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Implementation PBL Model Assisted by E-Module Based on Refutation Text to Overcome Student Misconceptions on Dynamic Electricity Topics

Lidiya Rahmawati[1,2], Stepanus Sahala Sitompul[1], Ray Cinthya Habellia[1] and Lanang Maulana Aminullah[1]
[1]Physics Education Study Program, Universitas Tanjungpura, Jl. Prof. Dr. H. Hadari Nawawi, Pontianak, West Kalimantan

[2]E-mail: f1051211029@student.untan.ac.id

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Abstract. This research was conducted with the aim of addressing students' misconceptions in dynamic electricity topics through the application of the Problem Based Learning (PBL) model assisted by an e-module based on refutation text. The research design uses an experimental method, in the form of a pre-experimental design and a one-group pretest-posttest design, as well as the cluster random sampling technique. This research was conducted at SMP Negeri 2 Pontianak, with a research sample consisting of 31 ninth-grade students. The data collection instrument consisted of five items in the form of a two-tier multiple-choice test, and the results were categorized based on the combination of students' answers and justifications. The data obtained in the study were analyzed using normality tests and the Wilcoxon test, as well as effect size calculations using Cohen's formula as adopted by Glass. The research results show that the average misconception rate among students decreased from 43.2% to 14.9%, with an average misconception reduction of 28.3%, as evidenced by the Wilcoxon test results with an Asymp.Sig value of 0.000 (0.000 < 0.05), and an effect size calculation result of 3.14 (high category). This study proves that the application of the PBL model assisted by an e-module based on refutation text can overcome students' misconceptions in dynamic electricity topics with a high level of effectiveness.

Keywords: problem based learning, e-module, refutation text, misconceptions

1. Introduction

Education plays an important and valuable role in preparing quality human resources, as it is expected to change a person's thinking [1]. In formal education, the teaching of Natural Sciences (IPA) in Junior High School (SMP) and Physics in Senior High School (SMA) has a very important role. Physics, as part of Natural Sciences, requires students to be skilled in understanding and applying the basic concepts and principles that have been learned, so they can become scientifically literate students and support scientific learning in the future [2].

Science learning in junior high school aims to develop scientific attitudes, understanding of science concepts, and science process skills that can be applied to solve everyday problems [3]. A deep understanding of science concepts is very important for every student to possess because the interconnection of these concepts will affect the learning process and the mastery of subsequent concepts.

Dynamic electricity topics is one of the sub-topics in the science subject for ninth-grade students at the junior high school level. The dynamic electricity topics at SMP Negeri 2 Pontianak refers to the Learning Outcomes (LO) set in the Merdeka Curriculum. These Learning Outcomes (LO) expect students to master several important concepts in dynamic electricity topics, such as electric current, series and parallel electric resistance circuits, electric current sources, and electric power. Through the

mastery of these concepts, students are also expected to understand electrical phenomena commonly found in everyday life, such as the use of lamps at home or the operation of electrical appliances.

However, the reality on the ground still shows that there are students who struggle to understand the concepts as a whole or have misconceptions about the concepts of dynamic electricity topics. This can be caused by the abstract nature of electrical concepts and low learning interest, which often leads to misconceptions and affects the low learning outcomes of students in dynamic electricity topics.
Science learning on dynamic electricity topics in junior high school is still a significant issue. Through the analysis of student learning outcome documents in the form of daily test scores on dynamic electricity topics and interviews with IX grade science educators, it was found that 14 out of 31 students did not meet the Learning Objective Achievement Criteria (KKTP). This indicates that students' learning outcomes in the dynamic electricity topics tend to be low. Additionally, it was also found that many students still make mistakes or have difficulties in understanding and mastering the basic concepts of dynamic electricity topics. This difficulty occurs due to a lack of understanding and mastery of basic concepts as well as the presence of misconceptions about dynamic electricity.

