JoSLEPI 4 (1) (2026)
Journal of Science Learning Process and Instructional Research
https://journal.riau-edutech.com/index.php/joslepi
Publisher :
Andester Riau Edutech
Pusat Inovasi Pendidikan dan Teknologi
ISSN 3031-3252

# ENHANCING HIGH SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING OF ENERGY SOURCES THROUGH THE SETS LEARNING MODEL

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Submiited: 04/02/2026
Review: 05/02/2026
Accepted: 07/03/2026
Published: 30/04/2026
Vol. 4
No. 1

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**Abstract-** This study investigates the effectiveness of the Science, Environment, Technology, and Society (SETS) learning model in improving senior high school students' conceptual understanding of energy resources. The study was motivated by the low level of students' conceptual understanding in physics learning, which is often caused by teacher-centered instruction, limited contextual learning experiences, and the lack of integration between scientific concepts and real-life phenomena. The research employed a quantitative approach using a quasi-experimental method with a posttest-only nonequivalent control group design. The population consisted of tenth-grade students at SMA IT Al Fikri Islamic Green School Pekanbaru during the 2025/2026 academic year. Two classes comprising 58 students were selected as research samples through random sampling. The experimental group was taught using the SETS learning model, while the control group received conventional instruction. Data were collected through a conceptual understanding test consisting of 21 multiple-choice questions covering the indicators of translation, interpretation, and extrapolation. The collected data were analyzed using descriptive and inferential statistical techniques, including the Independent Samples t-test. The findings revealed that students in the experimental class achieved significantly higher conceptual understanding scores than those in the control class. The average score of the experimental group was categorized as good, whereas the control group only reached the sufficient category. Statistical analysis showed a significance value below 0.05, indicating a significant difference between the two groups. Therefore, the SETS learning model can be considered an effective instructional approach for enhancing students' conceptual understanding of energy resource concepts in physics learning.

**Keywords:** *Conceptual Understanding, Energy Resources, Physics Learning, Senior High School Students, SETS Learning Model.*

## 1 Introduction

Education in the 21st century requires learning processes that not only emphasize mastery of knowledge, but also develop students' critical thinking, problem-solving, collaboration, and contextual understanding skills (Rahman et al., 2022). In science education, particularly physics, students are expected to understand scientific concepts deeply and relate them to real-life phenomena occurring in their environment. Physics learning is no longer oriented solely toward memorizing formulas and theories, but rather toward helping students construct conceptual understanding through meaningful learning experiences. This demand aligns with the current educational paradigm, which emphasizes student-centered learning and contextual approaches to improve learning quality and outcomes (Parwati et al., 2023).

Physics is one of the fundamental branches of science that plays a crucial role in technological advancement and scientific literacy development. As part of natural sciences, physics involves not only conceptual knowledge but also scientific processes and attitudes (Collette & Chiappetta, 1994). Students are expected to understand physical concepts and apply them to solve problems in everyday life. However, in practice, many students still perceive physics as a difficult and abstract subject because learning activities

**How to Cite**
Andini, J., Zulhemi, & Rahmat, M. (2026). Enhancing high school students' conceptual understanding of energy sources through the SETS learning model. *Journal of Science, Learning Process and Instructional Research* (JoSLEPI), 4(1). 8-16

are often dominated by mathematical equations and teacher explanations without connecting the material to contextual situations. Consequently, students tend to memorize concepts without truly understanding their meanings and applications (Febrianty et al., 2023). One of the major issues in physics education is students' low conceptual understanding. Conceptual understanding refers to students' ability to explain, interpret, and apply concepts appropriately in various contexts. According to Bloom's revised taxonomy, understanding is an essential cognitive domain that serves as the foundation for higher-order thinking skills such as analysis, evaluation, and creation (Gunawan & Palupi, 2016). Students who possess strong conceptual understanding are able to relate scientific ideas, interpret data, and solve problems systematically. Conversely, students with poor conceptual understanding often experience misconceptions and difficulties in applying knowledge to new situations. Several studies have reported that students' conceptual understanding in physics remains relatively low, particularly in topics closely related to environmental and technological issues (Elyana et al., 2017).

