IJORER : International Journal of Recent Educational Research
Homepage : https://journal.ia-education.com/index.php/ijorer
Email : ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 5, No. 3, May 2024
Page 690-701
© 2024 IJORER :
International Journal of Recent Educational Research

Description of Students' Critical Thinking Skills After Implementing the Problem Posing Model Assisted by PheT in Distance Learning

Roudhoutul Aulia Rochim[1*], Noer Af'idah[1], Desi Wulandari[2]
[1] Hasyim Asy'ari Tebuireng Jombang University, Jombang, Indonesia
[2] Billfath University, Lamongan, Indonesia

Check for updates OPEN ACCESS

DOI: https://doi.org/10.46245/ijorer.v5i3.601

Sections Info

Article history:
Submitted: April 27, 2024
Final Revised: May 8, 2024
Accepted: May 11, 2024
Published: May 20, 2024

Keywords:
Critical thinking skills;
Distance learning;
PheT;
Problem posing.

ABSTRACT

Objective: The primary objective of this research is to assess the development of critical thinking skills after implementing the PhET-assisted problem-posing learning model in distance education. **Method:** This study adopts a pre-experimental approach with a one-shot case study design. The study sample comprises 18 students enrolled in the 2023 cohort of the UNHASY Natural Science Education study program. **Results:** The findings indicate that the average critical thinking score is 79.86, falling within the high category. The distribution of students' critical thinking skills across various categories revealed that 44% belong to the highest category. Notably, the proportions of critical thinking skill indicators are exclusively concentrated in the medium, high, and very high categories, with no instances falling into the low categories. These results underscore the efficacy of employing the PhET-assisted problem-posing learning model as a viable strategy for enhancing students' critical thinking abilities. **Novelty:** The researcher chose the PhET-assisted problem-posing model, one of the media based on information and communication technology in the form of a virtual laboratory regarding critical thinking skills.

INTRODUCTION

The digitization of the educational sector, initially driven by technological advancements, is being further reinforced due to the impact of the COVID-19 pandemic. Observations of changes in the educational landscape are evident at various educational levels and tertiary education. The governmental mandate for individuals to stay at home has necessitated adjustments in both circumstances and regulations (Khasanah et al., 2020). Within higher education, the educational system utilizes distance learning (DL). This form of learning, whether remote or blended, involves using electronic devices such as computers, laptops, and smartphones for online learning, thereby digitalizing the learning process. Distance learning occurs when there is a physical separation between students and teachers who are not consistently present in the exact physical location at school (Setiawan, 2020). This approach's implementation can be entirely remote (hybrid) or a combination of remote and classroom-based learning (blended).

Distance education, commonly referred to as DL, denotes an educational initiative engaged in by both students and educators that does not take place in a traditional classroom setting but rather is conducted entirely through remote means utilizing communication technology, information, and various media with the aid of diverse communication tools for educational purposes (Yuangga & Sunarsi, 2020). Distance learning offers a unique educational setting for learners, encompassing students and instructors. Educators persist in delivering online instruction, while students can engage in remote study from their homes, commonly known as DL (Aziz, 2020). The presence frequently observed in the field suggests that students exhibit limited engagement in the

educational process. Moreover, lacking diversity in the selected instructional models leads to a tedious learning experience. Typically, a traditional instructional approach is employed. Furthermore, students often encounter tasks emphasizing memory enhancement rather than fostering critical thinking skills. Critical thinking proficiency involves the examination of various assumptions or viewpoints, identifying underlying values, evaluating evidence, and judging conclusions.

Critical thinking is a cognitive process involving a continuous curiosity toward information to achieve deep understanding. The importance of critical thinking skills lies in their ability to prepare students to face future challenges effectively. In the field of physics education, the development of critical thinking skills is considered essential (Neswary & Prahani, 2022; Prahani et al., 2023; Rohmah & Prahani, 2021; Saphira & Prahani, 2022). The core of critical thinking in physics teaching arises from the need for students to observe situations, ask questions, form hypotheses, collect empirical data, and draw logical conclusions. The extensive body of literature exploring this topic underscores the critical significance of critical thinking skills. Indeed, critical thinking abilities emerge as a fundamental aspect of the set of skills necessary for addressing the challenges of the 21st century (Adilla & Jatmiko, 2021; Bitzenbauer, 2023; Jatmiko et al., 2021; Septianita et al., 2023). Despite the significant changes in modern educational approaches, developing higher-order cognitive skills, especially critical thinking abilities, remains crucial in the educational landscape.

