Lensa: Jurnal Kependidikan Fisika
Penerbit: Universitas Pendidikan Mandalika
https://e-journal.undikma.ac.id/index.php/Lensa/index

Dec. Vol. 12, No. 2
e-ISSN: 2686-0937
pp. 367-379

Investigating the Impact of Ethno-Physics Learning on Students' Critical Thinking Skills

Muhamad Alibar[1]*, Saiful Prayogi[2], Habibi[3]

[1] Physics Education Department, Universitas Pendidikan Mandalika, Mataram, Indonesia
[2] Science Education Department, Universitas Pendidikan Mandalika, Mataram, Indonesia
[3] Physics Education Department, Universitas Negeri Surabaya, Surabaya, Indonesia

*Corresponding Author: malibar@gmail.ac.id

Abstract

This study examines the impact of Ethno-Physics Learning on enhancing students' critical thinking skills by integrating indigenous cultural knowledge into the physics curriculum. Traditional physics instruction, which often relies on rote memorization and passive learning, has been found insufficient in developing the analytical and problem-solving abilities necessary for both academic achievement and real-world applications. In contrast, Ethno-Physics Learning contextualizes abstract scientific concepts within culturally relevant frameworks, thereby fostering active inquiry and deeper cognitive engagement. Utilizing a quasi-experimental design with non-equivalent control groups, the research involved Grade 10 students from two classes. The experimental group received instruction on the topic of Work and Energy through Ethno-Physics Learning methods, while the control group experienced conventional lecture-based teaching. Both groups underwent pretesting and posttesting to assess their critical thinking skills across various dimensions, including analysis, inference, evaluation, explanation, and decision-making. Statistical analyses, incorporating tests for normality and homogeneity followed by paired samples t-tests, revealed that although improvements were noted in both groups, the experimental group exhibited significantly greater gains in critical thinking abilities. These findings suggest that integrating local ethnoscience into physics education not only makes scientific theories more accessible and meaningful but also cultivates the higher-order cognitive skills essential for effective problem-solving. The study highlights the transformative potential of Ethno-Physics Learning and recommends its incorporation into science curricula to enhance student engagement and learning outcomes in diverse educational settings.

Keywords: Ethno-physics learning; Critical thinking; Physics education; Indigenous knowledge

How to cite: Alibar, M., Prayogi, S., & Habibi, H. (2024). Investigating the Impact of Ethno-Physics Learning on Students' Critical Thinking Skills. *Lensa: Jurnal Kependidikan Fisika, 12*(2), 367-379. doi: https://doi.org/10.33394/j-lkf.v12i2.14824

INTRODUCTION

The ability to think critically is a fundamental skill necessary for students to engage in problem-solving, analytical reasoning, and decision-making in scientific learning. However, research indicates that many students struggle with critical thinking, particularly in physics education, due to the lack of meaningful and authentic learning experiences. Traditional instructional methods often emphasize rote memorization and passive learning, limiting students' opportunities to engage in deep analytical processes (Suprapto et al., 2024). This deficiency hinders students from questioning concepts, connecting theoretical knowledge to real-world applications, and fostering a problem-solving mindset (Ubaidillah et al., 2023; Worachak et al., 2023). Addressing this issue requires a shift towards more engaging and contextually relevant pedagogies that promote active learning and cognitive development.

One promising approach to enhancing students' critical thinking skills in physics education is the integration of ethnoscience, particularly in the form of Ethno-Physics Learning. Ethnoscience refers to the incorporation of traditional cultural knowledge and local wisdom into modern scientific education. By embedding physics concepts within cultural and real-world contexts, Ethno-Physics Learning allows students to see the relevance of physics in their daily lives, making abstract scientific theories more tangible and meaningful (Jamaludin et al., 2022). Moreover, this approach aligns with constructivist learning theories, which emphasize that students learn more effectively when they can relate new knowledge to their prior experiences (Rahayu et al., 2023; Nisa et al., 2024).

