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

Dec. 2025, Vol. 13, No. 2
e-ISSN: 2686-0937
pp. 296-309

The Effect of Discovery Learning Model on Reducing Students' Misconceptions in Renewable Energy Material

Ermila Sari Siregar[1]*, Juniar Hutahaean[1], Nurasyah Dewi Napitupulu[2]

[1] Physics Education Department, Universitas Negeri Medan, Medan, Indonesia
[2] Physics Education Department, Universitas Tadulako, Palu, Indonesia

*Corresponding Author: ermilasari15@gmail.com

Abstract

This study aims to determine the effect of the discovery learning model on reducing students' misconceptions about renewable energy. The research design is a quasi-experimental design with two sample classes selected using cluster random sampling, namely class X-2 as the experimental class and X-3 as the control class. The instrument used was a five-tier diagnostic test consisting of 20 questions that had been validated by validators and pilot-tested on students. The results showed that the average misconception rate among students in the experimental class before the intervention was 44.33%, and after the intervention, the average misconception rate was 24.53%. Thus, there was a 19.8% decrease in misconceptions in the experimental class. Meanwhile, in the control class, the average misconception rate of students before the treatment was 42.33%, and after the treatment, the average misconception rate of students was 31.17%, resulting in an 11.6% decrease in misconceptions. Based on the results of the one-tailed t-test on the posttest data, the t_{value} was 12.0196, which was far greater than the t_{table} value of 2.000, so H_a was accepted. This shows that the discovery learning model has a significant effect in reducing misconceptions in renewable energy material compared to conventional learning.

Keywords: Discovery learning; Misconceptions; Five-tier diagnostic test; Renewable energy; Quasi-experimental

How to cite: Siregar, E. S., Hutahaean, J., & Napitupulu, N. D. (2025). The Effect of Discovery Learning Model on Reducing Students' Misconceptions in Renewable Energy Material. *Lensa: Jurnal Kependidikan Fisika*, *13*(2), 296–309. https://doi.org/10.33394/j-lkf.v13i2.17925

INTRODUCTION

The survival and progress of a nation are often linked to the quality of its education system, although this relationship is neither automatic nor simple and depends strongly on how teaching and learning are designed and implemented. High-quality education is not reflected only in curriculum documents or school facilities, but especially in the quality of classroom instruction and in students' ability to develop a deep understanding of scientific concepts. One commonly used indicator to examine such abilities is the Programme for International Student Assessment (PISA). Results from PISA, organized by the OECD, place Indonesia at 67th out of 81 participating countries in science, with an average score of 383, and long-term trends suggest that Indonesian students' scientific literacy has remained relatively stagnant. In fact, the science score in 2022 declined compared with the score in 2006 (Limiansih et al., 2024). These data do not capture all the diversity of learning conditions across Indonesia, but they at least indicate that there are persistent and systemic issues in science education that still need to be addressed.

Students' scientific literacy is shaped by the interaction of complex internal and external factors. Internally, interest and motivation to learn, reading ability, willingness to ask questions, habits of interpreting data, and patterns of conceptual thinking all play important roles in how students construct understanding.

Externally, factors such as parents' educational background and guidance, the instructional approach used by teachers, the quality of teaching materials and media, the availability of learning resources, and the broader classroom and school climate also influence the quality of students' conceptual understanding in science (Limiansih et al., 2024). In many classrooms, science instruction still tends to focus on completing tasks and practicing exam-type problems rather than exploring the meaning of concepts in depth. Such patterns are likely to maintain, or even strengthen, misconceptions that students already bring with them before formal instruction begins.

Disparities in instructional quality are also visible at the regional level. According to the 2024 Indonesian Education Report (Rapor Pendidikan Indonesia), the quality of teaching at the upper-secondary level in North Sumatra is categorized as "Moderate." This suggests that classroom environments are becoming more conducive, but psychological support and teachers' efforts to build students' conceptual understanding are not yet optimal (Portal Data Kemendikdasmen, 2024). In this situation, students who are confused about concepts may hesitate to express their difficulties for fear of being judged or disrupting lessons. Rather than seeking clarification, they are inclined to construct their own explanations based on everyday intuition, which is not necessarily aligned with scientific ideas. This context creates substantial room for the emergence and consolidation of misconceptions.