One of the physics topics that frequently presents learning difficulties is energy resources. Energy resources are highly relevant to students' daily lives because they involve the use of renewable and non-renewable energy, environmental sustainability, technological development, and social impacts. Nevertheless, classroom instruction frequently presents energy concepts theoretically without linking them to real-world issues, resulting in students' inability to understand the significance and practical applications of the concepts learned (Puspita Sari et al., 2020). As a result, students often fail to connect physics concepts with environmental and technological problems occurring in society. Based on preliminary observations and interviews conducted with physics teachers at SMA IT Al Fikri Islamic Green School Pekanbaru, students' conceptual understanding of energy resources was found to be unsatisfactory. Many students experienced difficulties explaining the relationship between energy use, environmental impacts, and technological developments. Learning activities were still predominantly teacher-centered, relying heavily on lectures and textbook explanations. As a result, students were less actively involved in learning and had limited opportunities to explore concepts independently. Data from previous learning evaluations also showed that most students did not achieve the minimum mastery criteria established by the school. This condition indicates that learning strategies currently implemented in the classroom have not fully supported the development of meaningful conceptual understanding among students.

The low level of conceptual understanding can be influenced by several factors, including instructional strategies, learning models, and classroom interactions. Conventional learning methods often focus on transferring information from teachers to students without engaging students in meaningful learning experiences. Such approaches limit students' opportunities to construct knowledge actively and critically analyze scientific phenomena. In addition, teacher-centered instruction frequently reduces students' motivation and participation during classroom activities (Jainiyah et al., 2023). Therefore, innovative learning models that encourage active participation and contextual learning are needed to improve students' conceptual understanding in physics. Constructivist learning theory emphasizes that knowledge is actively constructed by learners through interaction with their environment and experiences. In constructivist learning, students are encouraged to explore, discuss, analyze, and reflect on concepts to build meaningful understanding. Teachers act as facilitators who guide students in discovering and connecting scientific concepts with real-world situations (Masgumelar & Mustafa, 2021). Learning models that incorporate contextual and constructivist principles are therefore considered effective in promoting deeper conceptual understanding and increasing students' engagement in learning activities.

One learning model that is considered suitable for achieving these goals is the SETS (Science, Environment, Technology, and Society) learning model. The SETS model emphasizes the interconnection between science concepts, environmental issues, technological developments, and societal contexts (Khasanah, 2013). Through this approach, students are encouraged to understand scientific concepts not only theoretically but also practically and socially. The SETS model provides opportunities for students to analyze real-world problems, discuss environmental impacts, evaluate technological applications, and propose solutions related to scientific issues. Consequently, learning activities become more contextual, interactive, and meaningful for students. The implementation of the SETS learning model in physics learning can create more meaningful and contextual learning experiences. By integrating science with environmental and societal issues, students become more engaged and motivated in learning activities. The model also encourages students to think critically and analytically about the relationship between scientific concepts and real-life applications. In learning energy resources, for example, students can discuss renewable energy technologies, environmental sustainability, energy conservation, and the social impacts of energy consumption. Such activities enable students to develop conceptual understanding while simultaneously increasing their environmental awareness and scientific literacy (Firdaus et al., 2023).

Previous studies have demonstrated the positive impact of the SETS learning model on students' learning outcomes and conceptual understanding. Widiantini et al. (2020) reported that the SETS approach supported by virtual laboratory activities significantly improved students' science knowledge competencies. Similarly, Rohmatun and Rasyid (2022) found that the implementation of the SETS model assisted by instructional videos enhanced students' conceptual understanding effectively. Other studies also indicated that SETS-based learning contributes to the development of critical thinking skills, problem-solving abilities, and scientific attitudes among students. These findings indicate that the SETS model has strong potential to improve the quality of physics learning through contextual and interdisciplinary approaches.

Despite its potential benefits, the implementation of the SETS learning model in physics learning, particularly on the topic of energy resources at the senior high school level, remains limited. Most previous studies focused on general science subjects or different educational levels. Therefore, further investigation is needed to examine the effectiveness of the SETS learning model in improving students' conceptual understanding of energy resources in physics learning contexts. This study aims to analyze the effectiveness of the SETS learning model in enhancing senior high school students' conceptual understanding of energy resources. Specifically, the study seeks to determine the differences in conceptual understanding between students taught using the SETS learning model and those taught through conventional instruction. The findings of this research are expected to contribute to the development of innovative and contextual physics learning strategies that align with the demands of 21st-century education. Furthermore, this study is expected to provide practical implications for physics teachers in selecting and implementing appropriate learning models to improve conceptual understanding. By applying the SETS approach, teachers can create learning environments that encourage active participation, critical thinking, and contextual learning. The study may also serve as a reference for future research related to contextual science learning and the integration of environmental and technological issues into physics education.

