.33369/diksains.3.1.1-6

Osborne, D. M., Byrne, J. H., Massey, D. L., & Johnston, A. N. B. (2018). Use of online asynchronous discussion boards to engage students, enhance critical thinking, and foster staff-student/student-student collaboration: A mixed method study. *Nurse Education Today, 70,* 40–46. https://doi.org/10.1016/j.nedt.2018.08.014.

Rahmadita, N., Mubarok, H., & Prahani, B. K. (2021). Profile of problem-based learning (PBL) model assisted by PhET to improve critical thinking skills of high school students in dynamic electrical materials. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 617–624. https://doi.org/10.29303/jppipa.v7i4.799

Rizki, I. A., Citra, N. F., Saphira, H. V., Setyarsih, W., & Putri, N. P. (2021). Eksperimen dan respon mahasiswa terhadap praktikum fisika non-laboratorium menggunakan aplikasi tracker video analysis untuk percobaan kinematika gerak. *Journal of Teaching and Learning Physics, 2,* 77–89. https://doi.org/10.15575/jotalp.v6i2.12640

Rohmah, A. A. & Prahani, B. K. (2021). Profile of implementation of free inquiry learning assisted by PhET and critical thinking skills of senior high school students on light material. *Prisma Sains, 9*(2), 1-13. https://doi.org/10.33394/j-ps.v9i2.4192.

Rosmasari, A. R., & Supardi, Z. A. I. (2021). Penerapan model pembelajaran problem based learning (PBL) untuk meningkatkan keterampilan berpikir kritis peserta didik pada materi usaha dan energi kelas X MIPA 4 SMAN 1 gondang. *PENDIPA Journal of Science Education, 5*(3), 472–478. https://doi.org/10.33369/pendipa.5.3.472-478

Rozi, Z. F., & Hadiwinarto, H. (2021). Evaluasi Pembelajaran Mahasiswa di Masa Pandemi Covid-19. *Jurnal Pendidikan Biologi dan Sains, 4*(2), 1-12. https://doi.org/10.31539/bioedusains.v4i2.3043

Saphira, H. V., & Prahani, B. K. (2022). Profile of senior high school students' critical thinking skills and the need of implementation PBL model assisted by augmented reality book. *Jurnal Pendidikan Sains Indonesia 10*(3), 579-591. https://doi.org/10.24815/jpsi.v10i3.25031

Sari, M. W., Indriyanti, N. Y., Antrakusuma, B., & Utami, B. (2021). The effectiveness of learning video usage to support online learning in basic chemistry course during the COVID-19 pandemic. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, *6*(1), 25–30. https://doi.org/10.26740/jppipa.v6n1.p25-30

Shorey, S., Ang, E., Ng, E. D., Yap, J., Lau, L. S. T., & Chui, C. K. (2020). Communication skills training using virtual reality: A descriptive qualitative study. *Nurse Education Today, 94,* 1-10. https://doi.org/10. 1016/j.nedt.2020.104592.

Siregar, M. B., & Narpila, S. D. (2023). The influence of the problem based learning model on students' critical thinking ability and learning motivation in mathematics learning. *Numerical: Jurnal Matematika Dan Pendidikan Matematika, 7*(2), 1-12. https://doi.org/10.25217/numerical.v7i2.3884

Sunarti, T., Wasis, W., Setyarsih, W., Zainudin, A., & Jauhariyah, M. N. R. (2021). Analysis of the development of critical thinking instrument tests in physics. *Proceedings of the International Joint Conference on Science and Engineering, 209,* 627–634.

Syahfitri, J., Firman, H., Redjeki, S., & Sriyati, S. (2019). Profil disposisi berpikir kritis mahasiswa pendidikan biologi di perguruan tinggi. *Jurnal Program Studi Pendidikan Biologi: BioEdUIN, 9*(1), 1-12. https://doi.org/10.15575/bioeduin.v9i1.4341

Syamsu, F. D. (2020). Pengembangan lembar kerja peserta didik berorientasi pembelajaran discovery learning untuk meningkatkan keterampilan berpikir kritis siswa. *Genta Mulia, 11*(1), 65–79.

Thornhill-Miller B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., Lubart, T. (2023). Creativity, critical thinking, communication, and collaboration: assessment, certification, and promotion of 21st century skills for the future of work and education. *Journal of Intelligence, 11*(3), 54-65. https://doi.org/10.3390/jintelligence11030054

Tiswarni, T. (2019). Usaha kepala sekolah dalam meningkatkan disiplin kerja guru (studi deskriptif kualitatif di SMP N 1 argamakmur kabupaten bengkulu utara). *At-Ta'lim : Media Informasi Pendidikan Islam, 18(1),* 261-271. https://doi.org/10.29300/attalim.v18i1.1650.

Wahyudi, W., Mauliana, M., Suwatno, S., & Santoso, B. (2019). Kajian analisis keterampilan berpikir kritis siswa sekolah menengah atas. *Jurnal Pendidikan Manajemen Perkantoran, 1*(1), 67- 82. https://doi.org/10.17509/jpm.v5i1.25853

Windari, C. O., & Yanti, F. A. (2021). Penerapan Model Problem Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik. *Edu Sains : Jurnal Pendidikan Sains Dan Matematika, 9(1), 61–70.* https://doi.org/10.23971/eds.v9i1.2716

Yu, L., & Zin, Z. M. (2023) The critical thinking-oriented adaptations of problem-based learning models: a systematic review. *Front. Educ. 8:1139987.* doi: 10.3389/feduc.2023.1139987

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