

Implementation of POE2WE Model-Based Teaching Materials Assisted by Google Sites to Improve Students' Critical Thinking Skills

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Abstract

This study aims to analyze the improvement of students' critical thinking skills and to examine the differences in their critical thinking abilities after the instructional materials were implemented, specifically on the concept of electromagnetic induction. The research was conducted at SMA Negeri 7 Halmahera Selatan with twelfth-grade science students during the even semester of the 2024/2025 academic year. The results showed that the average posttest score of the experimental group (86.56) was significantly higher than that of the control group (75.31), with a significance value of $p = 0.005 (< 0.05)$. These findings indicate that the developed instructional materials are effective in enhancing students' critical thinking skills. The POE2WE model encourages active engagement through systematic stages that support the development of higher-order thinking, while the integration of Google Sites provides access to interactive, structured materials that enable both independent and collaborative learning. Therefore, these instructional materials are recommended for wider implementation in school-based physics education.

Keywords: POE2WE Model; Teaching Materials; Google Sites; Critical Thinking

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1. INTRODUCTION

Critical thinking is a fundamental competency in 21st-century education, enabling students to analyze information, evaluate arguments, and solve problems logically and creatively. However, empirical evidence consistently shows that students' critical thinking skills remain underdeveloped, particularly in physics learning. Traditional instruction, which is often dominated by teacher-centered lectures, static textbooks, and rote memorization, provides limited opportunities for students to explore phenomena, test ideas, and reflect on their understanding. As a result, students experience difficulties in evaluating physical phenomena and formulating effective problem-solving strategies. These conditions highlight the need for instructional innovations that promote active learning and higher-order thinking in physics education.

One instructional approach that addresses this challenge is the Predict–Observe–Explain–Elaborate–Write–Evaluate (POE2WE) learning model. This constructivist-oriented model engages students in a structured learning process that begins with predicting phenomena, followed by observation and explanation of outcomes, conceptual elaboration, documentation of understanding, and evaluation of learning results. Through these integrated stages, POE2WE encourages students to actively construct knowledge and reflect on their learning, thereby supporting the development of critical thinking and conceptual understanding in physics.

Alongside pedagogical innovation, technological integration has become increasingly important in enhancing the effectiveness of physics instruction. Advances in digital technology provide opportunities to develop interactive and flexible learning media that support students' engagement and understanding. Studies have shown that technology-based learning media, including mobile learning, positively influence students' conceptual understanding, motivation, academic performance, and higher-order thinking skills (Anselmo et al., 2024). Moreover, learning media play a crucial role in

knowledge construction and serve as essential tools in the learning process (Anjani, 2020). Despite their potential, mobile devices are often underutilized for educational purposes, as students tend to use them primarily for social media and entertainment rather than learning activities (Ramadani, E.M, et. al, 2022). Therefore, appropriate instructional design is required to optimize the educational use of mobile technology.

The use of mobile phones has both positive and negative impacts on students' learning behavior, both at home and in the classroom, often leading to dependency. Teachers can leverage students' Android-based mobile phones as learning media for accessing educational materials or resources. The instructional materials employed should be aligned with students' characteristics and appropriately integrated with a suitable learning model. The use of such materials can facilitate students' learning and enhance their mastery of the subject matter. Instructional materials refer to all tools used by educators to support teaching and learning activities in the classroom. These materials may take both written and non-written forms (Saputri et al., 2020).

In this context, Google Sites offers a practical platform for developing digital instructional materials that are accessible, interactive, and adaptable to students' learning needs. Google Sites allows teachers to integrate various learning resources, such as text, images, videos, animations, and simulations, which can facilitate students' understanding of abstract physics concepts. Learning supported by IT-based applications has been shown to improve learning efficiency and motivation (Lin Y.T, & Jou, M, 2012), while digital instructional materials enhance students' engagement and comprehension when designed interactively and aligned with an appropriate learning model (Zainal & Kasmawati, 2021); (Komariah et al., 2024). (Kurniawan, I & Zabeta, 2025). When digital media is designed to be interactive and engaging, and applied using an appropriate learning model, it can significantly improve student participation in learning activities (Fadiya, S & Satianingsih, 2025);(Sriwati et al., 2025).

