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Effects of a Dual Space Inquiry Based E-Module on Students' Learning Outcomes in Work and Energy

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ABSTRACT

Learning outcomes are one indicator of successful learning, influenced by the use of appropriate instructional models and teaching materials. However, teaching physics on the topic of Work and Energy still faces various challenges, particularly in helping students understand abstract concepts. One approach to addressing this issue is through the use of Dual Space Inquiry-based e-modules that integrate inquiry activities in both digital and real-world learning environments. This study aims to analyze the effect of Dual Space Inquiry-based e-modules on student learning outcomes in the topic of Work and Energy. This study employed a quantitative method using a posttest-only control group design. The sample consisted of 76 tenth-grade students at SMA N 4 Padang, divided into an experimental class and a control class. Learning outcome data were obtained through a posttest and analyzed using appropriate statistical tests. The results showed that students who learned using the Dual Space Inquiry-based e-module achieved better learning outcomes than those in the control class. These findings indicate that the Dual Space Inquiry-based e-module can serve as an innovative teaching resource that supports physics learning and helps improve students' learning outcomes in the topic of Work and Energy.

INTRODUCTION

Educational developments in the 21st century have been strongly influenced by the rapid digital transformation of the learning process. This transformation has changed the patterns of interaction among teachers, students, and learning resources (Banarsari et al., 2023; Yuliandari et al., 2023). The changes are not limited to the transition from conventional media to digital media. They also involve the reconstruction of the learning ecosystem, which requires technology to be integrated effectively into pedagogical practices (Rum et al., 2025; Schellinger et al., 2019). In physics education, this condition highlights the need for adaptive and interactive digital learning models that can help students understand abstract concepts.

Digital technology plays an important role in learning because it expands students' access to diverse learning resources and enables learning activities to occur beyond the limitations of time and place. Its interactive features can encourage active participation, collaboration, and learning motivation, making the learning process more engaging and student-centered (Aliyah & Masyithoh, 2024; Sari & Munir, 2024). Digital platforms also enable teachers to provide more flexible, personalized, and adaptive learning experiences according to students' needs and learning pace (Sari & Munir, 2024). In constructivist learning, digital technology facilitates students' exploration, experimentation, and independent construction of knowledge through multimedia resources and online learning environments (Lathifah, 2024). The pedagogically appropriate and purposeful integration of digital technology into the learning process is essential for improving the overall effectiveness, efficiency, and quality of learning in the digital era.

Various studies indicate that teaching practices in schools are still largely dominated by conventional, teacher-centered approaches (Dewi et al., 2023; Nurmahmuddin et al., 2023; Usmeldi & Amini, 2022). This condition tends to limit students' active involvement in the learning process. As a result, students often show low participation and weak mastery of concepts, including higher-order thinking skills (Mulia et al., 2021; Yandi et al., 2023). In many classrooms, learning remains one-directional, so students do not have enough opportunities to construct knowledge independently.

In physics education, the topics of work and energy present considerable challenges for students. These concepts are abstract, involve mathematical relationships, and require students to visualize real-world phenomena (Ansar et al., 2026; Nasir et al., 2025). Misconceptions may arise when students have difficulty connecting mathematical representations with observable physical events (Herdiana et al., 2021). Limited access to interactive and visual learning media can further hinder students' conceptual understanding.

In line with these developments, e-modules have emerged as one of the innovations in digital learning media with great potential to support self-directed and structured learning. E-modules not only present material systematically but also allow for the integration of various multimedia features, simulations, and interactive activities that can enhance students' learning experiences (Gaol & Tampubolon, 2022; Novitasari et al., 2022). These characteristics make e-modules particularly relevant for physics education, which requires the visualization of concepts and step-by-step problem-solving practice. Several studies have also shown that the use of e-modules can increase student engagement and improve cognitive learning outcomes, especially when combined with technologies such as PhET simulations (Ansar et al., 2026; Azis & Ariani, 2025). However, most of these studies still focus on the instructional media aspect and have not yet fully integrated it with inquiry-based pedagogical models.