In physics education, misconceptions have long been identified as a central obstacle to meaningful conceptual understanding. Many studies show that students often enter physics lessons with prior ideas that conflict with accepted scientific principles, for example regarding the relationship between force and motion, energy transformations, and the properties of physical phenomena (Akmam et al., 2025; Clement, 1982; Wells et al., 2020; Camp & Clement, 2010). The review by Wandersee, as cited in Puspaningsih et al. (2021), indicates that out of 700 studies on alternative conceptions in physics, hundreds focus on misconceptions across various topics. This pattern suggests that the problem is both widespread and persistent. Misconceptions, in this view, are not just minor errors that can be easily corrected through additional explanation, but relatively stable cognitive structures that are internally coherent from the learner's perspective.

Research using instruments such as the Force and Motion Conceptual Evaluation (FMCE) has documented consistent patterns in students' misconceptions about dynamics and kinematics. Modified module analysis reveals that particular misconceptions tend to cluster, which implies that a failure to understand one concept can pull related concepts in the same erroneous direction (Wells et al., 2019; Wells et al., 2020). Classic and recent studies further indicate that traditional teaching dominated by lectures often fails to correct such misconceptions and may unintentionally reinforce them, because students assimilate new information into an already inaccurate conceptual framework (Thornton & Sokoloff, 1998; Camp & Clement, 2010). For example, many students interpret acceleration merely as "change in speed" without considering the role of net force and mass, thereby developing reasoning that is inconsistent with Newtonian mechanics (Clement, 1982; Thornton & Sokoloff, 1998).

These problems are not limited to force and motion. Misconceptions also arise strongly in the domain of energy and its use. Energy is often understood in a naive way as a kind of "stuff that can be used up," so students may believe that energy literally disappears when used, instead of recognizing that energy is conserved and transformed within and between systems. In the context of renewable energy, misconceptions can become even more complex, because students must understand the nature of renewable sources, the efficiency of energy conversion, and environmental impacts of different energy choices. Preliminary observations at SMA Negeri 11 Medan show that 31.2% of students hold a misconception about the statement "Energy can be exhausted if it is used continuously without stopping," which suggests that the concepts of energy conservation and transformation are not yet well understood. In addition, 78.1% of students agree with the statement "Lifting an object without moving it from its original place counts as work," which points to a misunderstanding of the physics definition of work that requires displacement (researcher's preliminary survey data). These findings are consistent with literature showing that students often cling to intuitive narratives even after formal instruction (Chambers & André, 1997; Streveler et al., 2008).

Classroom practice at SMA Negeri 11 Medan, based on interviews with the physics teacher, is still dominated by a conventional, teacher-centered model that relies on lecture as the main method. In such a pattern, students have limited opportunities to ask questions, explore their own ideas, or test their understanding against phenomena or data. Assessment data show that around 77.1% of students have not yet reached the minimum mastery criterion (KKM) in physics. This situation can be interpreted as an indication that many students have not developed sufficient conceptual understanding of the material taught. This is not simply a matter of "student ability," but is closely related to the design of instruction. When physics at earlier phases was taught only superficially, without conceptual exploration and direct experiences, students enter senior high school with fragile conceptual foundations that are highly vulnerable to misconceptions. This picture is compatible with findings that a one-directional, didactic approach that does not emphasize conceptual exploration and inquiry activities tends to fall short in developing robust understanding (Sripathi & Shadreck, 2025; Kamilah et al., 2025).