Previous studies have reported positive outcomes from the integration of the POE2WE learning model with digital platforms. POE2WE-based instructional materials have been classified as highly feasible and effective in supporting physics learning (Adam et al., 2023). The POE2WE model is a constructivist-based instructional model developed to help students discover and understand concepts. It structures students' knowledge beginning with the process of predicting solutions to a problem, conducting experiments to validate these predictions, describing experimental results orally or in writing, providing real-life application examples, documenting discussion outcomes, and evaluating students' understanding both orally and in writing (Nana, 2018). Several studies support this. For instance, (Fajriyah & Jatmiko, 2021) found that the application of digital platforms for physics learning based on the POE2WE model can enhance higher-order thinking skills. Moreover,(Maharani et al., 2024) reported that using Google Sites as a physics learning medium can improve students' learning outcomes and support them throughout the physics learning process. (Fitri et al., 2020)) concluded that implementing the POE2WE model in physics learning facilitates teachers in guiding students to study the material effectively, enabling them to construct their own understanding while directly connecting it to real-life problems. Similarly,(Adam et al., 2023) found that both teachers and students responded positively to POE2WE-based instructional materials assisted by Google Sites, highlighting their effectiveness, ease of use, and flexibility.

Based on these considerations, this study integrates the POE2WE learning model with Google Sites-assisted instructional materials to support physics learning, particularly on the topic of electromagnetic induction. The objectives of this study are to: (1) analyze the improvement of students' critical thinking skills in problem-solving, and (2) examine differences in critical thinking abilities between students who learn using POE2WE-based instructional materials assisted by Google Sites and those who experience conventional instruction. The findings of this study are expected to contribute empirical evidence to the development of effective digital instructional materials and provide practical insights for teachers in implementing innovative, technology-supported learning strategies to enhance students' critical thinking skills.

2. METHOD

This study employed an experimental research design using a randomized control group design. The research was conducted at SMA Negeri 7 Halmahera Selatan with twelfth-grade science (IPA) students in the even semester of the 2024–2025 academic year, consisting of four classes with a total of 128 students. The sample was selected using a purposive sampling technique, considering the similarities in sample characteristics. The study sample consisted of 64 students from Class XII IPA-1 and Class XII IPA-2. The study was conducted in accordance with the established design, as presented in Table 1.

Table 1. Research Design

Class	Pretest	Treatment	Post-Test
Experimental Class	O ₁	X ₁	O ₂
Control Class	O ₃	X ₂	O ₄

Source: (Fraenkel et al., 2015)

Description:

O₁: Pretest of the experimental class

O₂: Posttest of the experimental class

X₁: Treatment using POE2WE Model–Based Instructional Materials

O₃: Pretest of the control class

X₂: Treatment without POE2WE Model–Based Instructional Materials

O₄: Posttest of the control class

The stages of the research consisted of: 1) developing the test items, 2) conducting item trials, 3) determining the sample using purposive sampling, 4) administering the pretest to both the experimental and control classes, 5) implementing learning activities in the experimental class using POE2WE-model-based instructional materials supported by Google Sites and in the control class without POE2WE-model-based instructional materials supported by Google Sites, 6) administering the posttest to both the experimental and control classes, 7) conducting a normality test, 8) conducting a homogeneity test, 9) conducting an N-gain analysis, and 10) conducting an independent-samples t-test. The data obtained consisted of critical thinking scores collected through critical thinking tests. The tests were administered to both the experimental and control classes using instruments in the form of critical thinking test items related to the concepts presented in the instructional materials. The data were then analyzed using descriptive statistics, including normality testing, homogeneity testing, N-gain analysis, and a two-sample comparison test (t-test), employing SPSS version 20.

RESULTS AND DISCUSSION

A total of 15 test items were initially developed. After validity and reliability testing, 10 items were confirmed as valid and reliable and were subsequently used for both the pre-test and post-test in the experimental and control classes. The results of students' critical thinking ability tests are presented in Figures 1–4 and Tables 1–4.