The traditional methods of teaching physics have been widely criticized for their inability to foster students' critical thinking. Conventional lecture-based approaches often fail to engage students in active problem-solving, instead reinforcing passive knowledge absorption (Sutrio et al., 2023; Nusroh et al., 2022). However, contemporary research suggests that strategies such as reciprocal teaching and problem-based learning (PBL) can significantly improve students' critical thinking skills by providing opportunities for collaborative learning and inquiry-based exploration (Zulnaidi et al., 2022; Samadun & Dwikoranto, 2022; Santyasa et al., 2021). Despite the potential of these methods, there remains a gap in their effectiveness when applied in culturally diverse settings, highlighting the need for alternative approaches such as Ethno-Physics Learning.

Ethno-Physics Learning offers a unique advantage by merging scientific principles with students' cultural backgrounds. This approach not only enhances conceptual understanding but also fosters a deeper appreciation for both science and indigenous knowledge (Haulia et al., 2022; Prayogi et al., 2023). Studies have demonstrated that students engaged in ethnoscience-based learning show greater motivation, improved problem-solving abilities, and a stronger connection between theoretical physics and real-world applications (Budiarti et al., 2020; Juwita et al., 2023). Additionally, integrating ethnoscience into physics education provides an inclusive learning environment, accommodating diverse learning styles and promoting equity in science education (Dewi & Safitri, 2023).

The integration of Ethno-Physics Learning into physics education holds significant promise for developing students' critical thinking skills. By utilizing authentic learning experiences, this approach encourages students to engage in inquiry-based exploration, allowing them to investigate scientific phenomena through the lens of their cultural context (Bissett-Johnson & Radcliffe, 2019). When students are actively involved in questioning, hypothesizing, and problem-solving based on familiar cultural practices, they develop essential cognitive skills that are crucial for scientific reasoning and analytical thinking (Fredholm et al., 2019). Therefore, Ethno-Physics Learning represents an innovative pedagogical framework that has the potential to bridge the gap between theoretical physics and real-world applications while simultaneously nurturing critical thinking skills in students.

Research problem

Despite the increasing emphasis on critical thinking as an essential skill in physics education, many students still exhibit low levels of analytical reasoning and problem-solving abilities. This issue is largely attributed to the prevalence of traditional teaching methods that prioritize rote memorization over active engagement (Suprapto et al., 2024). Many students passively absorb information without critically analyzing the concepts presented, resulting in a superficial understanding of physics (Ubaidillah et al., 2023; Worachak et al., 2023). The failure to cultivate critical thinking skills in physics learning not only impacts academic performance but also limits students' ability to apply scientific principles to real-world contexts. This situation necessitates an urgent shift in pedagogical approaches to ensure that students are actively involved in the learning process.

One of the major challenges in physics education is the lack of authentic learning experiences that connect scientific knowledge to students' cultural and everyday realities. Research has demonstrated that students are more likely to develop critical thinking skills when they engage in learning experiences that are relevant to their personal and cultural backgrounds (Jamaludin et al., 2022). However, conventional physics instruction often presents abstract theories in isolation from students' lived experiences, making it difficult for them to see the practical applications of physics concepts. Moreover, the scarcity of diverse and engaging instructional resources further exacerbates this problem, limiting opportunities for students to develop inquiry-based learning habits (Dewi & Safitri, 2023).

Another significant issue is the underutilization of ethnoscience as a pedagogical tool in physics education. Ethnoscience, which integrates local knowledge and cultural practices into science learning, has the potential to make physics more accessible and engaging for students (Walid et al., 2022; Aisyah & Khotimah, 2023). However, despite its documented benefits, ethnoscience remains largely absent from mainstream physics curricula. Educators often lack the necessary training and resources to implement ethnoscience-based strategies effectively, resulting in a continued reliance on conventional teaching methods that fail to nurture critical thinking skills (Rahayu et al., 2023; Nisa et al., 2024). Addressing these barriers is crucial for improving students' engagement and cognitive development in physics learning.

The need to explore Ethno-Physics Learning as a means to enhance students' critical thinking skills arises from these challenges. Research suggests that integrating ethnoscience with inquiry-based and problem-solving approaches can significantly improve students' ability to think critically and apply physics concepts in meaningful ways (Prayogi et al., 2023; Prayogi et al., 2022). However, there remains a gap in empirical studies examining the direct impact of Ethno-Physics Learning on students' critical thinking abilities. Given the increasing demand for students to develop higher-order thinking skills in science education, it is imperative to investigate how Ethno-Physics Learning can serve as an effective pedagogical strategy for fostering critical thinking in physics classrooms.