Several studies have proposed more exploratory and knowledge-constructive teaching strategies, for example instruction based on cognitive conflict, the use of augmented reality, and other active learning models (Muttasyabiha, 2024; Hasan, 2025). These approaches start by eliciting students' initial ideas, confronting them with real phenomena or empirical data, and guiding students toward reconstructing more scientific conceptions. However, the effectiveness of such strategies depends strongly on teachers' capacity to build a classroom environment that supports questioning, encourages argumentation, and treats mistakes as a natural and useful part of learning. At the same time, research on students' epistemological beliefs suggests that misconceptions are linked to how learners view scientific knowledge: whether as a fixed collection of facts to be memorized, or as a body of ideas that can be tested and revised (Bahtaji, 2023). When knowledge is perceived as static, students are more likely to rely on their original intuitions and resist revising them, even when confronted with conflicting evidence.

Within this broader debate, the discovery learning model appears as a potentially relevant alternative to examine. Discovery learning places students as active agents who explore phenomena, collect data, identify patterns, and formulate concepts with guidance from the teacher. In principle, this process allows for productive cognitive conflict when students' initial ideas do not match observed results, which can prompt them to revise their understanding (Salamun et al., 2023). Evidence in the literature also suggests that strategies explicitly oriented toward conceptual restructuring, rather than simple information transmission, tend to be more promising in reducing misconceptions (Addido et al., 2022; Streveler et al., 2008). Even so, it is not reasonable to assume that discovery learning will work equally well in all contexts. The model needs to be tested in relation to specific topics and student characteristics, including topics such as renewable energy, which involves abstract ideas that are often oversimplified in everyday discourse.

Against this background, the issue of physics misconceptions, particularly on renewable energy, among students at SMA Negeri 11 Medan needs to be examined not only in terms of test scores but also in terms of how teaching models can contribute to reducing such misconceptions. This study therefore aims specifically to investigate the influence of the discovery learning model on the reduction of students' misconceptions about renewable energy. The focus is expected to yield empirical evidence on the extent to which discovery learning can correct and lessen entrenched misconceptions and to offer input for improving physics teaching practices at the senior high school level, especially in regions where scientific literacy outcomes still need substantial improvement.

METHOD

This study employed a quantitative descriptive approach with a quasi-experimental design. The specific design used was a pretest–posttest control group design, as presented in Table 1. In this design, both the experimental and control groups received a pretest (T_1) and a posttest (T_2). The experimental group (X_1) was taught using the discovery learning model, while the control group (X_2) received instruction using a conventional, teacher-centered model.

Table 1. Pretest-posttest control group design

Group	Pretest	Treatment	Posttest
Experimental	T_1	X_1	T_2
Control	T_1	X_2	T_2

Description:
T_1: Pretest (initial diagnostic test)
T_2: Posttest (final diagnostic test)
X_1: Instruction using the discovery learning model
X_2: Instruction using the conventional teaching model

The study was conducted in the 2025/2026 academic year. The population consisted of all Grade X IPAS students at SMA Negeri 11 Medan, comprising eight classes. The research sample consisted of two Grade X IPAS classes. The instrument used in this study was a five-tier diagnostic multiple-choice test administered to students at the beginning and at the end of the learning process. Each item consisted of five tiers: the first tier was an ordinary multiple-choice question; the second tier asked students to indicate their level of confidence in their answer to the first tier. The third tier presented a multiple-choice question regarding the reason for the answer in the first tier. The fourth tier asked students to state their level of confidence in the reason chosen in the third tier. The fifth tier asked students to identify the source of information they used as the basis for their answer. The five-tier diagnostic test consisted of 20 items. The data in this study were analyzed using normality tests, homogeneity tests, and hypothesis testing.

To identify students' levels of misconception before and after the treatment, combinations of responses from the pretest and posttest were organized and classified into the following categories: Sound Understanding (SU), where students have a correct and complete conceptual understanding; Partial Understanding (PU), where students are not yet able to fully explain the phenomenon; No Understanding (NU), where students do not understand the scientific concept; Misconception (MC), where students hold an incorrect understanding that does not align with the scientific concept; and Uncoded (UC), where students' answers cannot be interpreted (Kaniawati et al., 2019).