Misconceptions in dynamic electricity topics tend to cause students to misunderstand concepts, leading them to repeatedly make the same mistakes when solving problems or applying the given concepts. This will directly impact the low learning outcomes of the students, as errors in understanding concepts result in students struggling to achieve the predetermined KKTP [4]. Additionally, teaching that does not pay attention to the initial understanding possessed by students will make their misconceptions even more complex [4].

Electricity topics ranks second in the most studied misconceptions in the field of physics, supported by previous research that has identified various forms of misconceptions that often occur in dynamic electricity topics. Some misconceptions about dynamic electrical s based on previous research [5]; [6]; [7] include: (1) The potential difference of a battery or voltage source in an open circuit is equal to zero, (2) The brightness of a lamp in a series circuit depends on the distance of the lamp from the positive terminal of the battery, (3) The brightness of the lamp and the electric current will increase if one lamp in a parallel circuit is removed, (4) The brightness of two lamps in a parallel circuit will be dimmer than two lamps connected in series, (5) Adding a battery will always increase the electric current. Misconceptions about dynamic electricity topics show that these misconceptions do not only occur in one school but also have the potential to occur among students in various other schools. Therefore, it is very important to address or reduce this misconception in order to improve students' conceptual understanding and learning outcomes in dynamic electricity topics.

If misconceptions among students are not addressed promptly, they will have a negative impact both in the short term and in the long term. This is also in line with the statement that unaddressed misconceptions can disrupt and hinder the continuous learning process of students [8]. Students who continuously experience misconceptions are at risk of developing incorrect thinking and will face serious obstacles in the subsequent learning process. Therefore, misconceptions like this require targeted and effective efforts, one of which is through the PBL model.

The PBL model can help students develop their cognitive aspects, particularly in improving concept understanding and building stronger concepts. The PBL model involves students in the problem-solving process and provides direct experiences related to science or physics concepts through several stages or scientific methods, so that students are expected to be able to learn knowledge related to the problem and acquire skills in problem-solving [9]. As a constructivist learning model, PBL can construct its own knowledge to understand the conceptual changes that occur in resolving misconceptions [10]. The PBL model actively involves students in real problem-solving, forcing them to re-evaluate their understanding and correct conceptual errors.

To support the implementation of the PBL model in dynamic electricity topics, refutation text is used as an effective tool to address students' misconceptions. Refutation text is also in line with the process of conceptual change, as it aims to correct students' knowledge according to the scientific concept or scientific explanation presented in the text [11]. This refutation text has three main components, namely (1) a statement regarding the misconceptions that often occur, (2) a statement that attempts to deny or refute those misconceptions, and (3) providing and explaining the scientific concept recognized by experts as the correct explanation [11].

The use of technology in the form of e-modules can also be an effort to enhance the effectiveness of learning with the PBL model on dynamic electricity topics, in the form of modules based on refutation text. This innovation in learning can be a very important supporting factor and is expected to support the implementation of PBL. The use of e-modules was chosen because of their practicality and high flexibility, allowing students to learn independently, providing a more engaging and interactive learning experience, and making it easier to access topics anytime and anywhere [12].

Based on the explanation above, misconceptions in dynamic electricity topics are a serious problem that can affect students' learning outcomes. To address this issue, an effective and innovative learning model is needed. Therefore, this research focuses on efforts to address students misconceptions about dynamic electricity through the application of the PBL model assisted by e-modules based on refutation text. The combination of the PBL model supported by a refutation text-based e-module is expected to enhance conceptual understanding and efficiently address the misconceptions that frequently occur among students in dynamic electricity topics. Specifically, the objectives of this research are to determine the profile of students' misconceptions about dynamic electricity before and after the application of the PBL model assisted by an e-module based on refutation text, to determine the reduction of students' misconceptions about dynamic electricity before and after the application of the PBL model assisted by an e-module based on refutation text, and to determine the effectiveness of the PBL model assisted by an e-module based on refutation text in addressing students' misconceptions about dynamic electricity.