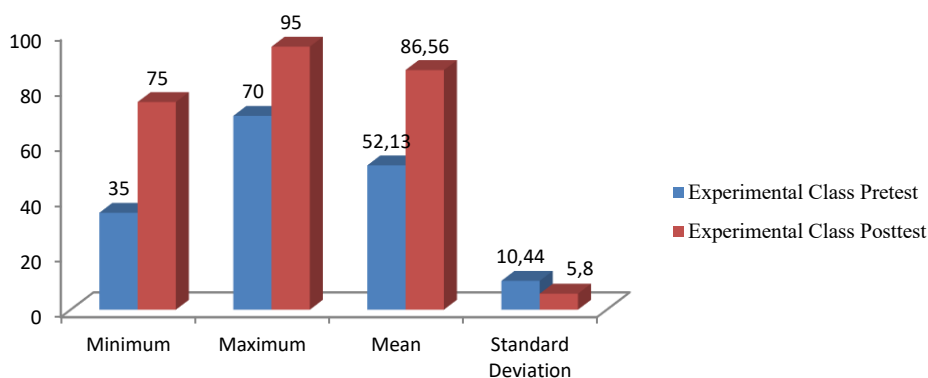


Figure 1. Students' Critical Thinking Ability Scores in the Experimental Class

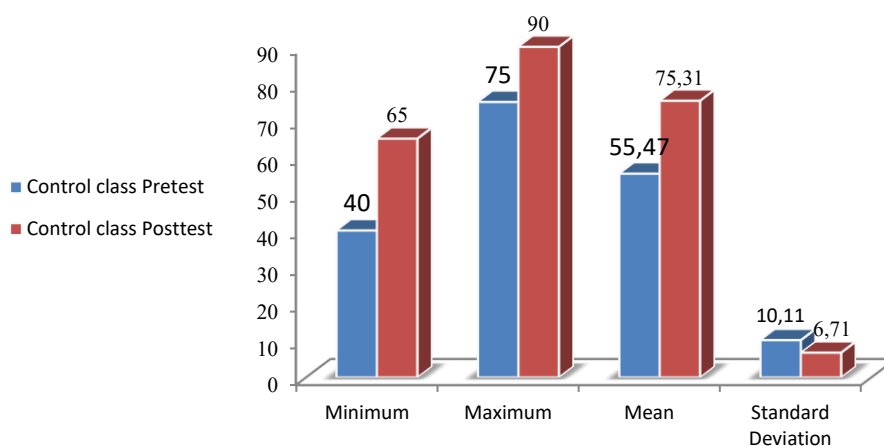


Figure 2. Students' Critical Thinking Ability Scores in the Control Class

Overall, the findings indicate that students in the experimental class demonstrated greater improvement in critical thinking skills compared to those in the control class. As illustrated in Figures 1 and 2, both classes showed an increase in scores from pre-test to post-test; however, the magnitude of improvement was notably higher in the experimental class. In this class, students' scores increased substantially across the entire ability range, indicating that the intervention benefited not only high-achieving students but also those with lower initial abilities. In contrast, improvements in the control class were more limited and unevenly distributed.

The frequency distribution graphs (Figures 3 and 4) further support these findings. Prior to the intervention, most students in both classes were categorized in the low and very low critical thinking levels. After the implementation of POE2WE-based instructional materials supported by Google Sites, the experimental class showed a marked shift toward the high and very high categories, with no students remaining in the low categories. Meanwhile, although the control class exhibited some improvement, a considerable proportion of students remained within the moderate category, indicating that conventional instruction was less effective in promoting higher-level critical thinking.

These results suggest that the POE2WE learning model, when integrated with digital instructional materials, facilitates a more comprehensive development of students' critical thinking skills. The structured learning stages prediction, observation, explanation, elaboration, writing, and evaluation, encourage students to actively engage in cognitive processes such as analysis, reflection, and evaluation. This aligns with constructivist learning theory, which emphasizes knowledge construction through active engagement and reflection rather than passive reception.