Table 2. Categories of answer combinations in the five-tier test

No	Answer at tier-					Conceptual level
	1	2	3	4	5	
1	0	Y	0	Y	Book Teacher Own Thinking Peer Internet	MC-B MC-G MC-PP MC-T MC-I
2	1	Y	1	Y	Book Teacher Own Thinking Peer Internet	SU-B SU-G SU-PP SU-T SU-I
3 4	1 1	Y TY	1 1	TY Y	Book	PU-B
5 6	1 1	TY Y	1 0	TY Y	Teacher	PU-G
7 8	1 1	Y TY	0 0	TY Y	Own Thinking	PU-PP
9 10 11	1 0 0	TY Y Y	0 1 1	TY Y TY	Peer	PU-T
12 13	0 0	TY TY	1 1	Y TY	Internet	PU-I
14	0	Y	0	TY	Book Teacher	NU-B NU-G
15	0	TY	0	Y	Own Thinking	NU-PP
16	0	TY	0	TY	Peer Internet	NU-T NU-I
Any tier unanswered or more than one option selected in a tier						UC

Description: MC-B = Misconception from Book; MC-G = Misconception from Teacher; MC-PP = Misconception from Own Thinking; MC-T = Misconception from Peer; MC-I = Misconception from Internet; 1 = Correct Answer; 0 = Incorrect Answer; Y = Confident; TY = Not Confident.

The level of students' misconceptions can be analyzed by interpreting the percentage of their understanding as shown in Table 3.

Table 3. Percentage of students' level of understanding

Percentage	Category
0% - 30%	Low
31% - 60%	Moderate
61% - 100%	High

Table 3 provides the criteria used to interpret students' levels of understanding based on the percentage of responses in each conceptual category. A percentage between 0% and 30% is classified as Low, indicating that only a small proportion of students demonstrate the targeted level of understanding (or, conversely, that misconceptions are relatively dominant). A percentage between 31% and 60% is categorized as Moderate, reflecting a transitional condition in which some students have begun to grasp the concepts but substantial difficulties or misconceptions remain. A percentage between 61% and 100% is classified as High, suggesting that most students show the intended understanding and that misconceptions in that category are relatively limited. This classification is used to describe and compare students' conceptual understanding before and after the instructional treatment.

RESULTS AND DISCUSSION

Mean Pretest and Posttest Scores

This section presents the results of the analysis related to the reduction of students' misconceptions in the experimental and control classes. The mean pretest and posttest scores for both classes are shown in Table 4.

Table 4. Mean pretest and posttest scores

	Experimental	Control
Pretest	39,8	37,8
Posttest	72,9	66,8

The results show that the mean pretest scores of the experimental group (39.8) and the control group (37.8) were relatively comparable. After the treatment, the posttest score of the experimental group increased to 72.9, while the control group reached 66.8.

Normality Test

The results of the normality test for the pretest and posttest data in both the experimental and control classes are presented in Table 5, which reports the calculated L value ($L\_{calculated}$) and the critical L value from the table (L_{table}) for each data set at both the pretest and posttest stages.

Table 5. Normality test results

Group	Pretest		Description	Posttest		Description
	L_{cal}	L_{tab}		L_{cal}	L_{tab}	
Experimental	0,090	0,156	Normal	0,128	0,156	Normal
Control	0,113	0,161	Normal	0,133	0,161	Normal

Based on Table 5, for the experimental class the $L\_{calculated}$ value for the pretest is 0.090, which is smaller than L_{table} of 0.156 at the 0.05 significance level. Similarly, for the posttest data in the experimental class, $L\_{calculated}$ is 0.128, which is also smaller than L_{table} of 0.156. This indicates that both the pretest and posttest data in the experimental class are normally distributed. In the control class, the $L_{calculated}$ value for the pretest is 0.113, which is smaller than L_table of 0.161. Likewise, for the posttest data in the control class, $L_{calculated}$ is 0.133, which is smaller than L_{table} of 0.161. Thus, the pretest and posttest data in the control class are also normally distributed. Taken together, the normality test results indicate that all data, both in the experimental and control classes, follow a normal distribution.