2. Method

This research falls under the category of quantitative research that uses experimental methods. The form of the experiment used is a pre-experimental design with a one-group pretest-posttest design, and cluster random sampling as the sampling technique.

This research was conducted at SMP Negeri 2 Pontianak during the odd semester of the 2024/2025 academic year, with the research population being all ninth-grade students at SMP Negeri 2 Pontianak and the research sample being class IX G, which consists of 31 students. The number of students participating in the research remained the same as the number of students in class IX G, which is 31 students, because no students were absent. The purpose of this research is to determine whether the application of the PBL model assisted by a refutation text-based e-module can address students' misconceptions in dynamic electricity topics, using a one-group pretest-posttest design as shown in Table 1.

Table 1. One-group pretest-posttest design [13].

Class	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X	O_2

The research design in Table 1 shows that this study is of the type that begins with the administration of a pretest. Before being given treatment or before the application of the PBL model assisted by the refutation text-based e-module, the students were first given a pretest. (O_1). The test consisted of five items in the form of a two-tier multiple-choice test, the results of which could be categorized based on the combination of answers (first tier) and reasons or justifications (second tier) provided by the students. After being given a pretest, the students were treated by undergoing a learning process that applied the PBL model assisted by an e-module based on refutation text on dynamic electricity topics for three sessions (X). Then, after the treatment, the students were given a posttest aimed at determining whether the application of the PBL model assisted by an e-module based on refutation text could overcome students' misconceptions about dynamic electricity topics (O_2). The flowchart of the stages of applying the PBL model assisted by an e-module based on refutation text to overcome students' misconceptions about dynamic electricity topics is shown in Figure 1.

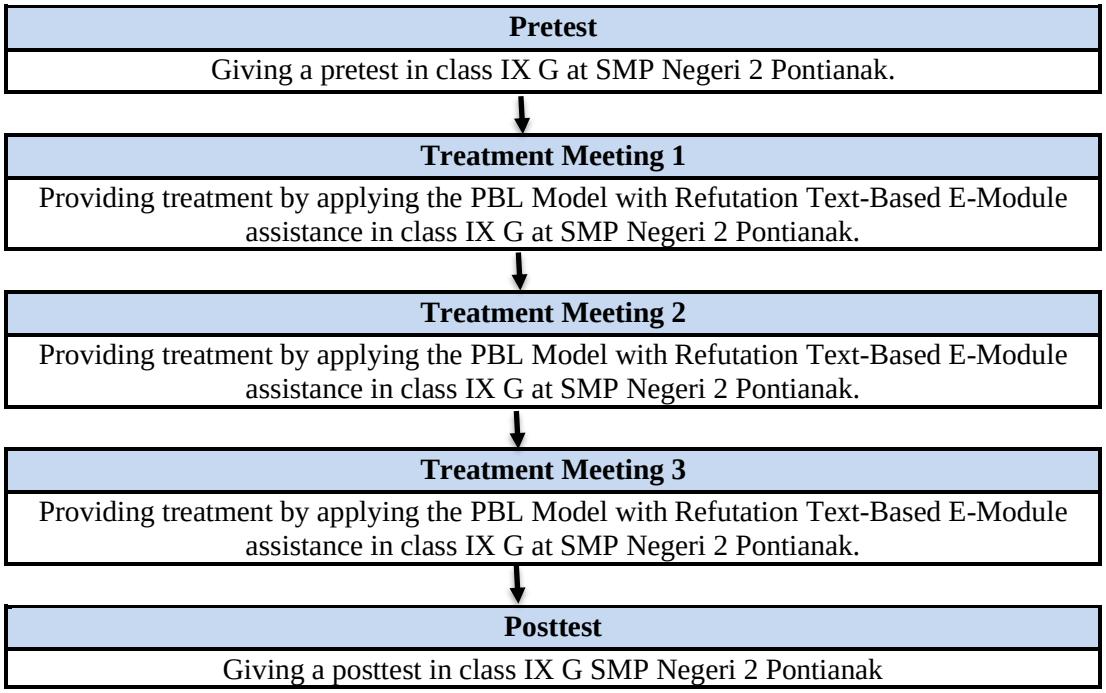

Figure 1. Flowchart of the stages of implementing the PBL model assisted by an e-module based on refutation text to address students' misconceptions in dynamic electricity topics.