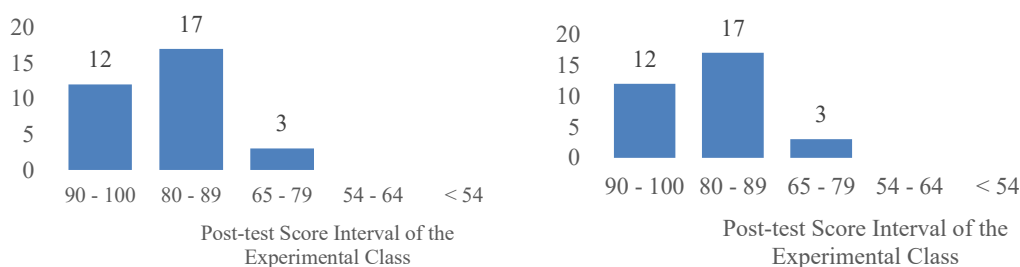


Figure 3. Frequency Distribution of Students' Critical Thinking Abilities (Pre-test and Post-test) in the Experimental Class

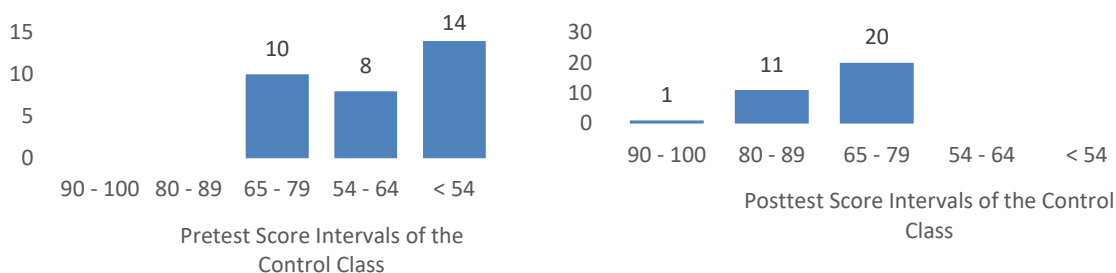


Figure 4. Frequency Distribution Graph of Students' Critical Thinking Skills (Pretest and Posttest) in the Control Class

The pretest results in the control class revealed that the majority of students fell within the low-score interval, with 43.75% obtaining scores below 54 (very low category), and no students achieving scores within the 80–100 interval (high and very high categories). Although there was an improvement in the posttest, indicated by 62.5% of students scoring within the 65–79 interval (moderate category), 3.13% of students (one student) achieved the very high category, and 34.38% fell within the 80–89 interval (high category), this increase demonstrates that the enhancement of critical thinking skills in the control class remained relatively limited. When compared to the class that employed POE2WE-based instructional materials supported by Google Sites, the improvement observed in the control class was considerably less optimal than that of the experimental class. Therefore, it can be concluded that learning without the use of POE2WE-based teaching materials supported by Google Sites still presents limitations in comprehensively developing students' critical thinking skills. In contrast, the POE2WE model integrated with digital media is more effective in fostering higher levels of learning achievement.

Before hypothesis testing, the data met the prerequisite assumptions of normality and homogeneity, as shown in Tables 1 and 2 ($p > 0.05$). Consequently, further analysis using the N-Gain test and independent samples t-test was conducted.

Table 1. Results of the Normality Test for Experimental Class and Control Class Data

Class		Kolmogorov-Smirnov ^a		
		Statistic	Df	Sig.
Experiment	Pretest	.127	32	.200*
	Posttest	.129	32	.190
Control	Pretest	.143	32	.093
	Posttest	.161	32	.035

Table 2. Results of the Homogeneity Test of Experimental Class and Control Class Data

Class		Levene Statistic	df1	df2	Sig.
Experiment-Control	Pretest	.479	1	62	.491
	Posttest	.017	1	62	.897

Based on
Mean

The N-Gain analysis (Table 3) revealed that the experimental class achieved a gain score of 0.73 (73.03%), categorized as quite effective, whereas the control class obtained a gain score of 0.45 (44.69%), classified as ineffective. These results indicate that the POE2WE-based instructional materials supported by Google Sites were significantly more effective in improving students' critical thinking skills than conventional learning approaches.