Homogeneity Test

At this stage, a homogeneity test was conducted as part of the prerequisite analysis. The results of the homogeneity test for the pretest and posttest data of the experimental and control classes are presented in Table 6.

Table 6. Homogeneity test of the two sample groups

No	Data	Variance	F_{cal}	F_{tab}	Conclusion
1.	Experimental Class (Pretest)	102,4	1,047	1,848	Homogeneous
2.	Control Class (Pretest)	97,7			
3.	Experimental Class (Posttest)	78,8	1,451	1,848	Homogeneous
4.	Control Class (Posttest)	54,2			

As shown in Table 6, the homogeneity test results indicate that for both the pretest and posttest data, the F_calculated values are smaller than the F_table value at the 0.05 significance level. This means that the variances of the experimental and control classes can be considered equal, so the data for both groups are homogeneous. This suggests that the sample used in the study is homogeneous and can reasonably be viewed as representative of the population.

Two-Tailed Hypothesis Test

The results of the two-tailed t-test on the pretest data for the experimental and control classes are presented in Table 7.

Table 7. Two-tailed t-test results for pretest

Data	Average	t_{cal}	t_{tab}	Conclusion
Pretest (Experimental class)	39,8	0,804	2,000	H_o accepted
Pretest (Control class)	37,8			

Based on Table 7, the value of t_calculated = 0.804 is less than t_{table} = 2.000 at the 0.05 significance level with 60 degrees of freedom. According to the decision rule ($t_{calculated} < t_{table}$), H_0 is accepted and H_a is rejected. This indicates that there is no significant difference between the mean pretest scores of the experimental and control classes. In other words, the initial abilities of students in both groups were comparable, so the instructional treatments given at the next stage can be compared on a more objective basis.

One-Tailed Hypothesis Test

The results of the one-tailed t-test on the posttest data for the experimental and control classes are shown in Table 8.

Table 8. One-tailed t-test results for posttest

Data	Average	t_{cal}	t_{tab}	Conclusion
Pretest (Experimental class)	72,9	12,019	2,000	H_a accepted
Pretest (Control class)	66,8			

As presented in Table 8, the value of $t_{calculated}$ = 12.019 is greater than t_table = 2.000 at the 0.05 significance level with 60 degrees of freedom. According to the decision rule ($t_{calculated} > t_{table}$), H_0 is rejected and H_a is accepted. This result indicates a statistically significant effect of the discovery learning model on reducing students' misconceptions in renewable energy material when compared to conventional instruction.

Results of Students' Misconception Reduction

The analysis of students' misconceptions was carried out based on their responses to the five-tier diagnostic test administered at the pretest and posttest stages. In the experimental class, the average level of student misconceptions before the treatment was 44.3%. After the treatment, the average misconception level decreased to 24.5%, indicating a reduction of 19.8%. In the control class, the average level of student misconceptions before the treatment was 42.3%, and after the treatment it decreased to 31.2%, resulting in a reduction of 11.6%.

Based on the analysis of the pretest data in both the control and experimental groups, students were found to experience various misconceptions originating from several sources, namely Book (B), Teacher (G), Own Thinking (PP), Peer (T), and Internet (I). In more detail, the sources of students' misconceptions at the pretest stage for the experimental and control classes are illustrated in the chart presented in Figure 2(a), while the sources of misconceptions at the posttest stage for the experimental and control classes are shown in Figure 2(b).