The PBL model is oriented towards contextual problem-solving that encourages students to actively engage in the learning process. This PBL model provides students with the opportunity to explore concepts through case studies relevant to everyday life, thereby enhancing their deep understanding of fundamental concepts. When the PBL model is combined with an e-module based on refutation text, both will have greater potential to address and correct students' misconceptions.

The refutation text is intentionally designed to provide a contrasting explanation between common misconceptions that often occur and the correct scientific concepts. In this study, the application of the PBL model assisted by a refutation text-based e-module is conducted with a focus on dynamic electricity topics. The e-module used highlights five main forms of misconceptions commonly found among students, namely the misconception that the potential difference of a battery or voltage source in an open circuit is zero, the brightness of a lamp in a series circuit depends on the distance of the lamp from the positive terminal of the battery, the brightness of the lamp and electric current will increase if one lamp in a parallel circuit is removed, the brightness of two lamps in a parallel circuit will be dimmer than two lamps connected in series, and adding a battery will always increase the electric current.

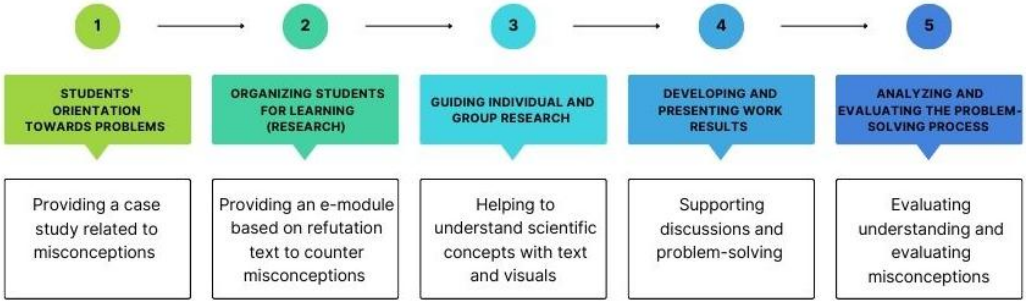

Figure 2. Steps in implementing the PBL model assisted by an e-module based on refutation text to address students' misconceptions in dynamic electricity topics.

In the implementation of the learning process in this research, students are directed to read the provided refutation text-based e-module and follow the steps of the PBL model. These steps include

orienting students to the problem, organizing students to learn (investigation), guiding individual and group investigations, developing and presenting their work, and analyzing and evaluating the problem-solving process.

In each meeting, students are given different case studies related to misconceptions in dynamic electricity. The case studies used are also problems commonly encountered in daily life and are relevant for addressing students' misconceptions in dynamic electricity. For example, the first case study asks students to analyze why the lights in the house dim when many electrical appliances are used simultaneously. This case study discusses and helps address misconceptions about electric current and voltage in parallel circuits. Learners are guided to understand that electric current in parallel circuits is divided, which can cause a voltage drop at certain points, explaining the phenomenon of dimming lights. This refutes the misconception that current and voltage are not affected by the number of connected devices.

In the second case study, students were asked to explain why one light bulb went out while the others remained lit. This case study aims to discuss and help address misconceptions about series and parallel circuits. Students are invited to understand that in a parallel circuit, each branch has its own current path, so they do not affect each other. With this analysis, students can refute the misconception that all the lights will go out if one light goes out in a circuit.