The inquiry-based learning model has long been regarded as an effective approach for enhancing critical thinking skills and conceptual understanding in science education (Arisa et al., 2022; Asrizal & Festiyed, 2020). Inquiry-based learning provides students with the opportunity to construct knowledge through scientific stages such as observation, experimentation, data analysis, and drawing conclusions (Madi et al., 2026). Nevertheless, the application of inquiry in various studies still tends to be separate from technology-based learning systems, thus failing to fully optimize the potential for integrating digital learning environments. In the context of technology utilization, various studies on blended learning and e-learning indicate that technology integration can enhance the quality of learning, particularly in terms of flexibility and accessibility (Chen et al., 2025; Wiyono et al., 2022).

However, blended learning models still tend to separate online and in-person learning experiences, so the interaction between the two has not yet been simultaneous or pedagogically integrated. This situation represents one of the significant limitations encountered in the current development and implementation of digital-based learning.

In response to these limitations, Dual Space Inquiry (DSI), developed by Novitra et al.(2025, 2026), emerges as an innovative learning framework that simultaneously integrates online and offline learning spaces at every stage of the inquiry process. Unlike blended learning, which merely combines the two spaces structurally, DSI emphasizes the functional interconnection between these two spaces within a cohesive learning system. Consequently, the learning process is not fragmented but proceeds seamlessly between digital and face-to-face activities. In its implementation, DSI consists of the stages of orientation, conceptualization, exploration, conclusion, and reflection, which are not only carried out sequentially but also occur in parallel across both learning spaces. This integration allows students to access various digital learning resources such as simulations, instructional videos, and learning management systems (LMS) while simultaneously conducting hands-on experiments in the classroom (Chen et al., 2025). This approach provides a richer learning experience because students can construct concepts through a combination of virtual exploration and empirical experiences.

Thus, DSI is not merely understood as a combination of two forms of learning, but as a learning design system that simultaneously integrates technological and pedagogical dimensions to support a more meaningful inquiry process. This approach has the potential to enhance the quality of understanding of physics concepts because it provides space for students to construct knowledge through various complementary representations and learning experiences. Although various studies have demonstrated the effectiveness of e-modules, inquiry-based learning, and digital technology separately, there remains a significant research gap regarding the integration of all three within a single integrated learning framework. To date, few studies have simultaneously examined the implementation of guided-inquiry-based e-modules within the Dual Space Inquiry framework to enhance cognitive learning outcomes in the topic of work and energy. This gap highlights the need to develop a more holistic, structured, and integrated learning model.

The novelty of this study lies in the development of a Dual Space Inquiry-based e-module that integrates digital and face-to-face learning into a single, integrated inquiry system to enhance students' cognitive learning outcomes. This approach not only combines learning media and models but also unifies them within a systematic instructional design grounded in multidimensional learning experiences. Based on the issues outlined above, this study focuses on analyzing the effect of Dual Space Inquiry-based e-modules on students' cognitive learning outcomes in the subject of work and energy, as well as determining the magnitude of the effect of using Dual Space Inquiry-based e-modules on students' cognitive learning outcomes. The purpose of this study is to analyze the effect of Dual Space Inquiry-based e-modules on students' cognitive learning outcomes in the subject of work and energy. Meanwhile, the theoretical benefits of this study are expected to enrich research on the development of digital and inquiry-based learning models in physics education. Practically, this study is expected to serve as an innovative and useful teaching resource for teachers in improving the overall quality of physics instruction, as well as in helping students understand abstract physics concepts more easily, clearly, and meaningfully.