Critical thinking skills are a thinking process that clarifies one's understanding of something to produce an intelligent decision. Critical thinking skills are essential in life and the world of work and have a practical function in all other aspects of life to improve human quality. Critical thinking skills are essential for students to connect concepts and material to understand and solve problems in class in an orderly and correct manner. This explanation concludes that critical thinking skills are needed in life, including education, to make valuable societal decisions. Ennis differentiates critical thinking indicators into 5, namely providing simple explanations, determining the basis for decision-making, drawing conclusions, providing further explanations, and estimating and combining (Safitri & Prasi, 2020).

Prior studies concerning assessing critical thinking skills among middle school students in Surakarta indicate an overall performance that remains within a relatively low range, specifically at 46.87% (Fakhrizal & Hashanah, 2021). Corresponding to the outcomes of initial investigations, a separate study reveals that the critical thinking proficiencies of students in Bogor are similarly lacking, averaging 46.30 (Lidiawati et al., 2022). The deficiency in students' critical thinking capabilities can be attributed to the inadequacy of the educational process in fostering the development of such skills. Despite educational initiatives being theoretically centered on student engagement, their practical application often leans towards traditional teacher-centric approaches. In distance learning, where the implementation of learning should be student-centered, in reality, in the field, educators are still the leading players in a meeting on Google Meet or Zoom.

Mainly in the field, it is found that educators do not train their ability to ask and answer questions to students and rarely carry out experiments or trials, especially during the COVID-19 pandemic. The experiments were only limited to the steps in the form of a cookbook. Students must be used to expressing ideas and opinions (Purwiningsih & Sari, 2022). Students who are passive and only listen to educators' explanations, whether

teachers or lecturers, will become individuals who do not dare to express opinions and tend to carry out instructions. Passive learning, as commonly observed in university settings, fails to offer students the chance to cultivate critical thinking skills.

The execution of educational instruction encompasses numerous objectives that necessitate attainment. This necessitates that educators strategically structure educational tasks to ensure the realization of learning goals. Students engage with topics that require advanced cognitive skills; hence, fostering a deeper level of critical thinking is imperative. This pedagogical approach leverages technological advancements while committing to a scientifically sound methodology. Efforts to improve students' critical thinking skills can be implemented using various methods. A particular method includes choosing an appropriate educational framework. Teachers significantly improve students' academic achievements and critical thinking abilities by using educational frameworks that encourage active participation in the educational journey.

In addition to demonstrating academic excellence as measured by grades and learning objectives, students should possess various sophisticated cognitive skills, including solving problems creatively, making sound decisions, communicating effectively, arguing persuasively, and thinking critically. In order to address these issues, it is imperative to devise innovative learning strategies that can enhance critical thinking abilities. The incorporation of critical thinking skills into educational endeavors is essential. One learning model that can integrate critical thinking skills is problem-posing. The problem-posing learning model is a form of learning design that emphasizes the formulation of problems or posing questions by students along with the answers to the problems or questions (Arzak & Prahani, 2023; Lorencia & Jatmiko, 2021; Pristianti & Prahani, 2022; Tong et al., 2023). This learning design can train critical thinking skills because students are trained to create questions and answer problems from these questions.

Students learning experiences to help train critical thinking skills can be helped by conducting experiments or trials related to problems in a lesson. During the pandemic, experiments cannot be carried out directly, especially in physics lessons, so virtual media assistance is needed to carry out these experiments. Media that can be used to help students understand abstract concepts in physics is Physics Education and Technology (PhET) (Rizaldi et al., 2020). The PhET simulation program is a fun interactive simulation media based on discovery in the form of software. It can be used to clarify physical concepts or phenomena that have been put into practice. Therefore, this research discusses the description of critical thinking skills after applying the problem-posing learning model assisted by PhET to students who are doing distance learning.