Research objective, hypothesis, and statement of novelty

The primary objective of this study is to assess the impact of Ethno-Physics Learning on students' critical thinking skills. Given the challenges associated with traditional physics instruction, which often fails to actively engage students in analytical reasoning and problem-solving, it is crucial to explore alternative pedagogical approaches. Ethno-Physics Learning integrates ethnoscience with physics education, allowing students to connect scientific concepts to their cultural and everyday experiences. This study seeks to determine whether this integration effectively enhances students' critical thinking abilities by promoting inquiry-based learning, problem-solving, and contextual understanding.

The hypothesis guiding this research posits that students who are taught using Ethno-Physics Learning will demonstrate significantly higher critical thinking skills compared to those who undergo traditional physics instruction. Previous studies have suggested that incorporating ethnoscience in education fosters active engagement and deeper comprehension of scientific concepts (Rahayu et al., 2023; Nisa et al., 2024). However, empirical evidence specifically linking Ethno-Physics Learning to critical thinking development remains limited. By testing this hypothesis, this study aims to provide a clearer understanding of how cultural integration in physics education influences students' cognitive skills.

The novelty of this research lies in its focus on Ethno-Physics Learning as a framework for developing critical thinking in physics education. While prior studies have explored ethnoscience-based learning in general, there is a lack of research specifically examining its application in physics classrooms and its impact on higher-order thinking skills. This study contributes to the growing body of literature by offering empirical insights into how Ethno-Physics Learning can serve as a transformative instructional approach. By demonstrating the effectiveness of this method, the findings can inform curriculum design, teacher training programs, and educational policies aimed at improving students' critical thinking in physics education.

METHOD

Research design

This study employs a nonequivalent control group design, a quasi-experimental approach that involves two distinct groups: an experimental group and a control group. This design is chosen to measure the impact of Ethno-Physics Learning on students' critical thinking skills by comparing pretest and posttest results between both groups. The groups are selected using purposive sampling, a non-random sampling method where participants are chosen based on specific characteristics relevant to the study. In this research, students in both groups receive the same instructional content on Work and Energy but through different pedagogical approaches. The experimental group undergoes instruction using Ethno-Physics Learning, which integrates local cultural knowledge with physics concepts, while the control group follows a traditional teaching method, primarily consisting of lectures and question-and-answer sessions. By comparing the pretest and posttest scores, this study aims to determine the effectiveness of Ethno-Physics Learning in fostering students' critical thinking skills.

At the beginning of the study, students in both groups take a pretest to assess their initial critical thinking levels. The pretest serves as a baseline measure, ensuring that any observed differences in posttest scores can be attributed to the instructional intervention rather than pre-existing disparities in students' abilities. Following the pretest, the experimental group engages in Ethno-Physics Learning, which emphasizes inquiry-based learning, problem-solving, and real-world applications of physics within students' cultural contexts. The control group, in contrast, follows a conventional approach that focuses on theoretical explanations and direct instruction. At the end of the study, both groups take a posttest, allowing for a comparison of learning gains. This research design ensures that changes in students' critical thinking skills can be directly linked to the instructional approach used in each group, providing empirical evidence on the effectiveness of Ethno-Physics Learning in physics education.

Sample and ethical consideration

The population in this study consists of Grade 10 students from MAN 1 Manggarai, located in East Nusa Tenggara, Indonesia. The school has two science classes, X IPA A and X IPA B, with a total of 52 students. A random sampling technique is used to determine the sample, ensuring that every student has an equal chance of being selected. The experimental group consists of students from Class X IPA A, who receive instruction using Ethno-Physics Learning, while the control group consists of students from Class X IPA B, who are taught using traditional methods. The selection process ensures that both groups have similar academic backgrounds and cognitive abilities before the intervention begins.