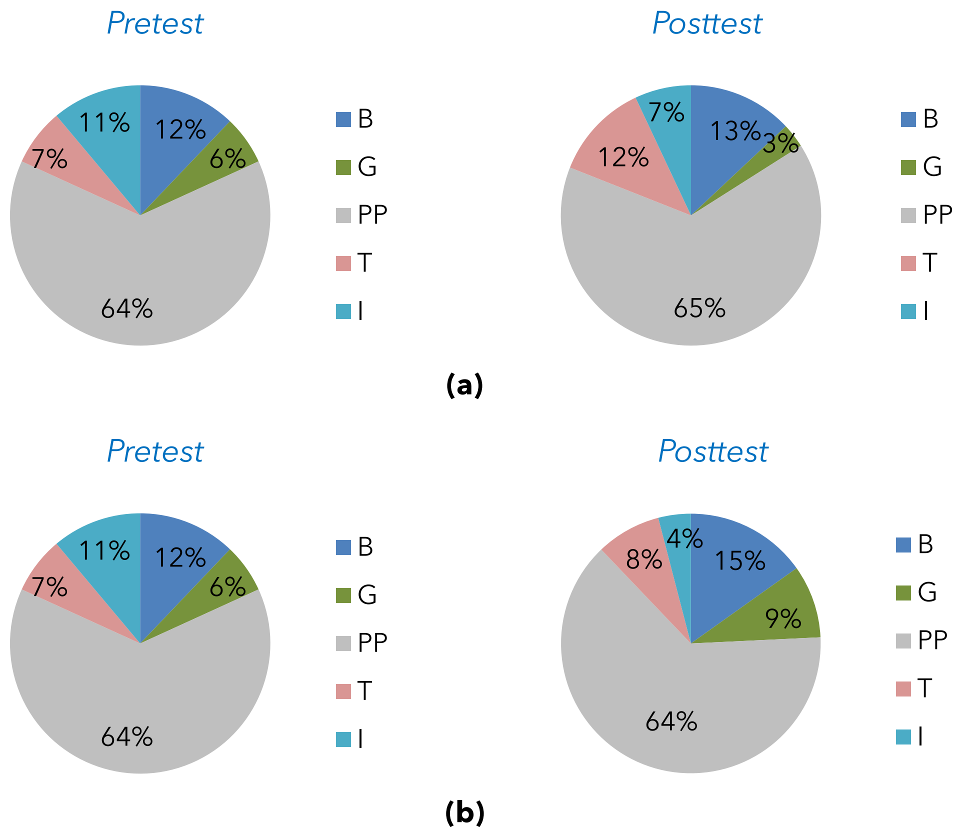

Figure 2. (a) Analysis of Students' Misconceptions in the Control Class, (b) Analysis of Students' Misconceptions in the Experimental Class

Figure 2 shows the sources of students' misconceptions at pretest and posttest in both the experimental and control classes. In the experimental class, the pretest data indicate that most misconceptions originated from students' own thinking (PP) at 64%, followed by books (B) at 12%, peers (T) at 7%, internet (I) at 11%, and teacher (G) at 6%. After the instructional treatment, the percentage of misconceptions originating from students' own thinking remained high at 65%, but small changes appeared in other sources: books 13%, peers 12%, internet 7%, and teacher 3%. In the control class, the pretest showed a similar distribution of misconception sources: own thinking (PP) 64%, books (B) 12%, peers (T) 7%, internet (I) 11%, and teacher (G) 6%. At the posttest, there was a decrease in misconceptions from own thinking to 64%, while other sources showed slight changes: books 15%, teacher 9%, peers 8%, and internet 4%.

Based on the analysis of the sources of students' misconceptions, the highest percentage was found in the MC-PP category, or misconceptions caused by students' own thinking, which reached 63% at both pretest and posttest in the experimental class, and 71% at pretest and 66% at posttest in the control class. Students' own thinking becomes a source of misconception when they hold incorrect ideas, reasoning, or intuitions about a concept, or when they misinterpret their personal experiences (Rosita et al., 2020). In contrast, the smallest percentage was found in the MC-I category, or misconceptions originating from the internet. This indicates that the number of students who experienced misconceptions on renewable energy material due to internet-based learning resources was relatively low.

