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The Implementation of the POE2WE Learning Model Assisted by PhET Simulation to Improve Conceptual Understanding of Grade XI Students at SMAN 1 Bukit Batu

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ABSTRACT

This study aims to examine the effectiveness of the POE2WE (Predict, Observe, Explain, Elaborate, Write, Evaluate) learning model assisted by PhET simulations in improving students' conceptual understanding of Newton's laws. The research employed a quantitative approach with a quasi-experimental design, specifically a posttest-only nonequivalent control group design. The population consisted of 68 eleventh-grade students at SMAN 1 Bukit Batu, Indonesia, in the 2025/2026 academic year. The sample was divided into two groups: the experimental class, which received instruction using the POE2WE learning model assisted by PhET simulations, and the control class, which was taught using conventional methods. Data were collected through a posttest consisting of multiple-choice questions designed to measure seven indicators of conceptual understanding: interpreting, exemplifying, classifying, generalizing, inferring, comparing, and explaining. Data analysis was conducted using both descriptive and inferential statistics. The results of the descriptive analysis showed that the experimental class achieved a higher average score (70.32) categorized as good, compared to the control class (53.94) categorized as fair. Inferential analysis using the Mann–Whitney U test revealed a significance value of $p = 0.000$ ($p < 0.05$), indicating a significant difference between the two groups. These findings suggest that the implementation of the POE2WE learning model assisted by PhET simulations is effective in enhancing students' conceptual understanding of Newton's laws. Therefore, this study contributes to the development of interactive and technology-based physics learning strategies.

Introduction

Physics education plays a vital role in fostering students' scientific literacy, critical thinking, and problem-solving abilities, which are essential competencies in the 21st century. Through physics learning, students are expected not only to master theoretical knowledge but also to develop the ability to analyze natural phenomena logically and systematically. However, despite its importance, the implementation of physics education in Indonesia continues to face significant challenges, particularly in facilitating students' conceptual understanding of abstract topics such as Newton's laws (Fathurohman, 2023).

International assessments have consistently shown that Indonesian students' performance in science remains below the global average. This condition reflects underlying issues in instructional practices, especially the dominance of teacher-centered approaches in classrooms. In such environments, teachers often rely heavily on lectures, while students passively receive information without actively engaging in the learning process. As a result, students tend to memorize formulas rather than understand the underlying physical concepts, leading to superficial learning outcomes and persistent misconceptions (Azhar, 2013).

One of the most challenging topics in high school physics is Newton's laws of motion. These laws require students to understand the relationships between force, mass, and acceleration, as well as the principles governing motion and interaction between objects. Many students experience difficulties in grasping these relationships due to the abstract nature of the concepts. In particular, misconceptions frequently occur in understanding Newton's third law, where students often assume that action and reaction forces are unequal, rather than equal in magnitude and opposite in direction. Such misconceptions indicate that students' conceptual understanding is still limited and requires targeted instructional interventions (Novianti, 2017).

Another contributing factor to students' low conceptual understanding is their limited ability to visualize dynamic physical phenomena. Many physics concepts, including force interactions and motion, cannot be directly observed in everyday situations without proper experimental tools. Unfortunately, limited laboratory facilities in many schools restrict students' opportunities to conduct hands-on experiments. Consequently, the learning process becomes less meaningful, as students lack concrete experiences that could help them construct their understanding of abstract concepts (Sagita, 2022).

In response to these challenges, the integration of educational technology into physics instruction has gained increasing attention. One promising approach is the use of interactive simulations, such as PhET (Physics Education Technology). PhET simulations provide a virtual environment where students can manipulate variables, observe outcomes, and explore physical phenomena in an interactive and visual manner. This type of learning environment allows students to actively engage in the learning process, making abstract concepts more accessible and easier to understand. Moreover, the immediate feedback provided by simulations helps students correct their misconceptions in real time (Zulkifli, 2022).