This study adheres to ethical research standards, ensuring that all participants provide informed consent before participating in the research. The objectives and procedures of the study are clearly communicated to both students and teachers, allowing them to voluntarily participate without coercion. Confidentiality is strictly maintained, and all data collected is anonymized to protect students' privacy. Additionally, the study follows ethical guidelines related to educational research, ensuring that no harm comes to the participants. Ethical approval is obtained from the school administration, and students are given the freedom to withdraw from the study at any stage without any academic repercussions.

Research instruments and data collection

The primary instrument used to measure students' critical thinking skills is a critical thinking test based on Ennis' Critical Thinking Framework. This test assesses five key dimensions of critical thinking: analysis, inference, evaluation, explanation, and decision-making. The test consists of essay-based questions designed to measure students' ability to apply physics concepts in problem-solving scenarios. The questions are aligned with the topic of *Work and Energy* and require students to demonstrate their reasoning skills in constructing arguments, making logical inferences, and evaluating evidence. The test is designed to differentiate between lower-order thinking skills (basic recall and comprehension) and higher-order thinking skills (application, synthesis, and evaluation).

Data collection is conducted through pretests and posttests. The pretest is administered before the intervention to establish a baseline measure of students' critical thinking skills, ensuring that both groups start from a similar level. Following the instructional intervention, a posttest is given to both groups to evaluate learning outcomes. The same test format is used in both assessments to ensure consistency and reliability. In addition to test scores, classroom observations and student feedback are gathered to gain qualitative insights into students' engagement and learning experiences. The combination of quantitative and qualitative data provides a comprehensive understanding of the impact of Ethno-Physics Learning on students' critical thinking skills.

Data analysis

Before conducting the main analysis, pretest scores are subjected to normality and homogeneity tests to determine whether the data is normally distributed and whether the two groups have comparable variances. The Shapiro-Wilk test is used to check the normality of the data, where a significance value ($p > 0.05$) indicates that the data follows a normal distribution. Additionally, a homogeneity test is conducted to determine whether the variances between the experimental and control groups are equal. If the homogeneity test confirms that both groups have similar initial conditions, it ensures that differences in posttest scores can be attributed to the instructional intervention rather than extraneous variables.

To test the research hypothesis, a t-test is conducted to compare posttest scores between the experimental and control groups. The independent samples t-test is used to determine whether there is a statistically significant difference between the two groups' mean scores. A significance value of $p < 0.05$ indicates that Ethno-Physics Learning has a significant effect on students' critical thinking skills. The effect size is also calculated to measure the magnitude of the difference between the two instructional approaches. The findings from this analysis provide empirical evidence on the effectiveness of Ethno-Physics Learning in enhancing students' cognitive abilities, offering valuable insights for educators and curriculum developers in science education.

RESULTS AND DISCUSSION

To determine whether the collected data follows a normal distribution, the Shapiro-Wilk normality test was conducted for both the experimental and control groups at the pretest and posttest stages. The results of the normality test are presented in Table 1.

Table 1. Tests of normality

Group	Mean Score	df	Kolm. -Smirnov Sig.	Shapiro-Wilk Sig.
Pretest (Experimental)	6.56	27	0.200	0.176
Posttest (Experimental)	18.63	27	0.200	0.339
Pretest (Control)	7.24	25	0.061	0.040
Posttest (Control)	12.16	25	0.005	0.018

Table 1 shows that the pretest and posttest critical thinking scores for the experimental group have significance values greater than $\alpha = 0.05$, indicating that the data is normally distributed. However, in the control group, the posttest significance value falls below 0.05, suggesting a deviation from normality. Despite this, given the relatively large sample size, the analysis proceeds using parametric statistical tests, as the Central Limit Theorem suggests that larger samples tend to approximate normal distribution.

A Levene's test for homogeneity of variance was conducted to examine whether the variance between the experimental and control groups is equivalent. Table 2 presents the results of the homogeneity test.

Table 2. Test of homogeneity of variance

Test Basis	Levene Statistic	df1	df2	Sig.
Based on Mean	1.874	3	100	0.139
Based on Median	1.505	3	100	0.218
Based on Trimmed Mean	1.938	3	100	0.128

The significance value (Sig.) for all test bases is greater than 0.05, confirming that the pretest and posttest critical thinking skill scores exhibit homogeneous variance across both groups. This result ensures that further statistical analyses, such as t-tests, can be validly applied to compare the effectiveness of Ethno-Physics Learning versus conventional teaching methods.