RESEARCH METHOD

This study employs a form of pre-experimental research called a one-shot case study design. Within this design, a single group is subjected to a specific treatment, followed by a descriptive test after each session, including critical thinking assessments (Saputri et al., 2016). The research design can be seen in Figure 1.

Figure 1. Design a one-shot case study (Nasrudin, 2019).

Information:
X: Treatment given (using the problem-posing learning model PheT assisted)
Y: Student's critical thinking abilities

The investigation was carried out during the unconventional semester of the 2022–2023 academic year at Hasyim Asy'ari University College, specifically in the Science Education Undergraduate Study Program. The participants in this study were from the Class of 2023, comprising 18 individuals. Specifically, the individuals selected for the study were those enrolled in the Optical Waves course. A test-based assessment tool assessed the students' critical thinking abilities. This test comprised five open-ended questions based on five distinct critical thinking indicators. Implementing the problem-posing learning approach supported by PhET, data concerning the students' critical thinking capabilities was collected after engaging in the educational process. Each query was assigned a point value ranging from 0 to 4, contingent upon the thoroughness and precision of the student's response. The total score was then computed using a specific formula.

$$\text{Score} = \frac{acquisition\ score}{total\ score} \text{ x } 100$$

In Table 1, the scores obtained by students based on this formula are then grouped based on critical thinking ability categories.

Table 1. Critical thinking ability categories.

Percentage	Category
89.00% < X ≤ 100.00%	Very high
79.00% < X ≤ 89.00%	high
64.00% < X ≤ 79.00%	Currently
54.00% < X ≤ 64.00%	Low
0.00%X ≤ 54.00%	Very low

(Anindya & Wusqo, 2020).

RESULTS AND DISCUSSION

Results

Distance learning, also known as online learning, is a viable approach to delivering education in Indonesia amidst the challenges posed by the COVID-19 pandemic, facilitating the effective pursuit of educational objectives (Nafrin & Hudaidah, 2021). Distinguished from traditional face-to-face instruction, distance learning boasts unique merits and demerits, underscoring the transformative nature of this educational paradigm shift rather than a hindrance. Every educational institution should provide effective learning. Educators must develop learning innovations to create a suitable formula to face every challenge in implementing learning. The study employed the problem-posing learning framework, reinforced by PhET's assistance. The model emphasizes students creating problems and finding solutions based on situations presented to them (Iswara & Sundayana, 2021). Problem-posing allows students to handle problem-solving in other ways (Deringöl, 2020). According to Chua, the problem-posing learning syntax can be seen in Table 2. PhET is utilized as a tool to facilitate the learning process. PhET is a research-based computer simulation that uses animations to make learning mathematics and science more effective. It is interactive, enjoyable, and free to use (Sylviani et al., 2020). PhET Simulation is accessible from the

PhET Simulation website (http://PhET.colorado.edu). PhET can be used directly online or downloaded first and then used offline.

Table 2. Syntax learning model of problem posing.

Syntax *Problem Posing*	**Explanation**
Reviewing material	a. Students link prior knowledge with new information obtained. b. Students read information c. Students remember what the teacher has taught. d. Students read using their own words
Forming a problem	a. Students check if they have found the desired problem. b. students should consider possible issues before submitting them c. Students must already understand the problem posed. d. Students can take notes to understand the problem to be posed and consider problem-solving models before posing the problem.
Checking the solution	a. Students examine the solutions to the problems created and see whether the solutions make sense. b. Students consider all solutions to problems that arise. c. Students should check the solution and work on it.
Review	a. Students can evaluate the processes carried out in forming and solving problems. b. This stage also allows students to pose different problems. c. Students can look back at how well the problem d. has been submitted.