METHODS

Method and Design of Research

This study employs a quantitative approach because the research data consists of numerical values analyzed using statistical techniques (Sugiyono, 2019). A quasi-experimental method was used to examine the effect of the treatment on students' learning outcomes. This design was selected because the researcher could not fully randomize the participants or control all external variables. Nevertheless, the research design still allowed the researcher to systematically compare the learning outcomes of the experimental and control groups under relatively similar learning conditions.

The research design used was a posttest-only control design. This design consisted of two groups: an experimental class and a control class, neither of which was selected through full randomization. The experimental class received an intervention in the form of learning using an e-module based on Dual Space Inquiry, while the control class received no special intervention and followed the conventional teaching methods typically used by teachers at the school. The research design is presented in Table 1.

Table 1. Design of Research

Group	Treatment	Posttest
Experiment	X	O_1
Control	$-$	O_2

(Sugiyono, 2019)

This study was conducted at SMA Negeri 4 Padang during the 2025–2026 academic year. The research procedure consisted of three stages: planning, implementation, and completion. During the planning stage, the researcher prepared a Dual Space Inquiry-based e-module and developed the lesson plans. The researcher also carefully prepared and validated a set of multiple-choice test items designed to accurately measure students' cognitive learning outcomes on the topic of work and energy.

During the implementation stage, the experimental and control classes received different treatments based on the research design. The experimental class learned using the Dual Space Inquiry-based e-module, which integrated digital and face to face learning activities throughout the inquiry process. In contrast, the control class followed the conventional teaching method commonly used by the physics teacher. After the learning activities were completed, both classes took a posttest, and the results were statistically analyzed to determine the effect of the e-module on students' cognitive learning outcomes.

Participants

The population in this study consisted of all tenth-grade students at SMA Negeri 4 Padang in the 2025/2026 academic year who were studying physics on the topic of work and energy. The total population was distributed into several classes. The research sample was selected using a purposive sampling technique, which is a sampling method based on specific considerations or criteria (Sugiyono, 2019). The criteria used in selecting the sample included classes with relatively similar academic achievement and taught by the same physics teacher to ensure comparability between groups. Based on these criteria, class X E6 was selected as the experimental class, which received learning using the e-module based on Dual Space Inquiry, while class X E5 was designated as the control class, which received conventional learning without the use of the e-module.

Data Analysis

The data in this study were analyzed using descriptive and inferential statistics. Descriptive analysis was used to describe the cognitive learning outcomes of students in the experimental and control classes based on their posttest scores on the topic of work and energy. Furthermore, inferential analysis was used to test the research hypothesis regarding the effect of the Dual Space Inquiry-based e-module on students' cognitive learning outcomes. Before testing the hypotheses, prerequisite tests were conducted, including normality and homogeneity tests. The normality test aimed to determine whether the data came from a normally distributed population. In this study, the normality test was conducted using the Shapiro-Wilk test with the following formula (Uyanto, 2019).

$$W = \frac{(\sum_{i=1}^{n} a_i x_i)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Homogeneity test is done to find out if the variances of the two sample groups are similar. In this study, the homogeneity of variance test was conducted using Levene's test to determine whether the data from both groups had equal variances. The statistical formula used for Levene's test is presented as follows. (Supriadi, 2021).

$$W = \frac{(n-k)\sum_{i=1}^{k} n_i(\bar{Z}_i - \bar{Z})^2}{(k-1)\sum_{i=1}^{k}\sum_{j=1}^{n_i}\left(Z_{ij} - \bar{Z}_i\right)^2}$$

After both prerequisite tests were met, hypothesis testing was conducted using the t-test (independent samples t-test). This test was used to determine whether there was a significant difference between the mean learning outcomes of students in the experimental class, which used the Dual Space Inquiry-based E-Module, and the control class, which used conventional instruction. This test is a parametric statistical test that requires the data to be normally distributed and homogeneous (Fauzi, 2023). The decision-making criteria in hypothesis testing are as follows: if the significance value (Sig.) is < 0.05, then the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, which means that the use of the Dual Space Inquiry-based E-Module has an effect on students' learning outcomes. Conversely, if the significance value is ≥ 0.05, the null hypothesis (H_0) is accepted and the alternative hypothesis (H_1) is rejected. The value of the t-test statistic was calculated using the following statistical formula.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_{gab}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