Next, the third case study directs students to compare two flashlights with different numbers of batteries and determine which one is brighter. This case study aims to help address misconceptions about the relationship between the number of batteries and electric current. The comparison of two flashlights with different numbers of batteries teaches students that adding more batteries does not always mean an increase in electric current. This case study will refute the misconception that more batteries will always produce a greater electric current. Through this case study, students will understand that the relationship between the number of batteries and electric current depends on the arrangement of the electrical circuit. Through the application of the PBL model supported by a refutation text-
Based e-module, students are invited to investigate, analyze, and deeply understand electrical phenomena, particularly dynamic electricity. Group discussions and investigations conducted in a structured manner according to the steps in the PBL model enable students to identify and become aware of the misconceptions they experience. Meanwhile, the refutation text provides explanations according to scientific concepts from experts that clearly show the misconceptions that occur, the existence of a rebuttal text against those misconceptions, and scientific concepts from experts that clearly refute the misconceptions that occur. The combination of applying the PBL model with an e-module based on refutation text is used in this study as a treatment to address students' misconceptions in dynamic electricity topics. The PBL model was chosen because its learning is student-centered and encourages the resolution of contextual problems, while the e-module based on refutation text is designed to identify and correct misconceptions by presenting information that contradicts students' initial understanding.

Before the research is conducted, the research instruments consisting of teaching modules and refutation text-based e-modules are first validated. The validity test of the instruments used in this study is content validity, conducted by two expert validators, namely one lecturer in Physics Education from FKIP Untan and one educator (teacher) of the 9th-grade Science subject at SMP Negeri 2 Pontianak. The validators assess the validity of the instruments that will be used in this research. And for the test instruments given to the students, there are two types: the pretest and the posttest. These tests consist of five items in the form of a two-tier multiple-choice test. The pretest and posttest items were adopted from the research of Yushintari [14] and Islami, Silitonga, & Hamdani [15], which have been validated and declared valid with a calculated correlation coefficient greater than the table correlation coefficient ($0.621 > 0.388$). Furthermore, the results of the reliability test of this test instrument fall into the high category with a value of 0.795. Therefore, the test instrument used in this study is considered suitable for measuring students' misconceptions.

The data analysis technique applied is the normality test to see whether the sample data distribution is normal or not and the hypothesis test. After conducting the normality test, it was found that the data did not have a normal distribution, so it was continued with the hypothesis test using the Wilcoxon test. The null hypothesis (H_0) in this study is that the application of the PBL model assisted by a refutation

text-based e-module cannot overcome students' misconceptions about dynamic electricity topics, while the alternative hypothesis (Ha) in this study is that the application of the PBL model assisted by a refutation text-based e-module can overcome students' misconceptions about dynamic electricity topics. Furthermore, to determine the effectiveness of the application of the PBL model assisted by a refutation text-based e-module in overcoming students' misconceptions about dynamic electricity topics, the effect size can be calculated using Cohen's effect size formula as adopted by Glass as follows:

$$ES = \frac{Y_E - Y_C}{S_C} \quad (1)$$

and with the criteria for the magnitude of the effect size shown in Table 2.

Table 2. Effect Size Criteria [16].

Interval	Criteria
$\mathbf{ES \leq 0.3}$	Low
$\mathbf{0.3 < ES \leq 0.7}$	Medium
$\mathbf{ES > 0.7}$	High

3. Results and Discussion

3.1. Profile of Student Misconceptions in Dynamic Electricity Topics

Analysis of students' misconception profiles on dynamic electricity topics before and after the application of the PBL model assisted by a refutation text-based e-module was conducted using questions in the form of a two-tier test multiple choice (two-tier multiple choice questions) that can be categorized based on the combination of answers (first tier) and reasons or justifications (second tier) of students in the pretest and posttest. (posttest). The results of the pretest data analysis indicate the presence of five main misconceptions in the topic of dynamic electricity experienced by students. Overall, the average percentage of misconceptions in the pretest was 43.2%, with the highest percentage misconception being that students believed "the potential difference of a battery or voltage source in an open circuit is equal to zero" at 54.8%. The lowest percentage misconception was that students believed "the light and electric current would increase if one of the lamps in a parallel circuit was removed" at 25.8%.