## 2 Research Methodology

This study employed a quantitative research approach using a quasi-experimental design to investigate the effectiveness of the Science, Environment, Technology, and Society (SETS) learning model in improving students' conceptual understanding of energy resources in physics learning. The research design applied in this study was the posttest-only nonequivalent control group design. This design was selected because the researcher did not administer a pretest to the participants but only measured students' conceptual understanding after the instructional treatment had been completed. The experimental group received instruction using the SETS learning model, whereas the control group was taught using conventional teaching methods.

**Tabel 1.** Research Design

| Group | Treatment | Post-test |
|---|---|---|
| Experimental Class | SETS Learning Model | O1 |
| Control Class | Conventional Learning | O2 |

Source: Adapted from Sugiyono (2014).

The research was conducted at SMA IT Al Fikri Islamic Green School Pekanbaru during the first semester of the 2025/2026 academic year. The study was carried out from July to December 2025, including preparation, implementation, data collection, and data analysis stages. The population of the study consisted of all tenth-grade students at the school, totaling 88 students distributed across three classes. The sample was selected using random sampling techniques after preliminary analysis of students' previous academic performance to ensure homogeneity among classes. Two classes were selected as research samples, consisting of one experimental class and one control class with a total of 58 students.

The experimental class was taught using the SETS learning model, which integrates scientific concepts with environmental, technological, and societal contexts. Learning activities in the experimental class involved contextual problem-solving, group discussions, environmental issue analysis, and exploration of technological applications related to energy resources. Students were encouraged to actively connect physics concepts with real-life phenomena, particularly issues concerning renewable and non-renewable energy. Meanwhile, the control class received conventional instruction dominated by teacher explanations, textbook discussions, and routine exercises without contextual integration.

The research instrument used in this study was a conceptual understanding test in the form of multiple-choice questions. The test consisted of 21 items designed to measure students' conceptual understanding based on three indicators: translation, interpretation, and extrapolation. The translation indicator measured students' ability to convert information from one form to another, such as interpreting diagrams, graphs, or verbal explanations. The interpretation indicator assessed students' ability to explain meanings and relationships among concepts, while the extrapolation indicator evaluated students' ability to predict, infer, and apply concepts to different situations.

Before being administered, the instrument was validated by experts to ensure content validity and suitability with the learning objectives. The test items were also analyzed to determine their reliability, difficulty level, and discrimination index. After the learning process had been completed, the posttest was administered to both groups under similar conditions.

**Table 3.** Blueprint of Conceptual Understanding Instrument

| Indicator | Item Numbers | Total Items |
|---|---|---|
| Translation | 1–6 | 6 |
| Interpretation | 7–15 | 9 |
| Extrapolation | 16–21 | 6 |
| Total | | 21 |

Data collection in this study focused on posttest results obtained from both experimental and control groups. The collected data were analyzed using descriptive and inferential statistical techniques. Descriptive analysis was used to determine the average scores, percentages, and categories of students' conceptual understanding. The results were categorized into very good, good, sufficient, and poor categories based on predetermined criteria. Inferential statistical analysis was conducted to test the research hypothesis. Prior to hypothesis testing, normality and homogeneity tests were performed. The Shapiro Wilk test was used to examine data normality, while Levene's test was applied to assess variance homogeneity between groups. After fulfilling the statistical assumptions, the Independent Samples t-test was conducted at a significance level of 0.05 to determine whether there was a significant difference in conceptual understanding between students taught using the SETS learning model and those taught using conventional methods.

The research procedure consisted of several stages, namely preparation, implementation, testing, and evaluation. During the preparation stage, lesson plans, instructional materials, and research instruments were developed. In the implementation stage, the SETS learning model was applied in the experimental class for several learning sessions on energy resources. Finally, posttest data were analyzed to determine the effectiveness of the SETS learning model in enhancing students' conceptual understanding.

## 3 Results and Discussion

### 3.1 Results

This study aimed to determine the effectiveness of the Science, Environment, Technology, and Society (SETS) learning model in improving senior high school students' conceptual understanding of energy resources. The results presented in this section were obtained from the posttest scores of students in both the experimental and control classes after the implementation of the learning treatments. The experimental class received instruction using the SETS learning model, while the control class was taught using conventional learning methods.