Misconceptions originating from books (MC-B) may occur because students have difficulty understanding the content of the book, because concepts are presented inaccurately, or due to errors in translation from the original text. Misconceptions from teachers (MC-G) may arise when teachers themselves hold similar misconceptions to their students, or when teachers are unable to explain concepts clearly, leading students to misunderstand what is being taught. Misconceptions originating from peers (MC-T) may result from inaccurate explanations of a concept provided by others (Sitorus & Dalimunthe, 2024).

Discussion of the Results

Based on the hypothesis test conducted using a two-tailed t-test on the students' pretest scores, the obtained $t_{calculated}$ of 0.804 was smaller than t_{table} of 2.000 ($\alpha = 0.05$). This indicates that the initial abilities of students in the two classes did not differ significantly. Thus, both classes were in an equivalent condition before the treatment, which means that the subsequent learning outcomes could be compared objectively. After the instructional treatment, the mean posttest score in the experimental class was 72.9, while in the control class it was 66.8. The one-tailed t-test on the posttest data yielded a $t_{calculated}$ value of 12.019, which was far greater than t_{table} of 2.000, so H_a was accepted. This result shows that the discovery learning model had a significant effect in reducing misconceptions on renewable energy material compared to conventional instruction.

The treatment in the experimental class was carried out over two weeks with two core instructional meetings, each with an allocation of three lesson hours. In the first meeting, a pretest was administered to measure students' initial abilities. In the second meeting, discovery learning was implemented using student worksheets that addressed potential, kinetic, and mechanical energy. The third meeting continued with worksheets focusing on energy transformation and the potential of energy sources in the surrounding environment. These activities encouraged students to construct a more coherent conceptual understanding and to correct misconceptions they previously held. In the fourth meeting, a posttest was administered to determine changes in students' understanding. The posttest at the final meeting was intended to assess the extent of conceptual change after students had undergone the full sequence of discovery learning stages. The posttest results showed that the reduction in misconceptions in the experimental class was greater than in the control class.

In the experimental class, the average level of misconceptions before the treatment was 44.3%, and after the treatment it decreased to 24.5%. Thus, there was a reduction of 19.8% in misconceptions in the experimental class. Meanwhile, in the control class, the average level of misconceptions before the treatment was 42.3%, and after the treatment it decreased to 31.2%, resulting in a reduction of 11.6%. The difference in the degree of misconception reduction among students suggests that the process of conceptual change is individual in nature. In addition, there were some students who did not show any reduction in misconceptions, meaning that they maintained the same confidence in their answers when the posttest was administered as they had during the pretest.

This study is relevant to and consistent with the findings of Mutia et al. (2025), who also reported that the application of the discovery learning model had a significant effect on reducing students' misconceptions. In that study, it was explained that discovery learning provides opportunities for students to better understand concepts and makes the learning process more engaging because students investigate real problems directly and are actively involved in learning tasks. Students are required to think and use their abilities to arrive at an accurate understanding of the final concept.

The different levels of misconception reduction observed here suggest that appropriate instruction can have a substantial impact on reducing students' misconceptions. These results are in line with the findings of Milenković et al. (2025), who showed that the implementation of discovery learning not only improves students' conceptual understanding, but also strengthens knowledge retention and helps students overcome conceptual errors when solving more complex problems. The discovery learning model is one of several constructivist approaches that require learners to build their knowledge based on their experiences with the surrounding environment. In practice, discovery learning does not merely encourage students to test their preconceptions, but also to construct new knowledge by drawing on prior experiences, intuition, imagination, and creativity (Ramadhana et al., 2025). Knowledge acquired through discovery-based instruction tends to be more durable and easier to recall (Putri & Wasis, 2022).