PhET stimulates interactive learning by providing visual and interactive science simulations. This simulation directly involves students exploring scientific concepts, stimulates their senses, and creates a more realistic learning experience (Mashurin et al., 2021; Prahani et al., 2021). Additionally, PhET allows virtual experiments so students can conduct experiments without needing expensive physical equipment or security concerns. This allows them more unrestricted exploration, free from physical limitations (Yani & Widiyatmoko, 2023). One of the goals of PhET Simulation is to provide an open medium that students can use to explore when studying certain concepts, especially physics. Learning using the problem-posing model assisted by PhET is designed to facilitate students' carrying out experimental activities at college or home, and practicing the questions can be done repeatedly. Hopefully, this worksheet can meet students' needs for carrying out experiments. Integrating PhET helps students simulate physics concepts and repeat them occasionally. The design aims to facilitate critical thinking skills in learning physics (Rahmat et al., 2024).

The issue-posing learning approach, implemented using PhET, encompasses four syntaxes that aim to cultivate students' critical thinking abilities. Critical thinking skills encompass a multifaceted cognitive process that involves the interpretation, analysis, inference, assessment, explanation, and self-regulation of information (Putri et al., 2020). Through learning that trains critical thinking skills, students can build, discover, and develop knowledge through scientific activities. Scientific activities encompass a variety of engaging experiments and trials, whether conducted physically or virtually that

necessitate students' active participation in the learning process. Based on the syntax of the problem-posing learning model in Table 2, the first stage reviews the material; the researcher provides examples of the material phenomena that will be presented. In this research, the subject studied is optical waves with reflection and refraction of light. The researcher played an opening video related to the reflection and refraction of light. Subsequently, the researcher presented concise content through a PowerPoint presentation displayed on the screen during an online conference conducted via Google Meet, utilizing a distance learning platform.

In the second stage of problem formation, students are asked to create questions or problems that require solving problems related to reflection and refraction in everyday life. Students then work in groups to answer and find original solutions based on group discussions. In the third stage, namely checking the solution, students carry out virtual trials or experiments with the help of PhET. Students examine the problem in the second stage with an experiment called "bending light" in PhET. Students work together in teams to create reports based on experimental results using Google documents that researchers have prepared. Researchers can monitor the progress of the work conducted by students and identify individuals who are not actively participating in the group.

The final stage contains review activities. At this stage, students in groups can review the results of their respective experiments through presentation activities. The other group and the researcher evaluated the experiment's results by asking questions and providing input. Presentations were made alternately to each group. In the end, researchers and students reviewed and concluded the overall discussion of the material on reflection and refraction of light. After implementing the problem-posing learning model assisted by PhET in distance learning, students were given questions regarding evaluating light reflection and refraction material, which was created to practice critical thinking skills. The evaluation questions consist of five reflection questions and five refraction questions. The results of students' critical thinking skills can be seen in Table 3.

Table 3. Results of student critical thinking skills.

Student	Average	Categories
1	80.00	high
2	92.50	Very high
3	85.00	high
4	82.50	high
5	90.00	Very high
6	70.00	Currently
7	52.50	Very low
8	55.00	Low
9	72.50	Currently
10	82.50	High
11	87.50	High
12	77.50	Currently
13	77.50	Currently
14	80.00	high
15	85.00	high
16	85.00	high

Student	Average	Categories
17	90.00	Very high
18	92.50	Very high
Average	**79.86**	**High**

Based on the data presented in Table 3, the mean score for critical thinking abilities among students in the class was 79.86, indicating a high level of proficiency. According to this table, students from the class of 2021 can be classified as very high, high, medium, low, and extremely low. Figure 2 displays the percentage grouping.