#### 3.1.1 Descriptive Analysis of Students' Conceptual Understanding

Descriptive statistical analysis was conducted to examine the differences in students' conceptual understanding between the experimental and control groups. The results revealed that students who learned through the SETS learning model achieved higher conceptual understanding scores than students who experienced conventional instruction.

**Table 4**. Posttest Results of Students' Conceptual Understanding

| Score Interval | Category | Experimental Class (%) | Control Class (%) |
|---|---|---|---|
| $85 \leq x < 100$ | Very Good | 58.63 | 0 |
| $70 \leq x < 85$ | Good | 41.37 | 3.46 |
| $50 \leq x < 70$ | Fair | 0 | 68.96 |
| $0 \leq x < 50$ | Poor | 0 | 27.58 |
| Average Score | | 84.23 | 54.83 |
| Category | | Good | Fair |

Based on Table 4, the average conceptual understanding score of students in the experimental class reached 84.23, which was categorized as good. In contrast, the control class only achieved an average score of 54.83, which fell into the fair category. More than half of the students in the experimental class were categorized as having very good conceptual understanding, while none of the students in the control class achieved that category. These findings indicate that the SETS learning model provided a more effective learning experience in helping students understand physics concepts related to energy resources.

The significant difference in the average scores between the two groups suggests that contextual learning activities integrated into the SETS model played an important role in enhancing students' conceptual understanding. Through the SETS approach, students were encouraged to connect scientific concepts with environmental issues, technological applications, and social phenomena occurring in everyday life. Consequently, students became more actively involved in the learning process and developed deeper understanding compared to those who learned through conventional methods.

#### 3.1.2 Analysis of Conceptual Understanding Based on Indicators

Students' conceptual understanding in this study was analyzed based on three indicators: translation, interpretation, and extrapolation. The analysis results for each indicator are presented in Table 5.

**Table 5.** Analysis of Conceptual Understanding Based on Indicators

| Indicator | Experimental Class (%) | Category | Control Class (%) | Category |
|---|---|---|---|---|
| Translation | 85.05 | Very Good | 59.75 | Fair |
| Interpretation | 85.86 | Very Good | 50.95 | Fair |
| Extrapolation | 81.10 | Good | 55.16 | Fair |

Table 5 demonstrates that students in the experimental class outperformed students in the control class on all conceptual understanding indicators. The highest achievement in the experimental class was found in the interpretation indicator, with a percentage score of 85.86%, categorized as very good. Meanwhile, the extrapolation indicator obtained the lowest percentage among the three indicators, although it still fell within the good category. The translation indicator measured students' ability to convert information from one representation to another, such as interpreting graphs, diagrams, and verbal descriptions related to energy resources. Students in the experimental class performed very well on this indicator because the SETS learning activities frequently involved discussions, contextual observations, and interpretation of real-world energy issues. Students became more familiar with connecting visual and textual information to scientific concepts.

Similarly, the interpretation indicator also showed excellent results in the experimental class. This finding indicates that students were able to explain scientific phenomena and understand the relationships among concepts more effectively after participating in SETS-based learning activities. The integration of science with environmental and technological contexts enabled students to construct conceptual understanding through meaningful experiences. The extrapolation indicator obtained slightly lower scores compared to the other indicators. This indicator required higher-order thinking skills because students needed to predict, infer, and apply concepts to new situations. Although the scores were lower, students in the experimental class still demonstrated better performance than students in the control class. This result suggests that the SETS learning model was capable of developing students' analytical and predictive thinking abilities.