To determine the combined standard deviation (S_{gab}), you can use the following equation

$$S_{gab} = \sqrt{\frac{(n_1 - 1){S_1}^2 + (n_2 - 1){S_2}^2}{(n_1 + n_2 - 2)}}$$

The data analysis in this study was conducted in several systematic stages. First, descriptive statistics were used to summarize the posttest scores of the experimental and control groups. Next, normality and homogeneity tests were performed to determine whether

the data met the assumptions required for parametric analysis. After these assumptions were fulfilled, an independent-samples t-test was used to examine the effect of the treatment on students' learning outcomes.

RESULTS AND DISCUSSION

Results

This study was conducted over five weeks, with each sample class consisting of five sessions. The purpose of this study was to collect data on the cognitive learning outcomes of students in the experimental class, which used an E-Module based on Dual Space Inquiry, and the control class, which used conventional instruction. Learning outcomes were assessed through a posttest after the entire learning process was completed.

Table 2. Posttest Results of the Experiment and Control

Statistical Data	Class	
	Experiment	Control
Number of Students (N)	38	38
Ideal Score	80	80
Highest Score	100	95.45
Lowest Score	59.09	59.09
Average	82.53	76.67
Variance	133.48	88.40
Standard Deviation	9.40227	11.55325

Based on Table 2, the experimental and control classes each consisted of 38 students, indicating that both groups had equal sample sizes. The identical ideal scores show that the same scoring standard was applied to both classes. The experimental class obtained a higher maximum score than the control class, with some students achieving the maximum score of 100. The mean posttest score of the experimental class was also higher than that of the control class. These descriptive results indicate that students who learned using the Dual Space Inquiry-based E-Module achieved better learning outcomes than those who received conventional instruction. The same minimum score in both classes indicates that low-scoring students were present in each group. However, this result cannot be used to conclude that the students had equivalent initial abilities because the study did not administer a pretest. Variance and standard deviation describe how widely the students' scores were distributed around the mean. A smaller standard deviation indicates that the scores were more consistent, whereas a larger value indicates greater variation among students. Overall, the descriptive findings suggest a positive difference in favor of the experimental class, although statistical testing is still required to determine whether the difference is significant.

The distribution of posttest scores of students in the experimental class is presented in Figure 1. The data are displayed in the form of a histogram and frequency polygon to provide an overview of the score distribution across each class interval as well as the variation in students' learning outcomes after participating in learning using the Dual Space Inquiry-based E-Modul. Through this visual representation, the overall pattern of students' score distribution can be more clearly identified as preliminary information that supports the subsequent analysis of learning outcomes presented in the discussion section.