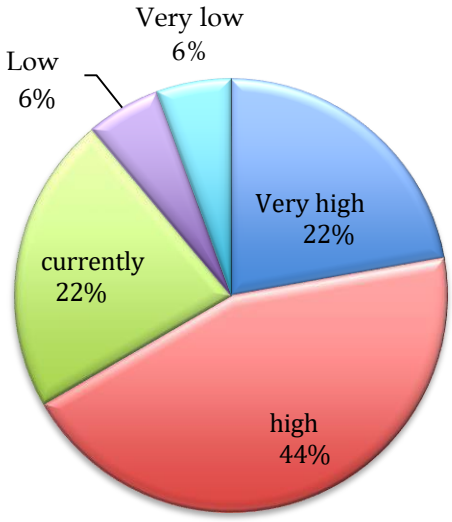
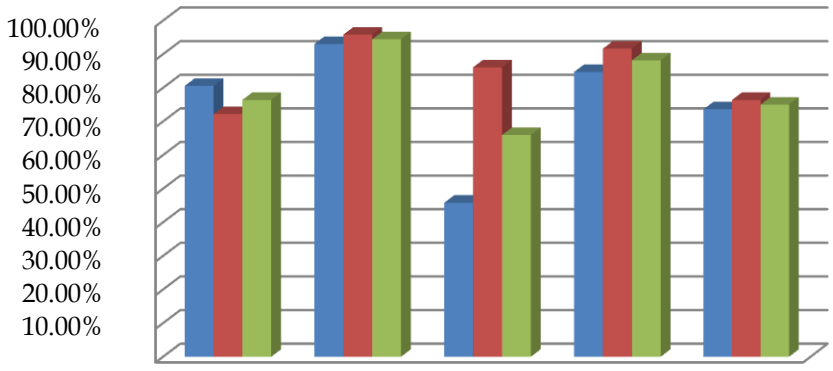


Figure 2. Percentage of students' critical thinking skills categories.

Based on Figure 2, it can be seen that the high category of critical thinking skills had the most significant proportion of pupils, accounting for 44.00%. In comparison, the exceptionally high and medium categories each had 22.00%. The low categories had the most diminutive proportions, with 6.00% each. The assessment measures five key indicators of critical thinking skills: elementary clarification, decision basis determination, inference drawing, advanced clarification, and supposition estimation and integration. Figure 3 displays student achievement scores based on these five indicators.



0.00%	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5
Reflection	80.56%	93.06%	45.83%	84.72%	73.61%
Refraction	72.22%	95.83%	86.11%	91.67%	76.39%
Reflection and Refraction	76.39%	94.44%	65.97%	88.19%	75.00%

Figure 3. Achievement of critical thinking skills for each indicator.

Discussion

Based on the data presented in Figure 3, it is evident that the second indicator, determining the basis for decision-making, holds the highest value at 94.44%, placing it in the very high category. Students can determine how to solve problems well. Students make decisions based on detailed, complete, transparent, and relevant reasons. To provide these reasons, they wait to answer quickly but are always careful so that the time required tends to be extended. The problem-posing learning methodology, facilitated by PhET, trains students to answer issues using various methods while providing logical justifications that align with the underlying concepts of the content.

The third indicator has the lowest percentage, namely the concluding (inference) activity, with a percentage of 65.97%. The percentage could be higher because some students needed to conclude the material correctly in the reflection material. However, students understood the concept of light refraction material better at the next meeting, so the percentage increase was relatively high, namely 40.28%. Students who did not correctly conclude the material were carried away until they worked on the questions. Students answer questions briefly and must answer more precisely and clearly what is asked. This is because students are less able to make conclusions by induction or deduction from events described by the concepts of the material being studied (Safitri & Prasi, 2020). This is reflected in their weak ability to analyze problems, low curiosity, and lack of independence and confidence (Darmawati & Mustadi, 2023). Students answer without considering the concepts they have studied previously. Figure 4 illustrates a student's response to the third indicator query.

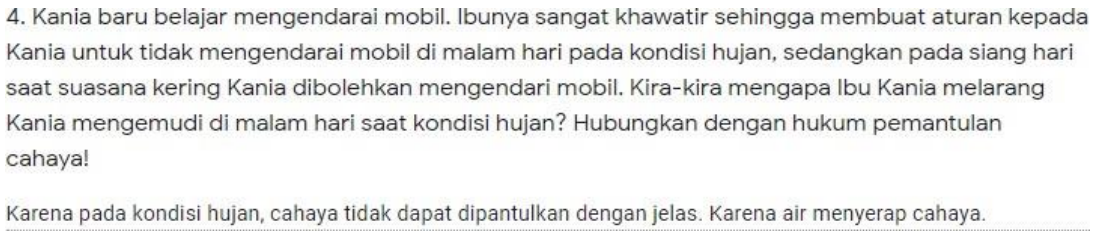


Figure 4. Example of student answers for the third indicator.