Although the effectiveness of PhET simulations in improving conceptual understanding has been widely recognized, their implementation in classrooms is still not optimal. Many teachers face challenges in integrating technology into their teaching practices due to limited training and lack of familiarity with appropriate instructional models. As a result, the use of simulations often lacks a structured pedagogical framework, reducing its potential impact on student learning (Putri, 2024).

To maximize the effectiveness of simulation-based learning, it is essential to integrate it with an appropriate instructional model that promotes active learning and conceptual change. One such model is POE2WE (Predict, Observe, Explain, Elaborate, Write, Evaluate), which is an extension of the traditional POE model. This model is grounded in constructivist learning theory and emphasizes the active involvement of students in constructing their own knowledge. Through the stages of prediction, observation, explanation, elaboration, writing, and evaluation, students are guided to engage in higher-order thinking processes, reflect on their understanding, and develop deeper conceptual insights (Aprilia, 2024).

The POE2WE model is particularly effective in addressing misconceptions because it creates cognitive conflict between students' initial predictions and the actual outcomes observed during the learning process. (Abdulghani & Sya'ban, 2026). This conflict encourages students to re-evaluate their prior knowledge and reconstruct their understanding based on scientific principles. When combined with interactive simulations such as PhET, the model can provide a powerful learning experience that integrates visualization, inquiry, and reflection (Syaflita & Efendi, 2024).

Previous studies have demonstrated the effectiveness of both POE2WE and PhET simulations when applied independently. The POE2WE model has been shown to enhance students' learning outcomes by promoting reflective and metacognitive thinking, while PhET simulations have been proven to improve conceptual understanding through interactive visualization. However, research that integrates these two approaches, particularly in the context of Newton's laws at the senior high school level, remains limited. This gap highlights the need for further investigation into the combined effect of inquiry-based learning models and digital simulations on students' conceptual understanding. (Siregar, 2020).

In addition, the current educational landscape emphasizes the importance of integrating technology into teaching and learning processes, as reflected in modern curriculum policies (Sya'ban et al., 2024). The use of innovative and technology-based instructional strategies is increasingly encouraged to support differentiated learning, student engagement, and the development of higher-order thinking skills. Therefore, exploring the integration of POE2WE and PhET simulations is not only relevant from a theoretical perspective but also aligned with current educational demands (Azhar, 2023).

Based on these considerations, this study aims to examine the implementation of the POE2WE learning model assisted by PhET simulations in improving students' conceptual understanding of Newton's laws. Furthermore, this research seeks to determine whether there is a significant difference in conceptual understanding between students who are taught using the POE2WE model with PhET simulations and those who are taught using conventional teaching methods. It is expected that the findings of this study will contribute to the development of more effective, interactive, and technology-based physics learning strategies, as well as provide practical insights for teachers in improving the quality of physics education (Permadi & Sya'ban, 2025).

Method

This study employed a quantitative approach using a quasi-experimental method with a posttest-only nonequivalent control group design to examine the effect of the POE2WE learning model assisted by PhET simulations on students' conceptual understanding of Newton's laws. The population consisted of 68 eleventh-grade students at SMAN 1 Bukit Batu in the 2025/2026 academic year, divided into two classes. The sample was selected through normality and homogeneity testing, followed by random assignment to determine the experimental class (34 students) and the control class (34 students). The experimental group received instruction using the POE2WE learning model integrated with PhET simulations, while the control group was taught using conventional teaching methods. Data were collected using a posttest in the form of a multiple-choice conceptual understanding test covering indicators such as interpreting, exemplifying, classifying, inferring, comparing, explaining, and generalizing. The data were analyzed using both descriptive and inferential statistics. Descriptive analysis was used to determine the mean scores and percentage levels of students' conceptual understanding, while inferential analysis was conducted to test the hypothesis. Prior to hypothesis testing, normality and homogeneity tests were performed using the Kolmogorov–Smirnov test and Levene's test, respectively. Depending on the results of these prerequisite tests, the hypothesis was tested using either an independent samples t-test for normally distributed data or the Mann–Whitney U test for non-parametric data. The decision criteria were based on a significance level of 0.05. Conclusions were drawn by comparing the posttest results between the experimental and control groups to determine whether the POE2WE learning model assisted by PhET simulations significantly improved students' conceptual understanding of Newton's laws.