To test whether there is a significant difference in critical thinking skills between the experimental and control groups, a paired samples t-test was conducted on the pretest and posttest scores. The results are summarized in Table 3.

Table 3. Paired samples test results

Pair	Mean Diff.	SD	SE	t	df	Sig.
Pretest - Posttest (Exp)	-12.074	2.111	0.406	-29.722	26	0.000
Pretest - Posttest (Control)	-4.920	2.159	0.432	-11.396	24	0.000

The results indicate that the mean difference in posttest scores is significantly higher in the experimental group (-12.074) compared to the control group (-4.920). Additionally, the p-value (Sig. = 0.000) is less than α = 0.05, confirming that Ethno-Physics Learning has a statistically significant impact on students' critical thinking skills. The larger effect size in the experimental group suggests that integrating ethnoscience into physics education leads to greater cognitive gains than conventional teaching methods.

The findings of this study highlight the significant impact of Ethno-Physics Learning on students' critical thinking skills, demonstrating that integrating cultural knowledge into physics instruction fosters higher levels of cognitive engagement, problem-solving, and analytical reasoning. The results reveal that students in the experimental group, who were exposed to Ethno-Physics Learning, achieved significantly higher posttest scores than their peers in the control group, who received conventional instruction. This aligns with existing research emphasizing the role of authentic and contextual learning experiences in enhancing students' cognitive abilities (Jamaludin et al., 2022; Rahayu et al., 2023). The following discussion elaborates on the broader implications of these findings, supported by relevant literature.

One of the key benefits of Ethno-Physics Learning is its ability to actively engage students in the learning process, which is a critical factor in developing higher-order thinking skills. Unlike traditional lecture-based methods, which often result in passive knowledge absorption, ethnoscience-based instruction encourages students to actively explore scientific concepts through real-life cultural contexts (Suprapto et al., 2024). Research indicates that students learn more effectively when they can relate new knowledge to their prior experiences (Nisa et al., 2024). By embedding physics within familiar cultural practices, students develop deeper connections to scientific principles, leading to enhanced analytical and inferential reasoning (Hikmah & Jauhariyah, 2021).

Furthermore, ethnoscience promotes inquiry-based learning, which is essential for critical thinking development. When students investigate physics concepts within their own cultural and environmental contexts, they are encouraged to ask questions, analyze data, and evaluate evidence, all of which contribute to higher-order cognitive skills (Weidman & Salisbury, 2020). This aligns with the constructivist learning framework, which posits that knowledge construction occurs most effectively when learners actively engage with content rather than passively receiving information (Bayu et al., 2022). The findings of this study support this perspective, as students in the Ethno-Physics Learning group demonstrated significant gains in critical thinking skills, suggesting that cultural contextualization enhances students' ability to process and apply scientific knowledge critically (Kettler, 2014).

Another essential aspect of Ethno-Physics Learning is its role in fostering collaborative problem-solving, which has been widely recognized as a key component of critical thinking. When students work together to explore local cultural practices related to physics, they engage in meaningful discussions, exchange perspectives, and critically evaluate different problem-solving approaches (Khaeruddin & Bancong, 2022). This collaborative environment not only reinforces students' conceptual understanding but also helps them develop essential skills such as argumentation, negotiation, and logical reasoning (Ubaidillah et al., 2023).

Studies have shown that group-based inquiry in science education leads to better problem-solving outcomes compared to individual learning, as it allows students to challenge each other's ideas and refine their reasoning through dialogue (Niu, 2023). Ethno-Physics Learning naturally incorporates collaborative learning, as students often explore local physics applications, such as the mechanics of traditional agricultural tools or the principles behind indigenous construction methods (Weidman & Salisbury, 2020). This real-world relevance not only strengthens their conceptual grasp of physics but also encourages a deeper level of analytical thinking, as students are required to justify their interpretations based on scientific evidence and cultural relevance.