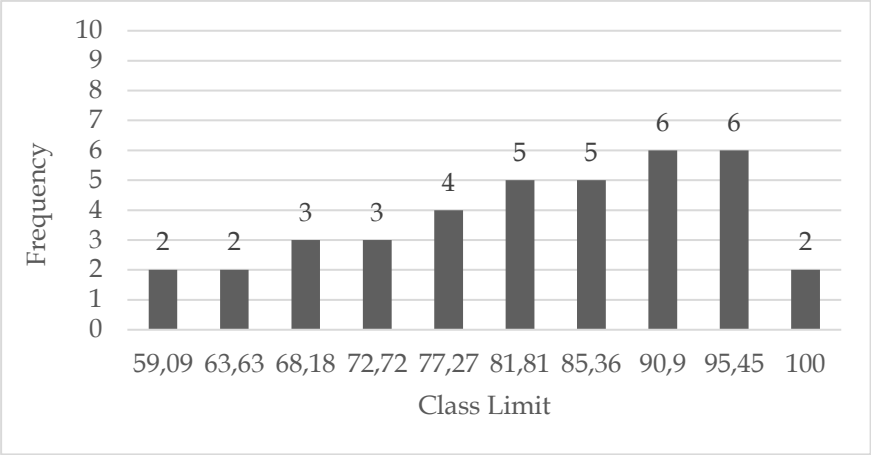

Figure 1. Histogram and Polygon of Posttest Scores for the Experimental Class

Based on Figure 1, the distribution of posttest scores for students in the experimental class after participating in learning using the Dual Space Inquiry-based E-Module shows that the scores tend to be concentrated in the middle-to-high range. The students' scores ranged from 59.09 to 100, indicating that the learning outcomes varied among students after the treatment. The highest frequencies occurred at scores of 90.90 and 95.45, each achieved by 6 students, followed by scores of 81.81 and 86.36, each achieved by 5 students. In addition, 4 students obtained a score of 77.27, while 3 students each obtained score of 68.18 and 72.72. Scores of 59.09, 63.63, and 100 were each achieved by 2 students. This distribution pattern indicates that most students achieved relatively high learning outcomes after using the Dual Space Inquiry-based E-Module.

Most students' scores were in the range of 81.81 to 100, with 24 of the 38 students achieving scores within this interval. The concentration of scores in the higher range indicates that the majority of students demonstrated a good understanding of the concepts of work and energy. However, several students still obtained scores below 70, showing that some students may have experienced difficulties in understanding certain concepts. The structured inquiry activities and the integration of digital and face-to-face learning spaces may have supported students in exploring and constructing physics concepts more actively. Overall, the distribution of students' scores, which was predominantly concentrated in the middle-to-high range, indicates that the implementation of the Dual Space Inquiry-based E-Module made a positive contribution to students' learning outcomes in the experimental class.

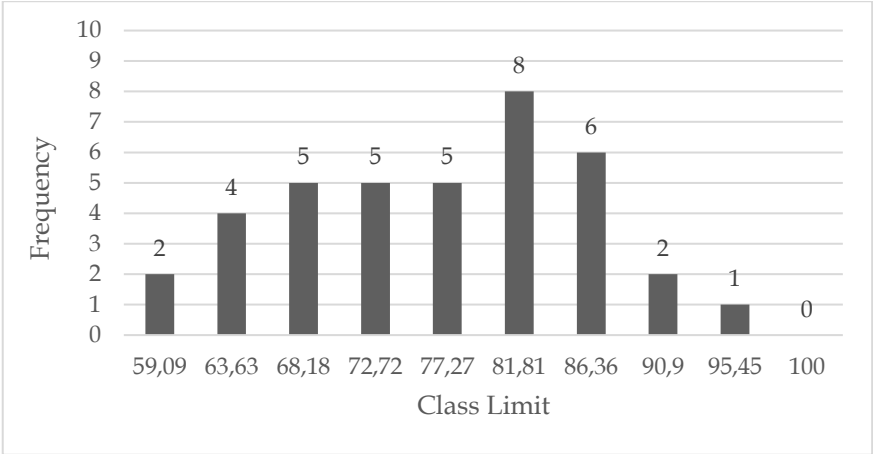

Figure 2. Histogram and Polygon of Posttest Scores for the Control Class

Figure 2 shows the distribution of posttest scores for students in the control class after participating in instruction using the conventional method. Based on the histogram, student scores ranged from 59.09 (achieved by 2 students), 63.63 (by 4 students), 68.18 (by 5 students), 72.72 (by 5 students), 77.27 by 5 students, 81.81 by 8 students, 86.36 by 6 students, 90.90 by 2 students, and 95.45 by 1 student. This distribution shows that the highest frequency is at the score of 81.81, indicating that the majority of students fall into the medium-achievement category. Although some students achieved high scores, their number is relatively smaller compared to the experimental class. In addition, there were still students in the low-score category, indicating that the distribution of learning outcomes in the control class was more varied and not overly concentrated in high scores. Overall, the distribution of students' scores in the control class indicated that their learning outcomes generally tended to fall within the moderate category and were spread across a broader range, suggesting that the equity of learning outcomes was not as optimal as that observed in the experimental class.