Tablel 1. Research Design (Posttest-Only Nonequivalent Control Group)

Group	*Treatment*	*Post-test*
Experimental	X	*O1*
Control	-	*O2*

Sumber : (Sugiyono, 2017:48)

Notes:

Experimental : Implementation of the POE2WE learning model

Control : Implementation of the conventional learning method

O1 : Post-test score of the experimental group after treatment

O2 : Post-test score of the control group without treatment

X : Instruction using the POE2WE learning model assisted by PhET simulations

– : Instruction using the conventional learning method

Table 2. Population of Grade XI Students at SMAN 1 Bukit Batu

No	*Class*	*Number of Students*
1	XI.3	*34*
2	XI.4	*34*
	Total	*68*

Source: School data from SMAN 1 Bukit Batu

In determining the sample, the researcher conducted normality and homogeneity tests using SPSS version 25, based on students' previous test scores on the prior topic, namely projectile motion. The results of these tests are provided in Appendices 7 and 8. The sample was then selected randomly to determine the experimental and control groups.

Accordingly, class XI.3 (34 students) was assigned as the experimental group, while class XI.4 (34 students) was assigned as the control group.

Table 3. Conceptual Understanding Indicators Instrument

No.	Conceptual Understanding Indicators	Number of Items	Item Numbers
1	Interpreting	2	9, 10
2	Exemplifying	2	7, 15
3	Classifying	2	4, 5
4	Inferring	2	6, 11
5	Comparing	2	8, 12
6	Explaining	3	1, 2, 3
7	Generalizing	2	13, 14

Descriptive analysis does not aim to draw conclusions but rather to present information derived from the observed data. Therefore, descriptive analysis is classified as descriptive statistics. In this study, descriptive analysis was conducted to obtain the mean final scores of students' conceptual understanding of Newton's laws for both the experimental and control groups. Students' conceptual understanding was calculated based on the ratio between the obtained score and the maximum possible score using the following formula:

$$\text{pemahaman konsep} = \frac{\text{skor yang diperoleh siswa}}{\text{skor maksimum}} x 100\%$$

This formula is used to convert raw scores into percentage form, thereby facilitating the interpretation of students' level of conceptual understanding of the material studied. The criteria for interpreting the mean scores of students' assessment results, adapted from Depdiknas (2007), are presented in Table 4.

Tabel 4. Criteria for Interpreting Students' Mean Scores

Percentage Interval (%)	Category
$85 \leq X \leq 100$	Very Good
$70 \leq X < 85$	Good
$50 \leq X < 70$	Fair
$0 \leq X < 50$	Poor

Source: Adapted from Depdiknas (2007) and Rose Amanda Puri & Riki Perdana (2023:98)

Based on the inferential statistical analysis, the conclusions of this study were drawn by comparing the posttest results between the experimental and control groups. Prior to hypothesis testing, the data were analyzed using normality and homogeneity tests to determine the appropriate statistical method. If the data met parametric assumptions, an independent samples t-test was applied; otherwise, the Mann–Whitney U test was used. The decision was based on a significance level of 0.05.

The results indicate that if the significance value (p) is less than 0.05, the null hypothesis (H_0) is rejected, meaning that there is a significant difference in students' conceptual understanding between those taught using the POE2WE learning model assisted by PhET simulations and those taught using conventional methods. Conversely, if the significance value (p) is greater than or equal to 0.05, the null hypothesis is accepted, indicating no significant difference between the two groups.

Furthermore, the final conclusion of this study is determined based on the comparison of the mean posttest scores. If the average score of the experimental group is higher than that of the control group, it can be concluded that the implementation of the POE2WE learning model assisted by PhET simulations effectively improves students' conceptual understanding of Newton's laws within the context of the selected sample.