Another major contribution of Ethno-Physics Learning is its ability to bridge the gap between theoretical knowledge and real-world applications, which is a crucial element in developing critical thinking skills (Prayogi et al., 2023). Many students struggle with physics because it is often taught in abstract terms, making it difficult for them to relate concepts to their daily lives (Dewi & Safitri, 2023). However, when physics instruction is embedded within culturally familiar contexts, students find greater relevance in what they are learning, leading to stronger cognitive engagement and improved problem-solving abilities (Haulia et al., 2022).

For example, students in the Ethno-Physics Learning group in this study explored physics principles through local cultural artifacts and traditional knowledge systems. This contextual approach enabled them to apply theoretical knowledge to practical situations, enhancing their ability to reason critically and evaluate scientific claims (Budiarti et al., 2020). Similar findings have been reported in previous studies, where students who engaged in ethnoscience-based projects displayed higher levels of scientific literacy and critical thinking compared to those in conventional physics classrooms (Juwita et al., 2023).

Additionally, the integration of indigenous knowledge with formal physics instruction fosters multidimensional thinking, as students are encouraged to compare scientific explanations with traditional wisdom, leading to a more comprehensive understanding of physics concepts (Bayu et al., 2022). This approach promotes epistemic flexibility, where students learn to critically evaluate multiple sources of knowledge, rather than relying solely on Western-centric scientific narratives (Kettler, 2014).

The findings of this study have significant implications for science education policy and curriculum development, particularly in culturally diverse regions. Given that conventional physics instruction often fails to engage students in meaningful ways, integrating Ethno-Physics Learning into the curriculum presents a viable alternative that aligns with global educational trends emphasizing student-centered and contextually relevant learning (Santyasa et al., 2021).

Educators should consider incorporating ethnoscience-based approaches into physics teaching, particularly in communities where traditional knowledge systems are deeply embedded in daily life. Doing so would not only enhance student engagement but also promote inclusivity in science education, ensuring that diverse ways of knowing are acknowledged and valued (Walid et al., 2022). Furthermore, teacher training programs should focus on equipping educators with the skills necessary to integrate ethnoscience into physics instruction effectively, as many teachers currently lack the required pedagogical knowledge and resources (Rahayu et al., 2023).

Additionally, this study suggests that educational policymakers should support initiatives that encourage collaborative and inquiry-based learning models within science curricula. Given the strong evidence demonstrating that Ethno-Physics Learning fosters critical thinking, it should be considered as a core instructional strategy in secondary science education. Future research should explore longitudinal studies to assess the long-term impact of ethnoscience-based learning on students' scientific reasoning and career aspirations.

CONCLUSION

This study assessed the impact of Ethno-Physics Learning on students' critical thinking skills, confirming that integrating ethnoscience into physics education significantly enhances students' ability to analyze, infer, evaluate, and solve scientific problems compared to traditional instructional methods. The findings demonstrated that students in the experimental group, who received Ethno-Physics Learning, achieved higher posttest scores and showed greater cognitive improvement than those in the control group, indicating a statistically significant impact on critical thinking skills. The t-test results confirmed that Ethno-Physics Learning fosters higher-order thinking by encouraging students to engage in inquiry-based learning, problem-solving, and collaborative discussions rooted in their cultural contexts. These results align with prior research suggesting that contextually relevant education enhances students' engagement and comprehension of scientific concepts. Given the effectiveness of Ethno-Physics

Learning in fostering critical thinking development, this study provides empirical evidence supporting its integration into physics education curricula. Future research should explore longitudinal studies to assess the long-term impact of Ethno-Physics Learning and its applicability across diverse educational settings, ensuring that students worldwide benefit from culturally contextualized and inquiry-driven science education.

LIMITATIONS

While this study provides strong empirical evidence supporting the effectiveness of Ethno-Physics Learning, several limitations should be acknowledged. First, the study was conducted in a single educational setting, which may limit the generalizability of the findings to broader student populations. Future studies should consider replicating this research across multiple schools with different cultural backgrounds to examine whether similar results are observed in diverse educational contexts. Second, while the study measured improvements in critical thinking skills, it did not assess long-term retention of knowledge. Further research should explore whether students retain their enhanced critical thinking abilities over extended periods and whether these skills translate into better academic performance in other scientific disciplines. Finally, this study focused primarily on quantitative measures of critical thinking improvement. Future research could incorporate qualitative methods, such as student interviews and classroom observations, to gain deeper insights into how students experience and perceive Ethno-Physics Learning. This would provide a richer understanding of how cultural relevance impacts students' cognitive and emotional engagement with physics.