After the learning process that applied the PBL model assisted by an e- module based on refutation text, the analysis of posttest data showed that the overall average percentage of students' misconceptions decreased to 14.9%. The highest percentage of misconception was that students believed "the brightness of two lamps in a parallel circuit would be dimmer than two lamps in a series circuit" at 25.8%. The lowest percentage of misconception was that students believed "the brightness of a lamp in a series circuit depends on the distance of the lamp from the positive terminal of the battery (the closer the lamp is to the positive terminal of the battery, the brighter the lamp will be)" at 6.5%. The recapitulation of the misconception profile from the pretest and posttest results of the students is shown in Table 3.

In Table 3, it is shown that before the implementation of the PBL model assisted by a refutation text-based e-module, the misconception profile of students on dynamic electricity topics was quite high with an average percentage of 43.2%. After the implementation of the PBL model assisted by a refutation text-based e-module, the average misconception profile of students on dynamic electricity topics decreased to 14.9%. The overall average decrease in misconceptions was 28.3%, with the highest decrease being the misconception that "the potential difference of a battery or voltage source in an open circuit is zero," which decreased by 45.1%. Meanwhile, the misconception with the lowest decrease was the belief that "the light and electric current will increase if one of the lamps in a parallel circuit is removed," which decreased by 6.4%.

Table 3. Recapitulation results of misconception profiles from pretest and posttest results of student.

No	Form of Misconception	Number of Students with Misconception Category (M)		Percentage of Misconception		Percentage of Misconception Reduction
		Pretest	Posttest	Pretest	Posttest	
1.	Students assume that the potential difference of a battery or voltage source in an open circuit is equal to zero.	17	3	54.8%	9.7%	45.1%
2.	Students believe that the brightness of the lamp in a series circuit depends on the distance of the lamp from the positive terminal of the battery (the closer the light is to the positive terminal of the battery, the brighter the light will be).	13	2	41.9%	6.5%	35.4%
3.	The students believe that the brightness of the light and the electric current will increase if one of the lights in the parallel circuit is removed.	8	6	25.8%	19.4%	6.4%
4.	Students believe that the brightness of two bulbs in a parallel circuit will be dimmer than two bulbs in a series circuit.	13	8	41.9%	25.8%	16.1%
5.	Students believe that adding more batteries will always increase the electric current.	16	4	51.6%	12.9%	38.7%
	Average			43.2%	14.9%	28.3%

Data analysis from the research shows that the application of the PBL model assisted by refutation text-based e-modules can significantly improve students' conceptual understanding, including in addressing misconceptions that often arise in science or physics subjects, particularly in dynamic electricity. The key to successfully addressing these misconceptions lies in the combination of implementing the PBL model, which encourages active problem-solving, and using refutation text-based e-modules that explicitly counter the misconceptions held by students.

The success in overcoming students' misconceptions through the application of the PBL model assisted by a refutation text-based e-module is due to several main factors. First, the PBL model encourages students to be more active in identifying and finding solutions to real problems, which deepens their cognitive processes to review their understanding. Second, the refutation text-based e-module plays a role in directly refuting misconceptions by presenting contradictions between students' initial understanding and the correct scientific concepts, thereby encouraging significant changes in their understanding. Third, through the application of the PBL model supported by this refutation text-based e-module, it not only provides a problem-based learning process but is also supported by texts that explicitly refute misconceptions. This makes it easier for students to understand and accept scientifically correct concepts.