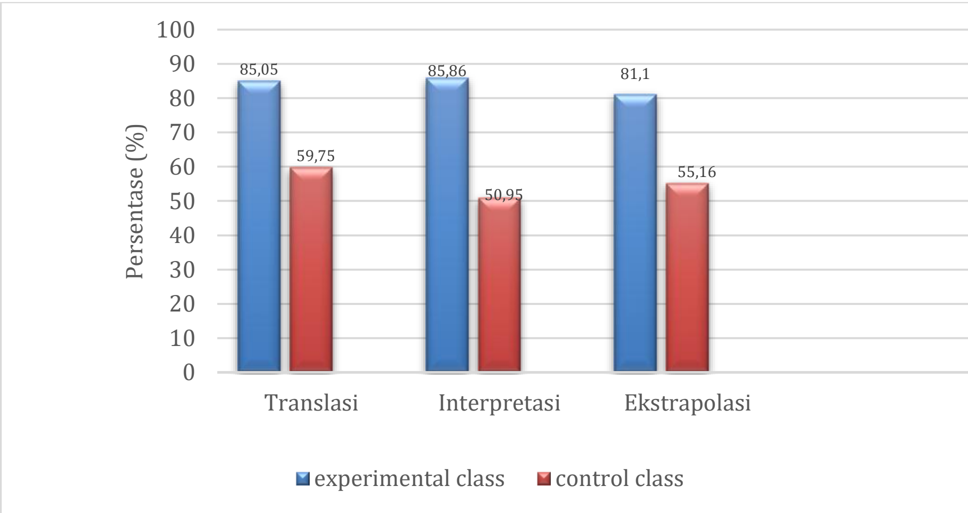


**Figure 1.** Comparison of Students' Conceptual Understanding Based on Indicators

The graphical comparison clearly illustrates that the experimental class consistently achieved higher percentages across all indicators. The largest gap between the two groups occurred in the interpretation indicator, indicating that contextual learning through the SETS model strongly supported students' ability to interpret and explain scientific information.

3.1.3 Inferential Statistical Analysis

Before conducting hypothesis testing, prerequisite analyses including normality and homogeneity tests were performed. The Shapiro–Wilk normality test indicated that the posttest scores in both the experimental and control groups were normally distributed because the significance values exceeded 0.05. In addition, Levene's homogeneity test showed a significance value of 0.104, indicating that the variances of the two groups were homogeneous.

After the statistical assumptions had been fulfilled, hypothesis testing was conducted using the Independent Samples t-test. The analysis revealed a significance value (Sig. 2-tailed) of 0.000, which was lower than the significance level of 0.05. Therefore, the null hypothesis (H0) was rejected, and the alternative hypothesis (H1) was accepted. This finding confirms that there was a statistically significant difference in conceptual understanding between students taught using the SETS learning model and those taught using conventional learning. The inferential analysis supports the descriptive findings that the SETS learning model significantly improved students' conceptual understanding. The combination of contextual issues, collaborative learning, and active student participation contributed positively to students' learning outcomes.

### 3.2 Discussion

The findings of this study demonstrate that the implementation of the SETS learning model significantly improved students' conceptual understanding of energy resources. Students who participated in SETS-based learning achieved higher scores in all conceptual understanding indicators compared to students who experienced conventional learning. These findings indicate that contextual and student-centered learning approaches are more effective in supporting conceptual learning in physics. One of the main strengths of the SETS learning model lies in its ability to connect scientific concepts with real-life situations. In this study, students were encouraged to discuss issues related to renewable energy, environmental sustainability, technological developments, and societal impacts. Such contextual learning experiences enabled students to understand the relevance of physics concepts to their daily lives. Consequently, students became more motivated and actively engaged in the learning process.

The results are consistent with constructivist learning theory, which states that knowledge is actively constructed through interaction and experience. In SETS-based learning, students were not passive recipients of information. Instead, they actively explored problems, discussed ideas, analyzed environmental phenomena, and proposed solutions. Through these activities, students constructed conceptual understanding independently and collaboratively. The high achievement in the translation indicator indicates that students became more capable of interpreting scientific information presented in different forms. During the learning activities, students analyzed graphs of energy consumption, interpreted diagrams of renewable energy systems, and discussed environmental data related to energy use. These activities trained students to connect abstract scientific concepts with concrete representations.

The interpretation indicator also showed excellent performance in the experimental class. Students demonstrated improved abilities in explaining relationships among concepts and interpreting scientific phenomena. This improvement can be attributed to the inquiry and discussion activities embedded in the SETS learning process. By engaging with contextual issues, students developed deeper understanding and were able to explain concepts more meaningfully. Meanwhile, the extrapolation indicator obtained slightly lower scores than the other indicators because it required higher-order cognitive skills. Students needed to apply concepts to unfamiliar situations, predict future consequences, and draw conclusions based on scientific reasoning. Although more challenging, the SETS learning model still produced significantly higher extrapolation scores than conventional learning. This suggests that contextual learning environments support students' analytical and predictive thinking skills.

The findings also indicate that conventional learning methods were less effective in improving conceptual understanding. In the control class, learning activities were dominated by teacher explanations and textbook-based instruction. Students had limited opportunities to discuss, explore, or relate concepts to real-world contexts. As a result, their conceptual understanding remained relatively low. The superiority of the SETS learning model can also be explained through the meaningful learning theory proposed by Ausubel. According to this theory, learning becomes meaningful when new information is connected to students' prior knowledge and experiences. The SETS model facilitated this process by integrating environmental and societal issues familiar to students. Consequently, students were able to retain and apply concepts more effectively.