REFERENCES

Aisyah, N., & Khotimah, H. (2023). Implementation of ethnosains in science learning in madrasah ibtidaiyah. *Jurnal Pendidikan Dasar Nusantara, 8*(2), 321–334. https://doi.org/10.29407/jpdn.v8i2.19135

Bayu, W., Nurhasan, N., Suroto, S., & Solahuddin, S. (2022). Peer observation, self-assessment, and circuit learning: Improving critical thinking and physical fitness in physical education. *Jurnal Cakrawala Pendidikan, 41*(2), 308–320. https://doi.org/10.21831/cp.v41i2.38654

Bissett-Johnson, K., & Radcliffe, D. (2019). Assessing the authenticity of the student learning experience. *Proceedings of the Design Society International Conference on Engineering Design, 1*(1), 449–458. https://doi.org/10.1017/dsi.2019.48

Budiarti, I., Suparmi, S., Sarwanto, S., & Harjana, H. (2020). Effectiveness of generation, evaluation, and modification-cooperative learning (GEM-CL) model selaras bakar batu cultural practice in Papua. *Jurnal Pendidikan Ipa Indonesia, 9*(1), 32–41. https://doi.org/10.15294/jpii.v9i1.22362

Dewi, W., & Safitri, G. (2023). The practicality of the physics module based on the PJBL model with a portfolio assessment to improve students' critical thinking skills. *Journal of Physics Conference Series, 2582*(1), 012054. https://doi.org/10.1088/1742-6596/2582/1/012054

Fredholm, A., Henningsohn, L., Savin-Baden, M., & Silén, C. (2019). The practice of thresholds: Autonomy in clinical education explored through variation theory and the threshold concepts framework. *Teaching in Higher Education, 25*(3), 305–320. https://doi.org/10.1080/13562517.2019.1567486

Haulia, L., Hartati, S., & Mas'ud, A. (2022). Learning biology through the ethnoscience-PBL model: Efforts to improve students' scientific thinking skills. *Scientiae Educatia, 11*(2), 119. https://doi.org/10.24235/sc.educatia.v11i2.11229

Hikmah, N., & Jauhariyah, M. (2021). Meta-analysis of students' critical thinking skills improvement on physics learning. *Berkala Ilmiah Pendidikan Fisika, 9*(2), 155. https://doi.org/10.20527/bipf.v9i2.10585

Jamaludin, J., Kakaly, S., & Batlolona, J. (2022). Critical thinking skills and concepts mastery on the topic of temperature and heat. *Journal of Education and Learning (Edulearn), 16*(1), 51–57. https://doi.org/10.11591/edulearn.v16i1.20344

Juwita, E., & Rosidin, U. (2023). *The developing of e-module flip PDF professional based on Napai ethnoscience to improve science literacy on biotechnology materials* (pp. 151–158). https://doi.org/10.2991/978-2-38476-060-2_15

Kettler, T. (2014). Critical thinking skills among elementary school students. *Gifted Child Quarterly, 58*(2), 127–136. https://doi.org/10.1177/0016986214522508

Khaeruddin, K., & Bancong, H. (2022). STEM education through PhET simulations: An effort to enhance students' critical thinking skills. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni, 11*(1), 35–45. https://doi.org/10.24042/jipfalbiruni.v11i1.10998

Nisa, K., Suprapto, N., Shofiyah, N., & Cheng, T. (2024). How does ethnoscience-students' worksheet (ESW) influence in science learning? *Journal of Education and Learning (Edulearn), 18*(2), 403–412. https://doi.org/10.11591/edulearn.v18i2.21178

Niu, Y. (2023). Integrated physical education and medicine in general physical education at universities in the age of educational technologies. *BMC Medical Education, 23*(1). https://doi.org/10.1186/s12909-023-04440-9