After the posttest data from the experimental and control classes were obtained, the next step was to analyze the data using prerequisite tests, which consisted of a normality test and a homogeneity test. The normality test was performed using the Shapiro-Wilk test at a significance level of $\alpha < 0.05$. This test aims to determine whether the research data obtained from both classes are normally distributed or not, so that the suitability of using parametric statistical tests in the next stage can be determined. The results of the normality test are presented in full in Table 3. Next, a homogeneity test was conducted to determine whether the variances of the data between the experimental and control classes were equal. This homogeneity test is essential as one of the prerequisites for using the independent samples t-test, ensuring that the results of the analysis have a higher level of statistical validity. The results of the homogeneity test are presented in Table 3.

Based on the results of these two prerequisite tests, it can be concluded that the posttest data from the experimental and control classes met the statistical assumptions, namely that they were normally distributed and had homogeneous variances. With these two assumptions met, the analysis could proceed to the hypothesis testing stage using the independent samples t-test. Hypothesis testing was conducted to determine whether there was a significant difference between the learning outcomes of students in the experimental and control classes. The results of the hypothesis test are presented in Table 3. Based on these results, the p-value was found to be less than $\alpha < 0.05$; therefore, H_1 was accepted and H_0 was rejected. This indicates that there is a significant difference in learning outcomes between the two classes compared in this study. The results obtained from the assumption and hypothesis testing procedures are presented in detail in Table 3.

Table 3. Results of Assumption and Hypothesis Testing

Statistical Test	Class	N	Statistics	Sig.	Information
Shapiro–Wilk normality test	Experiment class	38	0.959	0.180	Normal
Shapiro–Wilk normality test	Control class	38	0.944	0.055	Normal

Statistical Test	Class	N	Statistics	Sig.	Information
Levene's homogeneity test	Experiment and control classes	76	-	0.195	Homogeneous data
Independent-samples t-test	Experiment and control classes	76	-	0.018	H_1 is accepted and H_0 is rejected

Based on Table 3, the Shapiro–Wilk normality test produced significance values of 0.180 for the experimental class and 0.055 for the control class. Both values were greater than the significance level of 0.05, indicating that there was insufficient statistical evidence to reject the assumption of normality in either group. The Shapiro–Wilk statistics were 0.959 for the experimental class and 0.944 for the control class, with values relatively close to 1. This suggests that the observed score distributions showed a reasonably good correspondence with a normal distribution. Although the significance value of the control class was only slightly above 0.05, it still satisfied the predetermined normality criterion. The posttest data obtained from both the experimental and control classes were consequently considered appropriate and suitable for further analysis using parametric statistical procedures.

The Levene's homogeneity test produced a significance value of 0.195, which was greater than 0.05. This result indicates that there was no statistically significant evidence of a difference between the variances of the experimental and control classes. Accordingly, the variability of posttest scores in the two groups could be treated as relatively comparable for the purpose of statistical testing. The fulfillment of this assumption is important because the independent-samples t-test compares the mean scores of two groups under the assumption that their variances are sufficiently similar. Together with the normality test results, the Levene's test result confirmed that the posttest data met the main assumptions required for applying the independent-samples t-test. The difference in the mean learning outcomes between the two classes could then be further examined using the appropriate parametric test with an adequate level of statistical validity and reliability.