These findings are consistent with previous research [17], which shows that the use of the PBL model in educational activities can reduce students' misconceptions by actively involving them in solving real problems, forcing them to re-evaluate their understanding and correct conceptual errors. Then, this learning model can help students develop their cognitive aspects, particularly in improving conceptual understanding and building stronger concepts. In this regard, other researchers also show that the PBL model supports students in constructing their own knowledge through problem-solving activities and exploration of scientific concepts, so that students understand the conceptual changes that occur in resolving misconceptions [17]. Further reinforced by the research results and data analysis that have been conducted [18], the results also show that the application of the PBL model can significantly improve students' conceptual understanding, correct misconceptions, and influence the enhancement of a topics concept among students. Additionally, in the study [19], it was stated that the use of e-modules

can improve students' learning outcomes, as evidenced by the significant difference between pretest and posttest scores. Added with refutation text, as found in studies [20–22], which state that the effect of refutation text in correcting students' misconceptions based on previous research results is very strong. Reviews over the past twenty years on the use of refutation texts also reveal that refutation texts are one of the most effective text-based learning tools in changing or correcting readers' misconceptions.

Based on the analysis of data from the research on the misconception profile of students in the pretest and posttest of dynamic electricity topics before and after the application of the PBL model assisted by a refutation text-based e-module, it shows that overall, the misconception profile of students in dynamic electricity topics improved after the application of the PBL model assisted by a refutation text-based e-module. Thus, the combination of implementing the PBL model, which encourages active problem-solving, and the refutation text-based e-module, which explicitly refutes misconceptions, is the key to successfully addressing students' misconceptions.

3.2. Reduction of Student Misconceptions in Dynamic Electricity Topics

To analyze the reduction of misconceptions among students in dynamic electricity topics before and after the implementation of the PBL model assisted by a refutation text-based e- module, a Paired Sample t Test can be used if the data is normally distributed and the Wilcoxon test if the data is not normally distributed. The normality test is a form of testing the normality of data distribution. The aim is to prove whether the data to be analyzed is normally distributed or not [23]. In this study, the data being tested are the scores produced by students in the pretest and posttest. The results of the data normality test are shown in Table 4.

Table 4. Results of the normality pretest and posttest scores of students using the shapiro-wilk.

	Tests of Normality					
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest of Students	0.138	31	0.138	0.960	31	0.296
Posttest of Students	0.345	31	0.000	0.707	31	0.000
a. Lilliefors Significance Correction						

Table 4 shows the results of the normality test of the data produced by the students in the pretest and posttest. The normality test was conducted using the Shapiro-Wilk method and followed the steps for data normality testing. Data can be said to be normally distributed if the Shapiro-Wilk significance value is ≥ 0.05. And data can be said to be not normally distributed if the Shapiro-Wilk significance value is ≤ 0.05. Based on Table 4, it is shown that the significance value in the students' pretest is 0.296 (0.296 ≥ 0.05), which means the Shapiro-Wilk significance value is ≥ 0.05, so the data is normally distributed, and the significance value in the students' posttest is 0.000 (0.000 ≤ 0.05), which means the Shapiro-Wilk significance value is ≤ 0.05, so the data is not normally distributed. Based on these results, it can be concluded that the normality test results indicate the data is not normally distributed. Because the data is not normally distributed, the hypothesis test can proceed directly using the Wilcoxon test.

Before conducting the Wilcoxon test, the formulation of the hypothesis is carried out first. Based on the testing criteria or the conditions for using the Wilcoxon test, if the Asymp.Sig value < 0.05, then H0 is rejected, and Ha is accepted. And if the Asymp.Sig value > 0.05, then H0 is accepted, and Ha is rejected. The results of the Wilcoxon test are shown in Table 5.

Table 5. Wilcoxon test results.