Table 3. N-Gain Analysis Results

N-Gain Test (Pretest-Posttest)			Conclusion
Experimental Class	N-Gain	0,7303	Quite Effective
	% N-Gain	73,03 %	
Control Class	N-Gain	0,4469	Not Effective
	% N-Gain	44,69 %	

The independent samples t-test results (Table 4) further confirmed a statistically significant difference between the experimental and control classes ($p < 0.05$). The experimental class achieved a higher mean post-test score than the control class, demonstrating that the instructional intervention had a meaningful impact on students' critical thinking abilities. This finding supports previous studies reporting that POE2WE-based and technology-assisted learning environments enhance higher-order thinking skills and learning outcomes (Fajriyah & Jatmiko, 2021; Adam et al., 2023; Maharani et al., 2024).

The effectiveness of the intervention can also be attributed to the use of Google Sites as a learning platform. Google Sites provides structured, visual, and interactive learning resources that support independent and collaborative learning. This digital environment enables students to access materials anytime, engage with multimedia content, and reflect on their learning through documentation and evaluation activities. These features are consistent with previous findings that technology-based instructional materials enhance critical thinking, communication, and self-directed learning (Prabowo et al., 2019); (Khan & Setiawan, 2019).

Table 4. Independent Samples t-Test Results for the Experimental and Control Class Data

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Experimental Class	Equal variances assumed	13.495	.001	16.312	62	.000	34.438	2.111
		8.516	.005	9.251	62	.000	19.844	2.145
& Control Class	Equal variances not assumed			16.312	48.455	.000	34.438	2.111
				9.251	53.888	.000	19.844	2.145

The notable difference in average scores between the experimental group (86.56) and the control group (75.31), along with the statistical significance ($p = 0.005$), reinforces the evidence that this approach is not only effective but also viable for broader adoption in educational contexts. Therefore, the use of POE2WE-based instructional materials supported by Google Sites can be recommended as an innovative teaching strategy to significantly enhance students' critical thinking skills. These findings are consistent with the study by (Adam et al., 2023) which reported that the instructional materials facilitate the understanding of physics concepts through the POE2WE stages integrated within the Google Sites platform.

The results of the SPSS analysis revealed a highly significant difference between the experimental and control classes, with scores of 34.44 and 19.84, respectively. These findings indicate that POE2WE-based instructional materials supported by Google Sites are highly effective in enhancing students' critical thinking skills. This effectiveness is reflected not only in the increased number of

students achieving high scores after the learning process but also in the reduction of students categorized with low critical thinking ability. The integration of the POE2WE learning model with digital media such as Google Sites creates a more interactive, structured, and student-centered learning environment that supports the development of critical thinking skills. These results are consistent with previous studies, which reported that the POE2WE model integrated with Google Sites effectively improves students' critical thinking abilities while fostering a more engaging and enjoyable learning atmosphere (Rahman et al., 2024; Panggabean et al., 2023). Several studies further support the effectiveness of the POE2WE model in enhancing higher-order thinking skills. (Nana, 2020); (Fajriyah & Jatmiko, 2021) reported that the application of the POE2WE model in virtual physics learning, particularly for alternating current electricity topics, effectively trains students' higher-order thinking skills. Additionally (Nana, 2018b) explained that POE2WE-based learning improves students' conceptual understanding and increases their interest and motivation in learning. Furthermore, (Marfungah., 2024) emphasized that the use of the POE2WE model combined with technology-assisted media, such as Google Sites, in developing instructional materials significantly enhances students' conceptual understanding.

The effectiveness of the POE2WE model can be attributed to its structured and systematic learning stages, which actively engage students in the learning process and promote critical thinking. In the Predict phase, students are encouraged to forecast experimental outcomes, fostering analytical skills and curiosity. During the Observe phase, students conduct systematic observations by recording and analyzing data, which helps bridge theoretical concepts and experimental evidence. The Explain phase provides students with opportunities to articulate and justify their observations, for example by explaining the relationship between the number of coil turns and induced electromotive force (EMF) in electromagnetic induction. This stage plays a crucial role in developing students' communication and argumentation skills, which are essential components of critical thinking.