Results and Discussion

Result

1. **Descriptive Analysis**

   The data analyzed in this study consisted of students' conceptual understanding scores in both the experimental and control groups on the topic of Newton's laws. These data were obtained from the posttest results, where the POE2WE learning model assisted by PhET simulations was implemented in class XI.3 as the experimental group, while conventional instruction was applied in class XI.4 as the control group at SMAN 1 Bukit Batu. The posttest score data for students' conceptual understanding in both groups are presented in Appendices 8, 9, and 10. The results of the posttest score analysis for each indicator of conceptual understanding can be seen in Table 5.

Table 5. Analysis of Students' Conceptual Understanding

Conceptual Understanding Indicators	Experimental Class	Category	Control Class	Category
Interpreting	44.2	Poor	38.3	Poor
Exemplifying	82.3	Good	70.6	Good
Classifying	72	Good	60.3	Good
Generalizing	67.8	Fair	51.6	Fair
Inferring	63.2	Fair	51.5	Fair
Comparing	64.7	Fair	63.3	Fair
Explaining	89.2	Very Good	48.1	Poor
Average	70.32	Good	53.94	Fair

Based on Table 5, it can be observed that the scores for each indicator of conceptual understanding in the experimental class are higher than those in the control class.

The average score obtained by the experimental class falls into the good category with a score of 70.32, while the control class is categorized as fair with a score of 53.94. This comparison indicates that students' conceptual understanding achieved through the implementation of the POE2WE learning model assisted by PhET simulations is higher than that achieved through conventional learning methods.

Furthermore, these results demonstrate that the POE2WE learning model assisted by PhET simulations makes a significant contribution to improving students' conceptual understanding across all seven indicators, namely interpreting, exemplifying, classifying, generalizing, inferring, comparing, and explaining. The most notable improvement can be seen in the explaining indicator, where the experimental class achieved a very good category, while the control class remained in the poor category. This suggests that the integration of structured inquiry-based learning with interactive simulations effectively enhances students' ability to understand and explain physics concepts more deeply.

2. **Inferential Analysis**

Inferential analysis in this study was conducted using SPSS version 25 with a confidence level of 95%. The analysis included normality testing, homogeneity testing, and hypothesis testing. Prior to hypothesis testing, prerequisite tests were performed, namely the normality and homogeneity tests of students' conceptual understanding scores. These initial tests were also used to determine the sample from the population.

The results of the normality test (Appendix 8) indicated that the population data for classes XI.3 and XI.4 were normally distributed, as the significance values were greater than 0.05. Similarly, the homogeneity test results showed significance values greater than or equal to 0.05, indicating that the population data were homogeneous. Based on these results, the sample was selected randomly, resulting in class XI.3 as the experimental group and class XI.4 as the control group.

Inferential analysis was further conducted to determine the improvement in students' conceptual understanding after the implementation of the POE2WE learning model assisted by PhET simulations in the experimental group and conventional learning in the control group. Before conducting hypothesis testing, the data were required to meet the assumptions of normality and homogeneity. The normality test was performed using the Kolmogorov–Smirnov test, while the homogeneity test was conducted using Levene's test through the One-Way ANOVA procedure in SPSS version 25.

The results of the normality and homogeneity tests for the experimental and control groups on the topic of Newton's laws (Appendix 12) showed significance values less than 0.05, indicating that the data were not normally distributed and not homogeneous. Specifically, the experimental class had a significance value of 0.000, while the control class had a significance value of 0.006. These values (< 0.05) indicate that the data from both groups were not normally distributed. Furthermore, the homogeneity test using Levene's test also resulted in significance values less than 0.05, indicating that the data were not homogeneous.

Based on these findings, it can be concluded that the data did not meet the assumptions for parametric testing. Therefore, the hypothesis testing was conducted using a non-parametric test, namely the Mann–Whitney U test. This test was used to determine whether there was a significant difference in students' conceptual understanding between the experimental and control groups.

The hypothesis testing was performed using the Mann–Whitney U test in SPSS version 25 (Appendix 13). This test aimed to examine whether there was a significant difference in posttest results of conceptual understanding between students in the experimental group, who were taught using the POE2WE learning model assisted by PhET simulations, and those in the control group, who were taught using conventional methods. The results of the inferential analysis based on the posttest data are presented in Table 6.