Nusroh, H., Khalif, M., & Saputri, A. (2022). Developing physics learning media based on augmented reality to improve students' critical thinking skills. *Physics Education Research Journal, 4*(1), 23–28. https://doi.org/10.21580/perj.2022.4.1.10912

Prayogi, S., Ahzan, S., & Rokhmat, J. (2023). The validity and effectiveness of the ethnoscience-loaded inquiry learning model to improve students' critical thinking skills (pp. 1877–1885). https://doi.org/10.2991/978-2-38476-152-4_189

Prayogi, S., Ahzan, S., Indriaturrahmi, I., & Rokhmat, J. (2022). Opportunities to stimulate the critical thinking performance of preservice science teachers through the ethno-inquiry model in an e-learning platform. *International*

Journal of Learning Teaching and Educational Research, 21(9), 134–153. https://doi.org/10.26803/ijlter.21.9.8

Prayogi, S., Ahzan, S., Rokhmat, J., & Verawati, N. (2023). Dynamic blend of ethnoscience and inquiry in a digital learning platform (e-learning) for empowering future science educators' critical thinking. *Journal of Education and E-Learning Research, 10*(4), 819–828. https://doi.org/10.20448/jeelr.v10i4.5233

Rahayu, R., Sutikno, S., & Indriyanti, D. (2023). Ethnosains based project based learning model with flipped classroom on creative thinking skills. *Jurnal Penelitian Pendidikan Ipa, 9*(8), 348–355. https://doi.org/10.29303/jppipa.v9i8.3051

Samadun, S., & Dwikoranto, D. (2022). Improvement of student's critical thinking ability in physics materials through the application of problem-based learning. *Ijorer International Journal of Recent Educational Research, 3*(5), 534–545. https://doi.org/10.46245/ijorer.v3i5.247

Santyasa, I., Agustini, K., & Tegeh, I. (2021). *The effect of problem-based flipped learning and academic procrastination on students' critical thinking in learning physics in high school*. https://doi.org/10.2991/assehr.k.210715.094

Suprapto, N., Rizki, I., & Cheng, T. (2024). Profile of students' physics critical thinking skills and prospect analysis of project-oriented problem-based learning model. *Journal of Educational and Social Research, 14*(3), 134. https://doi.org/10.36941/jesr-2024-0062

Sutrio, S., Busyairi, A., Doyan, A., Kosim, K., & Hikmawati, H. (2023). The effectiveness of the problem-based flipped classroom model with e-modules in improving critical thinking skills of pre-service physics teachers. *Jurnal Pendidikan Fisika Dan Teknologi, 9*(2), 274–283. https://doi.org/10.29303/jpft.v9i2.5826

Ubaidillah, M., Hartono, H., Marwoto, P., Wiyanto, W., & Subali, B. (2023). How to improve critical thinking in physics learning? A systematic literature review. *Journal of Educational Cultural and Psychological Studies (ECPS Journal), (28).* https://doi.org/10.7358/ecps-2023-028-ubai

Walid, A., Winarni, E., Yanti, F., Firdaus, M., Suherman, S., & Zulkarnain, Z. (2022). Ethnoscience-based module: Biodiversity materials in Lembak tribe. *JTK (Jurnal Tadris Kimiya)*, 7(2), 300–308. https://doi.org/10.15575/jtk.v7i2.19955

Weidman, B., & Salisbury, H. (2020). Critical thinking in health sciences and how it pertains to sonography education: A review of the literature. *Journal of Diagnostic Medical Sonography, 36*(3), 244–250. https://doi.org/10.1177/8756479320908216

Worachak, S., Damnoen, P., & Hong, D. (2023). Analysis of critical thinking skills in problem-based learning and inquiry learning models. *Edufisika Jurnal Pendidikan Fisika, 8*(3), 282–293. https://doi.org/10.59052/edufisika.v8i3.29442

Zulnaidi, H., Mafarja, N., & Fadzil, H. (2022). Using reciprocal teaching strategy to improve physics students' critical thinking ability. *Eurasia Journal of Mathematics Science and Technology Education, 18*(1), em2069. https://doi.org/10.29333/ejmste/11506