The Write phase further strengthens students' understanding by encouraging them to document their findings and reflections, thereby developing academic writing skills and reinforcing conceptual comprehension. Finally, the Extend phase enables students to connect physics concepts to real-world applications, such as electric generators and bicycle dynamos, highlighting the relevance of electromagnetic induction in everyday life. Through these integrated stages, POE2WE supports deeper conceptual understanding and meaningful learning experiences.

In addition to pedagogical structure, the integration of technology through Google Sites enhances the accessibility and interactivity of learning materials. eported that technology integration in learning improves material accessibility and student engagement. Similarly, (Rahman et al., 2025) emphasized that incorporating digital learning tools within appropriate instructional models positively impacts student engagement, critical thinking, and self-directed learning. Google Sites facilitates collaboration and interaction, enabling students to communicate, discuss, and explore learning materials more effectively. This dynamic learning environment supports deeper understanding and the development of critical thinking skills.

Moreover, (Ramadannisa & Hartina, 2021) asserted that students involved in research-based and technology-supported learning tend to demonstrate deeper conceptual understanding, as they not only memorize information but also apply it in real-world contexts—an essential characteristic of critical thinking ability. The implementation of POE2WE-based instructional materials integrated with Google Sites thus provides a structured and supportive learning environment that significantly enhances students' critical thinking skills.

These findings are in line with (Haryanti, A. S, et al., 2024), who emphasized the importance of active learning approaches, such as those embodied in the POE2WE model, particularly for students with lower levels of critical thinking skills. The structured learning process helps build students' confidence in problem-solving and encourages active participation. The significant differences observed between the experimental and control classes provide strong empirical evidence supporting the effectiveness of POE2WE-based instructional materials assisted by Google Sites. With well-designed instructional materials, an engaging learning model, and appropriate digital media, students are able to engage in deeper and more meaningful learning processes. Therefore, teachers are encouraged to continuously develop and implement innovative instructional materials to prepare students for future challenges, as emphasized by (Maryani et al., 2022) who highlighted that quality

education is essential for developing learners who are not only academically competent but also capable of critical and creative thinking.

4. CONCLUSION

This study demonstrates that the implementation of POE2WE-based instructional materials assisted by Google Sites is highly effective in enhancing students' critical thinking skills in physics learning, particularly on the topic of electromagnetic induction. The significant differences in critical thinking performance between the experimental and control classes confirm that the integration of a constructivist learning model with digital instructional media provides measurable advantages over conventional instructional approaches. The structured learning stages of the POE2WE model Predict, Observe, Explain, Elaborate, Write, and Extend actively engage students in the learning process and promote higher-order cognitive skills, including analysis, reasoning, reflection, and evaluation. The integration of Google Sites further strengthens the learning environment by improving accessibility, interactivity, and opportunities for independent and collaborative learning. These features enable students to connect theoretical concepts with experimental observations and real-world applications more effectively.

The findings of this study are consistent with previous research indicating that POE2WE-based and technology-assisted learning environments positively influence students' critical thinking skills, conceptual understanding, motivation, and engagement. Therefore, POE2WE-based instructional materials supported by Google Sites can be considered a viable and effective alternative for physics instruction, particularly in fostering critical thinking skills among senior high school students. Based on these results, it is recommended that physics teachers integrate innovative learning models and digital platforms in their instructional practices to support meaningful learning experiences. Future studies are encouraged to explore the application of POE2WE-based digital instructional materials across different physics topics, educational levels, and learning contexts to further validate and extend the findings of this research.

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 A portrait of a woman wearing a patterned hijab and a floral-patterned top, set against a light background.	<p>Fatma Hamid, a lecturer in the Physics Education Study Program at Universitas Khairun, Ternate, Indonesia. His research interests include physics education and instructional media. He can be contacted at email : fatmahamid@unkhair.ac.id</p>
 A portrait of a woman wearing a black hijab and a dark blazer over a white top, set against a solid red background.	<p>Hutri Handayani Isra, a lecturer in the Physics Education Study Program at Universitas Khairun, Ternate, Indonesia. His research interests include physics education and learning outcome evaluation. He can be contacted at email : hutrihandayaniisra04@gmail.com</p>