Table 6. Results of Inferential Analysis

Inferential Test	Experimental Class	Control Class
Normality Test	0.000	0.006
Homogeneity Test	0.036	–
Hypothesis Test	0.000	–

Based on Table 6, it can be seen that the posttest data of students' conceptual understanding are not normally distributed and not homogeneous. The normality test results show that the experimental class obtained a significance value of $0.000 < 0.05$, while the control class obtained a significance value of $0.006 < 0.05$, indicating that the data in both groups are not normally distributed. Furthermore, the homogeneity test yielded a significance value of $0.036 < 0.05$, indicating that the data are not homogeneous.

The results of the Mann–Whitney U test conducted using SPSS version 25 (Appendix 13) show that the Asymp. Sig. (2-tailed) value is $p = 0.000$. Based on the decision criteria, if $p < 0.05$, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. Therefore, it can be concluded that there is a significant difference in students' conceptual understanding between the experimental group and the control group after the implementation of the POE2WE learning model assisted by PhET simulations on the topic of Newton's laws.

In addition, the analysis results indicate that the mean rank of the experimental class is higher than that of the control class. This finding suggests that students in the experimental group demonstrate better conceptual understanding compared to those in the control group.

Discussion

Based on the results of the descriptive analysis of the mean scores of students' conceptual understanding presented in Table 4.1, it is evident that the experimental group achieved a higher average score compared to the control group. This indicates that the implementation of the POE2WE learning model assisted by PhET simulations is effective in improving the conceptual understanding of eleventh-grade students on the topic of Newton's laws (AlArabi et al., 2022).

Previous studies have also demonstrated that the integration of the POE2WE model and PhET simulations has a positive impact on enhancing students' mastery of fundamental physics concepts such as force, acceleration, and the laws of motion. Other research findings further support that the use of PhET applications, particularly those integrated within a POE2WE learning framework, significantly improves students' conceptual understanding.

Therefore, the findings of this study are consistent with prior research, confirming that the experimental group taught using the POE2WE learning model assisted by PhET simulations outperformed the control group that received conventional instruction (Anderson & Krathwohl, 2001).

In the experimental class, the POE2WE learning model assisted by PhET simulations was implemented through six systematic stages, namely predict, observe, explain, elaborate, write, and evaluate. This model is grounded in constructivist learning theory, which actively engages students in the learning process and facilitates the construction of knowledge through direct experience and reflection. As a result, students are able to develop a deeper understanding of the concepts being learned (Dahar, 2011).

Furthermore, the analysis shows that there are noticeable differences in each indicator of conceptual understanding between the experimental group and the control group. These differences highlight the effectiveness of the POE2WE learning model assisted by PhET simulations in enhancing various aspects of conceptual understanding. A more detailed explanation of each conceptual understanding indicator is presented in the following section (Dancy et al., 2024).

1. **Interpreting**

   Interpreting refers to the ability to transform information from one form to another, such as converting verbal descriptions into graphs or images, words into numerical representations, or rephrasing information through summarizing or paraphrasing. This ability represents a cognitive skill at the second level (C2), which is categorized under conceptual understanding. In this study, students' interpreting ability was measured through items 9 and 10 (Duit & Treagust, 2020).

   The results indicate that the experimental class achieved an average score of 44.2, categorized as poor, while the control class obtained an average score of 38.3, also categorized as poor. Although both groups fall within the same category, the higher mean score in the experimental class suggests that the implementation of the POE2WE learning model assisted by PhET simulations contributes positively to improving students' interpreting ability. This is because interpreting requires flexible thinking and the ability to translate information across multiple representations, which are facilitated through interactive and inquiry-based learning environments (Firdianika et al., 2023).

   The structured stages of the POE2WE model, combined with the visual and interactive features of PhET simulations, enable students to observe, analyze, and reinterpret information more effectively. Continuous exposure to such learning activities helps students become more accustomed to processing and translating data or information. Therefore, the POE2WE learning model assisted by PhET simulations can enhance students' interpreting ability. This finding is consistent with previous research, which also reported that the integration of POE2WE and PhET effectively supports the development of conceptual understanding, particularly in interpreting skills (Hendawati & Kurniati, 2017).