The first indicator gets 76.39%, including the medium category. Students can explain simple concepts, events, or phenomena in everyday life. This is because when learning using the problem-posing model with the help of PhET, students are used to analyzing a phenomenon with simple experiments through PhET, and the learning activities and close atmosphere look conducive. However, sometimes, students need to explain more fully. The fourth indicator obtained a percentage of 88.19%, including the high category, providing further explanation. Students can provide assumptions about solving problems (Putri et al., 2020). The fifth indicator regarding estimating and combining got a percentage of 75.00%, including the lowest number, 2. This is because pupils have a

lower capacity to apply the concept to the specific image asked for in the question. Students' proficiency in these indicators involves the capacity to think critically and logically about the correlation between a concept and a specific circumstance. This enables them to articulate the relationship between interconnected concepts, facts, or methods.

The findings of this study demonstrate that the development of critical thinking abilities is achievable through the utilization of the problem-posing learning framework with the support of PhET. Educational materials using technology and simulations can strengthen students' comprehension of concepts. Combat rope sport, which uses ropes to create waves, is a real-world illustration of the wave phenomenon. Thus, media that offers realistic simulations can enhance students' critical thinking abilities to help them comprehend the notion of waves (Yuanata et al., 2023).

As outlined in a scholarly publication, the utilization of the problem-posing learning approach aids in enhancing critical thinking skills as it encourages individuals to engage in open discussions regarding the authenticity of the issue, evaluate various suppositions, and determine the resolution status of the problem (Darhim et al., 2020). Implementation of learning with the help of PhET can provide direct experience to students that can be accessed anywhere and at any time, thus stimulating them to be actively involved in learning. This learning can train critical thinking skills because students are trained to express opinions logically based on experimental results.

CONCLUSION

Fundamental Finding: Implementing the problem-posing model with the support of PhET is a highly effective strategy for improving students' critical thinking skills in the context of distance or online education. **Implication**: Lecturers can apply critical thinking skills to students so that students get used to being skilled in the learning process—**limitations** regarding time management. The time required for this research model and approach is quite large. **Future Research:** The results of this research will carry out further research on the R & D scheme on virtual laboratory media by adding the Internet of Things to the practicum sheet. This is the peak of the downstreamization of learning media towards school digitalization.

REFERENCES

Adilla, I. N., & Jatmiko, B. (2021). Keefektifan pembelajaran daring fisika SMA berbasis probing promting untuk meningkatkan keterampilan berpikir kritis peserta didik. *PENDIPA Journal of Science Education*, *5*(3), 426–435. https://doi.org/10.33369/pendipa.5.3.426-435

Anindya, F. A., & Wusqo, I. U. (2020). The influence of PjBL-STEAM model toward students' problem solving skills on light and optical instruments topic. *Journal of Physics: Conference Serries, 1567*(4), 1-10. https://doi.org/10.1088/1742-6596/1567/4/042054

Arzak, K. A., & Prahani, B. K. (2023). The physics problem solving skills profile of high school students in elasticity material and the implementation of augmented reality book-assisted PBL model. *Momentum: Physics Education Journal*, *7*(1), 66–77. https://doi.org/10.21067/mpej.v7i1.6704

Aziz, F. (2020). Dampak COVID-19 terhadap pembelajaran di perguruan tinggi. *Bioma, 2*(1), 14-20.

Bitzenbauer, P. (2023). ChatGPT in physics education: A pilot study on easy-to-implement activities. *Contemporary Educational Technology*, *15*(3), 1-10. https://doi.org/10.30935/cedtech/13176

Darhim, D., Prabawanto, S., & Susilo, B. E. (2020). The effect of problem-based learning and

mathematical problem posing in improving student's critical thinking skills. *International Journal of Instruction*, *13*(4), 103–116. https://doi.org/10.29333/iji.2020.1347a

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.v11i2.5562

Deringöl, Y. (2020). Problem posing activities in primary school mathematics textbooks. *Elementary Education Online*, *19*(3), 1619–1646. https://doi.org/10.17051/ilkonline.2020.734556

Fakhrizal, T., & Hasanah, U. (2021). Upaya meningkatkan kemampuan berpikir kritis siswa pada mata pelajaran biologi melalui penerapan model pembelajaran problem based learning di kelas X SMA negeri 1 kluet tengah. *Biotik: Jurnal Ilmiah Biologi Teknologi dan Kependidikan, 8*(2), 200-217. https://doi.org/10.22373/biotik.v8i2.8222

Iswara, E., & Sundayana, R. (2021). Penerapan model pembelajaran problem posing dan direct instruction dalam meningkatkan kemampuan pemecahan masalah matematis siswa. *Jurnal Pendidikan Matematika*, *1*, 223–234.