Furthermore, the SETS learning model contributed not only to cognitive development but also to students' awareness of environmental and societal issues. During the learning process, students discussed the environmental impacts of fossil fuel consumption, the importance of renewable energy, and the role of technology in sustainable development. Such discussions encouraged students to think critically about real-world problems and increased their scientific literacy. These findings are supported by previous studies. Widiantini et al. (2020) reported that SETS-based learning significantly improved students' science competencies through contextual and technology-supported learning activities. Similarly, Rohmatun and Rasyid (2022) found that the SETS learning model enhanced students' conceptual understanding and learning motivation. Other studies also revealed that SETS learning positively affects students' critical thinking and problem-solving skills. In addition, the collaborative activities integrated into the SETS model contributed to students' conceptual understanding. Students worked in groups to discuss environmental problems, analyze energy-related cases, and present their findings. Such collaborative learning activities promoted communication, argumentation, and reflective thinking, which are important components of conceptual learning. The implementation of the SETS learning model in this study also aligns with the goals of 21st-century education. Modern education emphasizes the development of critical thinking, creativity, communication, collaboration, and scientific literacy. Through contextual and interdisciplinary learning activities, the SETS model helps students develop these competencies while simultaneously improving conceptual understanding.

Although the findings of this study demonstrate the effectiveness of the SETS learning model, several limitations should be acknowledged. First, the study involved a relatively limited number of participants from a single school, which may affect the generalizability of the findings. Second, the research focused only on conceptual understanding without examining other important variables such as critical thinking skills, problem-solving abilities, or learning motivation. Future studies are recommended to involve larger and more diverse samples to obtain broader insights into the effectiveness of the SETS learning model. Researchers may also investigate the integration of SETS with digital learning technologies, project-based learning, or inquiry-based learning approaches. Furthermore, future research could explore the long-term impact of SETS-based learning on students' scientific literacy and environmental awareness.

Overall, the results of this study indicate that the SETS learning model is an effective and innovative approach for improving students' conceptual understanding in physics learning. By connecting science with environmental, technological, and societal contexts, the SETS model creates meaningful learning experiences that encourage active participation, critical thinking, and contextual understanding. Therefore, the SETS learning model can be recommended as an alternative instructional strategy for physics teachers, particularly in teaching topics related to energy resources and environmental issues.

## 4 Conclusion

Based on the results and discussion of this study, it can be concluded that the implementation of the Science, Environment, Technology, and Society (SETS) learning model significantly improves senior high school students' conceptual understanding of energy resources in physics learning. The SETS learning model proved to be more effective than conventional learning methods in facilitating students to understand physics concepts in a more meaningful, contextual, and comprehensive manner.

The descriptive analysis showed that students taught using the SETS learning model achieved higher average conceptual understanding scores compared to students taught through conventional instruction. Most students in the experimental class reached the good and very good categories, whereas students in the control class were generally categorized as fair. These findings indicate that contextual learning activities integrating science with environmental, technological, and societal issues can enhance students' understanding of physics concepts more effectively.

The results based on conceptual understanding indicators also demonstrated that the SETS learning model positively influenced students' abilities in translation, interpretation, and extrapolation. The highest achievement was found in the interpretation indicator, suggesting that students became more capable of explaining scientific phenomena and interpreting information after participating in SETS-based learning activities. Meanwhile, the extrapolation indicator showed relatively lower achievement because it required higher-order thinking skills such as predicting, concluding, and applying concepts to new situations.

Nevertheless, students in the experimental class still performed better than those in the control class on this indicator.

Inferential statistical analysis using the Independent Samples t-test revealed a significance value below 0.05, confirming that there was a statistically significant difference between the experimental and control groups. Therefore, the hypothesis stating that the SETS learning model affects students' conceptual understanding was accepted. The findings of this study imply that the SETS learning model can be used as an effective alternative instructional strategy in physics learning, especially for topics related to environmental and technological issues such as energy resources. By connecting scientific concepts with real-life contexts, the SETS approach encourages active participation, critical thinking, and meaningful learning experiences among students.

Although this study produced positive findings, several limitations remain. The research involved a limited number of participants from a single school and focused only on conceptual understanding. Future studies are recommended to involve larger samples and investigate other variables such as critical thinking skills, problem-solving abilities, scientific literacy, and learning motivation.

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