2. **Exemplifying**

   Exemplifying refers to the ability to provide examples of a general concept or principle. This skill requires students to identify the defining characteristics of a concept and use those characteristics to construct relevant examples. In this study, students' exemplifying ability was measured through items 7 and 15 (Hidayat et al., 2024).

   The results show that the experimental class achieved an average score of 82.5, categorized as good, while the control class obtained an average score of 70.6, also categorized as good. Despite both groups being in the same category, the higher mean score of the experimental class indicates that the POE2WE learning model assisted by PhET simulations has a stronger impact on improving students' ability to provide examples (Hidayati et al., 2023).

This improvement can be attributed to the learning process in the experimental class, where students were actively engaged in analyzing examples related to Newton's laws and discussing them collaboratively. Through the POE2WE stages, students were encouraged to connect theoretical concepts with real or simulated phenomena, enabling them to construct more accurate and meaningful examples. Students with a strong conceptual understanding tend to provide more detailed and relevant examples, reflecting their deeper comprehension of the material (Inayah et al., 2024).

These findings are consistent with previous studies, which suggest that the integration of interactive simulations within structured learning models enhances students' ability to understand and apply concepts in various contexts. Thus, the exemplifying indicator of conceptual understanding is effectively developed through the implementation of the POE2WE learning model assisted by PhET simulations (Kaldaras et al., 2024).

3. **Classifying**

Classifying refers to the ability to recognize that an object or phenomenon belongs to a particular category based on its characteristics. In this study, students' classifying ability was measured through items 4 and 5. The results show that the experimental class achieved an average score of 72, categorized as good, while the control class obtained an average score of 60.3, categorized as fair. These findings indicate that the experimental class, which implemented the POE2WE learning model assisted by PhET simulations, achieved a higher average score in the classifying indicator (Kosim & Zuhdi, 2024).

The improvement in classifying ability among students in the experimental class can be attributed to the structured learning stages that actively engage students in identifying and grouping objects or phenomena based on relevant concepts. Through the learning process, students were encouraged to analyze characteristics and categorize them accordingly, which strengthened their conceptual understanding. Repetitive exposure to such activities further enhanced students' competence in classification tasks. These findings are consistent with previous studies, which indicate that structured and interactive learning approaches effectively support the development of classification skills. Therefore, the classifying indicator of conceptual understanding is well developed through the implementation of the POE2WE learning model assisted by PhET simulations (Lintangesukmanjaya et al., 2024).

4. **Generalizing**

Generalizing refers to the ability to draw general conclusions based on patterns, data, or specific examples that have been learned. In this study, students' generalizing ability was measured through items 13 and 14. The results indicate that the experimental class achieved an average score of 67.8, categorized as fair, while the control class obtained an average score of 51.6, also categorized as fair. Despite both groups being in the same category, the experimental class demonstrated a higher average score in this indicator (Liswar et al., 2023).

This result suggests that the POE2WE learning model assisted by PhET simulations contributes to improving students' ability to generalize concepts. The learning process in the experimental class encouraged students to observe phenomena, identify patterns, and connect these patterns to broader concepts. Through repeated practice and active engagement, students became more capable of formulating general conclusions from specific cases. This ability is particularly supported by learning activities that emphasize exploration and repetition, allowing students to internalize conceptual relationships more effectively. These findings are in line with previous research, which highlights the role of structured and interactive learning environments in enhancing students' generalization skills (Melati et al., 2025).

5. **Inferring**

Inferring refers to the ability to identify patterns and draw conclusions based on a series of examples or observed facts. In this study, students' inferring ability was measured through items 6 and 11. The results show that the experimental class achieved an average score of 63.2, categorized as fair, while the control class obtained an average score of 51.5, also categorized as fair. These findings indicate that the experimental class outperformed the control class in the inferring indicator.