Jatmiko, B., Prahani, B. K., Hariyono, E., Dwikoranto, D., Wibowo, F. C., Mahtari, S., Misbah, M., & Asy'ari, M. (2021). Critical thinking skills on physics learning during COVID-19 pandemic : A bibliometric analysis using VOSViewer. *Journal of Physics: Conference Series*, 1–9. https://doi.org/10.1088/1742-6596/2110/1/012020

Khasanah, D. A., Pramudibyanto, H., & Widuroyekti, B. (2020). Pendidikan dalam Masa Pandemi COVID-19. *Jurnal Sinestesia, 10*(1), 41-48.

Lidiawati, L., Pursitasari, I. D., & Heliawati, L. (2022). Critical thinking skills and self-regulated learning of students during the COVID-19 pandemic. *EduChemia (Jurnal Kimia dan Pendidikan), 7*(1), 1-13. https://doi:10.30870/educhemia.v7il.10627

Lorencia, G., & Jatmiko, B. (2021). Online learning PBL model with the STS approach to improve high school students' critical thinking ability. *PENDIPA Journal of Science Education*, *5*(3), 459–465. https://doi.org/10.33369/pendipa.5.3.459-465

Mashurin, A. H., Mubarok, H., & Prahani, B. K. (2021). Profile of guided discovery learning implementation assisted by 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

Nafrin, I. A., & Hudaidah, H. (2021). Perkembangan pendidikan indonesia di masa pandemi COVID-19. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(2), 456–462. https://doi.org/10.31004/edukatif.v3i2.324

Nasrudin, J. (2019). *Metodologi penelitian pendidikan.* Bandung: PT Panca Terra Firma.

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

Prahani, B. K., Saphira, H. V., Jatmiko, B., & Amelia, T. (2023). Research trends of pre- service physics teachers ' critical thinking skills during 2001 to 2022. *International Journal of Emerging Research and Review*, *1*(2), 1–11.

Prahani, B. K., Susiawati, E., Deta, U. A., Lestari, N. A., Yantidewi, M., Jauhariyah, M. N. R., Mahdiannur, M. A., Candrawati, E., Misbah, Mahtari, S., Suyidno, & Siswanto, J. (2021). Profile of students' physics problem-solving skills and the implementation of inquiry (free, guided, and structured) learning in senior high school. *Journal of Physics: Conference Series*, *1747*(1), 1-10. https://doi.org/10.1088/1742-6596/1747/1/012012

Pristianti, M. C., & Prahani, B. K. (2022). Profile of students' physics problem solving skills and problem based learning implementation supported by website on gas kinetic theory. *Jurnal Pendidikan Progresif*, *12*(1), 375–393. https://doi.org/10.23960/jpp.v12.i1.202229

Purwiningsih, S., & Sari, Y. D. (2022). Analisis pengaruh mind mapping terhadap minat belajar siswa pada materi tata nama senyawa menggunakan model inkuiri di sekolah menengah kejuruan. *Edukatif: Jurnal Ilmu Pendidikan*, 1639-1647.

Putri, C. D., Pursitasari, I. D., & Rubini, B. (2020). Problem based learning terintegrasi STEM di era pandemi COVID-19 untuk meningkatkan keterampilan berpikir kritis siswa. *Jurnal IPA & Pembelajaran IPA*, *4*(2), 193–204. https://doi.org/10.24815/jipi.v4i2.17859

Rahmat, A. D., Wilujeng, I., Kuswanto, H., Daud, A. N., & Saepuzaman, D. (2024). Development worksheet integrated PhET simulation to improve critical thinking skills in junior high school. *Indonesian Journal of Science Education*, 111-123. https://dx.doi.org/10.24815/jpsi.v12i1.34742

Rizaldi, D. R., Jufri, A. W., & Jamal. (2020). PhET: Simulasi interaktif dalam proses pembelajaran fisika. *Jurnal Ilmiah Profesi Pendidikan*, 10-14. https://dx.doi.org/10.29303/jipp.v5i1.103

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), 233–246.