Test Statistics[a]	
	Posttest of Students - Pretest of Students
Z	-4.636[b]
Asymp. Sig. (2-tailed)	0.000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Based on Table 5, the Wilcoxon test results show that the Asymp.Sig value is 0.000 (0.000 < 0.05), which means the Asymp.Sig value < 0.05. Thus, the Wilcoxon test results indicate that H0 is rejected and Ha is accepted, leading to the conclusion that "There is a decrease in students' misconceptions about dynamic electricity topics before and after the implementation of the PBL model assisted by a refutation text-based e-module." The average decrease in misconceptions based on Table 3 reached 28.3%, indicating that the PBL model assisted by a refutation text-based e-module applied in this study can reduce or lower students' misconceptions about dynamic electricity topics. This is in line with the findings of the study [24] which showed that the use of refutation text is effective in addressing misconceptions in the concept of projectile motion. This success can be achieved not only due to the use of refutation text but also due to the implementation of the PBL model, which encourages changes to identify, discuss, and correct students' misconceptions more actively. In addition, the interactivity of the e-module, which not only contains text but also includes videos and simulations, allows students to understand the concept of dynamic electricity more concretely, thereby accelerating the process of misconception correction.

3.3. The Effectiveness Of The PBL Model Assisted By Refutation Text-Based E- Module In Overcoming Misconceptions

Based on the results of the Wilcoxon test, there was a decrease in students' misconceptions about dynamic electricity before and after the implementation of the PBL model assisted by an e-module based on refutation text. To determine the level of effectiveness, it was calculated using Cohen's effect size formula adopted from Glass. From the research data, the pretest standard deviation value was 2.22, the pretest average value was 4.90, and the posttest average value was 11.87. The calculation using Cohen's effect size formula adopted by Glass resulted in an effect size value of 3.14, which falls into the high category (3.14 > 0.7).

These results indicate that the implementation of the PBL model assisted by refutation text-based e-modules is highly effective in addressing students' misconceptions in dynamic electricity topics. Based on the effect size criteria proposed by Cohen, the significant difference between the pretest and posttest also has a strong impact on students' understanding. Thus, the reduction of misconceptions that occurred not only proves the effectiveness of the given model but also provides a strong foundation for the application of a similar model in future learning processes. This result is in line with the findings of research [25], which shows that refutation text in e-modules can correct misconceptions by refuting existing misconceptions and replacing them with correct scientific concepts, effectively helping students improve their understanding. The presence of this PBL model allows students not only to receive new concepts but also to undergo a process of re-evaluation and change their perspectives or knowledge to achieve a better understanding. The PBL model assisted by e-modules based on refutation text, which focuses on solving real problems, can actively identify and correct existing misunderstandings, support a learning process based on investigation or research to find solutions, and provide more in-depth feedback to enhance conceptual understanding. Thus, this success also demonstrates that the implementation of the PBL model assisted by refutation text-based e-modules not only makes learning systematic but also effectively addresses students' misconceptions.

4. Conclusion

The results of data analysis, data processing, and findings obtained from this study indicate that the application of the PBL model assisted by a refutation text-based e-module can address students' misconceptions in dynamic electricity topics with a high level of effectiveness. Overall, the profile of students' misconceptions in dynamic electricity topics improved after the implementation of the PBL model assisted by refutation text-based e-modules. Before the implementation of this model, the analysis of pretest data showed the presence of five forms of misconceptions or misconception profiles of students on dynamic electricity topics with an average percentage of 43.2%. After the implementation, the average misconception profile of students on dynamic electricity topics decreased to 14.9% with an average misconception reduction of 28.3%. The decrease in students' misconceptions about dynamic electricity before and after the implementation of this model is also evidenced by the Wilcoxon test results with an Asymp.Sig value of 0.000 (0.000 < 0.05), indicating that the application

of the PBL model assisted by a refutation text-based e-module can reduce students' misconceptions about dynamic electricity. Additionally, the results of the calculation using Cohen's effect size formula adopted by Glass, with an effect size value of 3.14, which falls into the high category (3.14 > 0.7), indicate that the application of this model has a high effectiveness in addressing students' misconceptions in dynamic electricity topics. Thus, the PBL model assisted by a refutation text-based e-module has proven to be effective in overcoming students' misconceptions in dynamic electricity topics.

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