The ability to infer is closely related to other aspects of conceptual understanding, such as summarizing and explaining (Mohamad et al., 2025). This skill requires students to process information, identify relationships, and draw logical conclusions. In the experimental class, this ability was developed through continuous engagement in discussion and reflective learning activities. The POE2WE model encourages students to actively interpret information and formulate conclusions during each stage of the learning process, particularly in the explanation and evaluation phases. As a result, students become more accustomed to synthesizing information and drawing meaningful conclusions. These findings are consistent with previous studies, indicating that inquiry-based and interactive learning approaches effectively enhance students' ability to make inferences (Muthmainnah et al., 2023).

6. **Comparing**

Comparing refers to the ability to identify similarities and differences between two objects, ideas, or situations. In this study, students' comparing ability was measured through items 8 and 12. The results indicate that the experimental class achieved an average score of 64.7, categorized as fair, while the control class obtained an average score of 63.3, also categorized as fair. Although both groups fall within the same category, the experimental class demonstrated a slightly higher mean score than the control class (Novianti et al., 2023).

This finding suggests that the implementation of the POE2WE learning model assisted by PhET simulations provides a better contribution to improving students' comparing ability. In the experimental class, this skill was developed through interactive and collaborative learning activities, particularly during group discussions, where students were encouraged to analyze similarities and differences between various physical phenomena and concepts. Such activities promote critical thinking and enable students to construct deeper conceptual connections. These results are consistent with previous studies, which indicate that structured and inquiry-based learning approaches effectively support the development of comparison skills. Therefore, the comparing indicator of conceptual understanding is well facilitated through the implementation of the POE2WE learning model assisted by PhET simulations (Nursabila & Warliani, 2025).

7. **Explaining**

Explaining refers to the ability to construct and apply cause-and-effect relationships within a system. In this study, students' explaining ability was measured through items 1, 2, and 3. The results show a substantial difference between the two groups, where the experimental class achieved an average score of 89.2, categorized as very good, while the control class obtained an average score of 48.1, categorized as poor.

This significant difference indicates that the POE2WE learning model assisted by PhET simulations is highly effective in enhancing students' explaining ability. In the experimental class, this skill was particularly developed during the intellectually engaging stages of learning, where students were required to explain phenomena based on the concepts they had learned. Through these activities, students were trained to construct logical explanations and establish relationships between different physics concepts (OECD, 2022).

Moreover, the integration of PhET simulations provided visual and interactive representations of physical phenomena, enabling students to better understand causal relationships. This combination of structured inquiry and interactive visualization allowed students to connect abstract concepts more effectively, leading to a deeper level of understanding. These findings are consistent with previous research, which highlights that interactive and constructivist-based learning approaches significantly improve students' ability to explain scientific concepts. Therefore, the explaining indicator shows the most prominent improvement among all indicators, demonstrating the effectiveness of the POE2WE learning model assisted by PhET simulations in enhancing students' conceptual understanding (Panggabean & Naibaho, 2023).

Conclusion

Based on the data analysis conducted, it can be concluded that, descriptively, the class that implemented the POE2WE learning model assisted by PhET simulations in learning Newton's laws achieved a good level of conceptual understanding. This finding indicates that the integration of the POE2WE model with PhET simulations is effective in enhancing students' conceptual understanding. Furthermore, the inferential analysis revealed a significant difference in students' conceptual understanding between the experimental and control groups. The class that applied the POE2WE learning model assisted by PhET simulations demonstrated better conceptual understanding compared to the class that received conventional instruction at SMAN 1 Bukit Batu.

Based on these findings, the POE2WE learning model assisted by PhET simulations can be considered an effective instructional approach for improving students' conceptual understanding. However, this study focused primarily on the cognitive domain, particularly conceptual understanding, while affective aspects such as students' interest and learning motivation were not examined in depth. Therefore, future researchers are encouraged to extend this study by incorporating other learning media or combining the POE2WE model with different instructional approaches to enhance its effectiveness across various subjects. Additionally, further research is recommended to investigate the impact of the POE2WE learning model assisted by PhET simulations on other learning outcomes, such as students' motivation, creativity, and critical thinking skills.

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