Discovery learning requires students to be more active in observing and discovering theories related to the content and in practicing scientific thinking similar to that of scientists. Students can develop their "discovery ability" to find conceptual relationships relevant to the material they are studying. Their active engagement in resolving doubts that arise within themselves directs them toward scientific thinking. Such a way of thinking helps free students from misconceptions, as they are trained to ground their understanding in evidence and logical reasoning. Learning using the discovery learning model is more effective in reducing students' misconceptions than conventional teaching models (Suryawan et al., 2020). Through the stages of instruction, students are encouraged to test their preconceptions and compare them with scientific facts obtained from observations or experiments. This process creates a discrepancy between students' initial knowledge and the new information or experiences they encounter. The discrepancy prompts students to re-examine and revise their understanding, leading to conceptual change and minimization of misconceptions. These findings are consistent with the results of Liu and Fang (2023), who reported that enhanced hands-on experimentation was significantly effective in correcting university students' misconceptions on work and energy, because experimental activities require students to test and compare their initial conceptions against empirical evidence.

The discovery learning model can reduce students' misconceptions because it consists of phases that provide positive impacts in the form of more meaningful learning. The phases of discovery learning include providing a stimulus, identifying problems, collecting data, processing data, verification, and drawing conclusions. In these stages, students are encouraged to test their preconceptions and compare them with scientific facts obtained from observations or experiments (Subekti & Sunarti, 2020). These stages are believed to reduce the number of misconceptions because at the beginning students present the concepts they hold, then carry out experiments, and after obtaining data they check whether their initial concepts are supported by the experimental results. In this way, students become aware of where their errors lie and are able to develop new, more accurate concepts (Fitri & Putra, 2023).

The discovery learning process begins with the stimulation stage, in which the teacher presents phenomena or problems that provoke students' curiosity. At this stage, students are encouraged to use their full thinking capacity to explore and investigate information systematically, critically, logically, and analytically. Next, in the problem statement stage, students formulate the problem and propose tentative hypotheses as initial answers. Students with stronger initial abilities tend to be more systematic and analytical in formulating hypotheses, while those with weaker initial abilities may appear less critical at this stage. The following phase is data collection, in which students work in groups to conduct experiments, make observations, or gather information from various sources to obtain relevant data. The data collected are then analyzed in the data processing stage to test the validity of the hypotheses. After that, in the verification stage, students compare the results of their analysis with established concepts or theories to confirm the accuracy of their findings. The learning process concludes with the generalization stage, where students draw general conclusions from the learning results. At this phase, students present their group discussions, other groups provide feedback, and the teacher clarifies and reinforces the final conclusions with the entire class. The discovery learning model is able to reduce students' misconceptions because each of its stages, from observing, questioning, trying, associating, to communicating, encourages students to test and refine incorrect preconceptions based on evidence and direct experience.

Among these six stages, the syntax most dominant in reducing students' misconceptions is the verification stage. This is because in the verification stage students test the hypotheses or initial conjectures they proposed against the data they have collected and processed. According to Bruner (in Suparno, 2013), the verification process in discovery learning encourages students to experience cognitive conflict when their incorrect initial conceptions do not match empirical evidence, thereby triggering a restructuring of knowledge in a more scientific direction as students themselves recognize the mismatch between their initial conceptions and reality.

Thus, based on the results of this study conducted in Grade X at SMA Negeri 11 Medan, it can be concluded that learning using the discovery learning model has a positive effect on reducing students' misconceptions on renewable energy material.

CONCLUSION

Based on the results of the study conducted in the experimental and control classes, it was found that the level of students' misconceptions on renewable energy material in the experimental class decreased from 44.3% (moderate category) to 24.5% (low category), with a reduction of 19.8%. Meanwhile, in the control class, the misconception level decreased from 42.3% (moderate category) to 31.2% (moderate category), with a reduction of 11.2%. Statistical analysis showed that the discovery learning model had a significant effect on reducing students' misconceptions on renewable energy material. Thus, the discovery learning model proved to be more effective than conventional teaching in reducing students' misconceptions and can be recommended as an appropriate alternative instructional strategy to improve students' conceptual understanding of renewable energy.

RECOMMENDATION

It is recommended to use innovative learning media such as interactive games, comics, or augmented reality and virtual reality, as well as to develop integrated assessments based on five-tier tests and computer-based diagnostic tests to enhance instructional effectiveness and further reduce misconceptions related to renewable energy.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to all parties who provided support and assistance during the implementation and preparation of this research.

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