Safitri, A. N. R., & Prasi, I. G. N. (2020). Analisis hubungan motivasi belajar terhadap keterampilan berpikir kritis mahasiswa pada pokok bahasan dinamika partikel. *Jurnal Kependidikan Betara*, *1*(2), 48–55.

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

Saputri, A. D., Hartono, & Handayani, L. (2016). Integrasi tembang pocung dalam pembelajaran kooperatif tebak kata pada tema alat optik untuk mendeskripsikan sikap ilmiah dan motivasi belajar siswa. *Unnes Physics Education Journal, 5*(2), 85-94. https://doi.org/10.15294/upej.v5i2.13627

Septianita, R., Suharini, E., Widiyatmoko, A., Marwoto, P., & Mulyono, S. E. (2023). Interactive modules containing problem based learning with socioscientific issues on the water cycle material. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2462–2471. https://doi.org/10.29303/jppipa.v9i5.2730

Setiawan, A. R., 2020. Lembar kegiatan saintifik untuk pembelajaran jarak jauh topik penyakit coronavirus 2019 (Covid-19). *Edukatif: Jurnal Ilmu Pendidikan,* 2(1), 28-37. https://doi.org/10.31004/edukatif.v2i1.80

Sylviani, S., Permana, F. C., & Utomo, R. G. (2020). PHeT simulation sebagai alat bantu siswa sekolah dasar dalam proses belajar mengajar mata pelajaran matematika. *Edsence: Jurnal Pendidikan Multimedia*, *2*(1), 1–10. https://doi.org/10.17509/edsence.v2i1.25184

Tong, D., Tao, Y., Zhang, K., Dong, X., Hu, Y., Pan, S., & Liu, Q. (2023). Investigating ChatGPT-4's performance in solving physics problems and its potential implications for education. *Asia Pacific Education Review*, 1-10. https://doi.org/10.1007/s12564-023-09913-6

Yani, L. P., & Widiyatmoko, A. (2023). The effectiveness of the PhET-assisted creative problem solving model on students' creative thinking abilities and cognitive learning outcomes. *Jurnal Inovasi Pendidikan IPA*, 9(2), 146-156.

Yuanata, B. E., Dwikoranto, & Setiani, R. (2023). Profile of PhET assisted problem-based learning model for improving critical thinking skills of high school students. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 11*(3), 870-880. https://doi.org/10.33394/j-ps.v11i3.8415

Yuangga, D. K. & Sunarsi, D. (2020). Pengembangan media dan strategi pembelajaran untuk mengatasi permasalahan pembelajaran jarak jauh di pandemi COVID-19. *Jurnal Guru Kita,* 4(3), 51-58. https://doi.org/10.24114/jgk.v4i3.19472

* **Roudhoutul Aulia Rochim, M.Pd. (Corresponding Author)**
Department of Natural Science Education, Faculty of Educational Science,
Hasyim Asy'ari Tebuireng Jombang University,
Jl. Irian Jaya 55, Tebuireng Jombang, East Java, 61471, Indonesia
Email: roudhoutulrochim@unhasy.ac.id

Noer Af'idah, M.Si.
Department Natural Science Education, Faculty of Educational Science,
Hasyim Asy'ari Tebuireng Jombang University,
Jl. Irian Jaya 55, Tebuireng Jombang, East Java, 61471, Indonesia
Email: noerafidah@unhasy.ac.id

Desi Wulandari, M.Pd.
Department of Electrical Engineering, Faculty of Engineering
Billfath University,
Kompleks Pondok Pesantren Al Fatah Siman Sekaran, Lamongan, East Java, 62261, Indonesia
Email: desiwulan770@gmail.com.