The experimental and control classes each consisted of 38 students. The results of the independent-samples t-test showed a significance value (Sig. 2-tailed) of 0.018. Since this significance value was lower than the significance level of 0.05 ($0.018 < 0.05$), H_0 was rejected and H_1 was accepted. This result indicates that there was a statistically significant difference between the learning outcomes of students in the experimental class and those in the control class. The difference suggests that the use of the Dual Space Inquiry-based E-Module affected the cognitive learning outcomes of tenth-grade students at SMA Negeri 4 Padang on the topic of work and energy. The higher mean score obtained by the experimental class indicates that the Dual Space Inquiry-based E-Module was more effective in improving students' learning outcomes than the conventional instruction used in the control class.

Discussion

The results of the study show that the use of Dual Space Inquiry (DSI)-based e-modules has a significant effect on students' learning outcomes in the topic of Work and Energy. This was demonstrated through hypothesis testing using an independent samples t-test, which yielded a Sig. (2-tailed) value of 0.018 smaller than the significance level of 0.05. Thus, H_0 is rejected and H_1 is accepted, indicating a significant difference in learning outcomes between students who learned using Dual Space Inquiry-based e-modules and those who learned

through conventional instruction. These findings suggest that the implementation of Dual Space Inquiry-based e-modules is more effective at improving students' cognitive learning outcomes than instruction that does not use these e-modules.

Improvements in student learning outcomes can be explained by the characteristics of Dual Space Inquiry, which integrates digital learning spaces (online spaces) and real-world learning spaces (offline spaces) into a single, interconnected learning system (Novitra et al., 2025). This integration allows students to have a more flexible learning experience without compromising the scientific inquiry process, which is at the core of learning. Through the stages of orientation, conceptualization, exploration, conclusion, and reflection, students are encouraged to construct knowledge through activities such as observation, inquiry, data analysis, and drawing conclusions based on evidence gathered during the learning process. Learning activities centered on the process of discovering concepts have been shown to enhance students' conceptual understanding and learning outcomes because students play an active role in constructing their own knowledge (Arisa et al., 2022; Nadira et al., 2026). This is evident during the learning process when students not only receive explanations from the teacher but also engage in exploring various learning resources available in the e-module and connecting them to the phenomena being studied.

In addition to being influenced by the instructional model used, improved learning outcomes are also supported by the characteristics of e-modules as digital instructional materials capable of facilitating self-directed learning. E-modules are designed to present content in a systematic, structured, and easily accessible manner so that students can learn according to their individual needs and learning pace (Novitasari et al., 2022). The use of various multimedia features, such as images, videos, and interactive activities, also enhances student engagement in the learning process and helps explain concepts that are difficult to grasp through verbal explanations alone (Azis & Ariani, 2025). These advantages provide students with the opportunity to review material, explore additional information, and practice independently, thereby improving their conceptual understanding. This aligns with previous findings indicating that the use of e-modules can improve student learning outcomes in the subject of Work and Energy because they create a more interactive and flexible learning experience (Ansar et al., 2026; Gaol & Tampubolon, 2022).

The positive impact of DSI-based e-modules on learning outcomes can also be attributed to the characteristics of the Work and Energy material, which requires strong visualization skills and conceptual understanding. Physics material is often considered difficult because students must be able to connect mathematical representations with physical phenomena that occur in everyday life (Nasir et al., 2025). These difficulties have the potential to lead to misconceptions if students merely receive information passively without engaging in in-depth exploration of the concepts. Limited ability to understand abstract concepts may also be influenced by the limitations of the instructional media used to clearly visualize physical phenomena (Herdiana et al., 2021). Through the Dual Space Inquiry-based e-module, students have the opportunity to learn the concepts of work and energy through various representations such as text, images, videos, and inquiry activities that are integrated with one another. Consequently, students can more easily connect theoretical concepts with real-world phenomena, leading to a stronger conceptual understanding.

The results of this study are consistent with various previous studies showing that inquiry-based learning can improve students' learning outcomes. Inquiry-based learning provides students with the opportunity to construct knowledge through observation,

experimentation, data analysis, and drawing conclusions, thereby making the learning process more meaningful (Arisa et al., 2022). Students' active engagement in the inquiry process also contributes to improved conceptual understanding and scientific thinking skills (Nadira et al., 2026). In the "Work and Energy" unit, the application of the Inquiry Training model was shown to significantly improve student learning outcomes because students were encouraged to discover concepts through a systematic investigative process (Madi et al., 2026). Similar results were also found in the implementation of guided inquiry, where students' active engagement during the learning process had a positive impact on improved learning outcomes (Ritonga & Istiyono, 2023). The consistency of these findings reinforces the hypothesis that the success of learning in the experimental class is influenced by students' active engagement in the process of discovering and constructing the concepts being studied.

In addition to reinforcing findings regarding the effectiveness of inquiry-based learning, the results of this study also support various studies that emphasize the importance of integrating technology into science education. The use of technology in inquiry-based learning can increase student engagement while expanding their opportunities to explore various learning resources independently (Schellinger et al., 2019). The integration of technology and inquiry activities has also been shown to contribute to improved science literacy and conceptual mastery among students by providing richer and more contextual learning experiences (Chen et al., 2025). In this study, technology serves not only as a medium for delivering content but also as a tool that supports the implementation of each stage of inquiry through e-modules designed in accordance with the characteristics of Dual Space Inquiry. This effective integration of technology and pedagogy enables the development of a more interactive, engaging, and student-centered learning process.

The findings of this study are also relevant to the demands of 21st-century education, which emphasize the importance of utilizing digital technology in learning. Digital transformation in education calls for learning innovations that can integrate technology with effective learning strategies so that students can learn more flexibly and independently (Banarsari et al., 2023; Yuliandari et al., 2023). Technology-based learning is known to enhance accessibility, flexibility, and the quality of students' learning experiences (Nkechi, 2020; Rum et al., 2025; Wiyono et al., 2022). Through the use of Dual Space Inquiry-based e-modules, students can access learning resources both inside and outside the classroom without being constrained by the time and place of learning. This level of flexibility provides students with broader and more meaningful opportunities to further deepen their conceptual understanding, thereby contributing to improved learning outcomes.

Although the results of this study support various previous findings regarding the effectiveness of e-modules and inquiry-based learning, this study makes a distinct contribution compared to previous research. Most previous studies examined the effectiveness of e-modules, inquiry-based learning, or digital technology separately. In contrast, this study integrates these three aspects through the implementation of e-modules based on the Dual Space Inquiry framework. The integration of online and in-person learning spaces within a single, cohesive inquiry cycle enables students to gain a more comprehensive learning experience compared to approaches that focus solely on one aspect. Thus, the novelty of this study lies not only in the use of e-modules as digital teaching materials but also in the application of the Dual Space Inquiry framework as a learning system that simultaneously connects digital and face-to-face learning activities. These findings indicate that Dual Space

Inquiry-based e-modules have the potential to serve as an innovative alternative for improving physics learning outcomes, particularly in the topic of Work and Energy.

CONCLUSION

The implementation of the Dual Space Inquiry-based E-Module contributes positively to improving students' learning outcomes in the topic of Work and Energy. The integration of digital learning resources with inquiry activities encourages students to actively construct knowledge through exploration, investigation, and reflection, resulting in a deeper understanding of concepts. The use of interactive and flexible learning materials also supports students in connecting abstract physics concepts with real-world phenomena, making learning more meaningful and engaging. This study highlights that the combination of e-modules and the Dual Space Inquiry framework provide a learning environment that integrates online and offline learning experiences within a unified inquiry process. This integration not only supports students' conceptual understanding but also offers an innovative approach to physics learning in the digital era. Therefore, the Dual Space Inquiry-based E-Module can serve as an alternative learning resource to support the improvement of students' learning outcomes, particularly in learning physics concepts that require strong conceptual understanding and visualization.

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