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Effect of Dual Space Inquiry E-Student Worksheet on Improving Physics Learning Outcomes in Temperature and Heat Material

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ABSTRACT

Low student learning outcomes on the topics of temperature and heat indicate the need for learning materials that can increase student engagement in the learning process. Ideally, physics learning can facilitate students to actively construct knowledge through inquiry activities supported by the use of technology. One solution that can be applied is Dual Space Inquiry E-Student Worksheet, which integrates online and offline learning activities. This study aims to find out the effect of using Dual Space Inquiry E-Student Worksheet on the physics learning outcomes of 11th-grade students at SMA Negeri 1 Pancung Soal for the 2025/2026 academic year. This study used a quasi-experimental method with a posttest-only control group design. The research population consisted of 207 students, with classes XI F1 and XI F2 purposively selected as the sample. Learning outcome data were collected through objective tests and analyzed using a t-test. The analysis results showed a significance value of 0.047 < 0.05, so H_1 is accepted. The study's findings indicate that using a Dual Space Inquiry E-Student Worksheet has a significant effect on students' learning outcomes. These results suggest that integrating online and offline learning spaces can create a more meaningful learning experience, increase student participation, and strengthen understanding of concepts in the topics of temperature and heat. The implication of this research is that Dual Space Inquiry E-Student Worksheet can be used as an innovative teaching material alternative to support more effective physics learning that meets the demands of digital-era education.

INTRODUCTION

Education plays an important role in improving the quality of human resources who can adapt to rapidly developing science and technology (Adha & Wahyuni, 2020). Therefore, learning that involves student activity can help them understand concepts more deeply and retain knowledge for a longer period of time (Sari et al., 2022). In physics learning, this goal can be reflected through students' learning outcomes, which show their level of concept

mastery and their ability to apply concepts to solve various problems. Learning outcomes are one of the important indicators to assess the success of the learning process that has been carried out (Noviwati et al., 2023). Even though various efforts have been made to improve the quality of learning, students' physics learning outcomes still show achievements that are not yet optimal (Hartono, 2022). This condition shows that improving physics learning outcomes is still an important concern in the world of education.

However, learning outcomes in physics remain a challenge in many schools. Previous studies reported that students' physics learning outcomes are still relatively low, particularly in topics that require conceptual understanding and scientific reasoning (Mutiasih, 2022). Similar conditions were identified at SMA Negeri 1 Pancung Soal, where the average scores of Grade XI students in the Physics Mid-Semester Examination were below the school's minimum mastery criterion. Classroom observations and interviews with physics teachers further revealed that learning activities were predominantly conducted through expository teaching, resulting in limited student participation during the learning process. Students tended to rely on teacher explanations, experienced difficulties in relating physics concepts to real-life phenomena, and encountered challenges in solving contextual problems. These findings indicate the need for innovative learning strategies that can improve students' engagement and learning outcomes.

One of the reasons for low physics learning outcomes is the limited use of learning resources that support active learning. The learning resources commonly used in schools are still dominated by printed books and conventional worksheets that focus more on exercises, so they don't fully help students to investigate, analyze phenomena, and build conceptual understanding on their own. Along with technological developments, various digital learning innovations are beginning to be used to support more effective learning processes. Anisah et al (2021) stated that digital learning positively affects student learning outcomes because it can create more interactive learning and increase student engagement in the learning process. Research Asrizal et al (2022) states that ICT-based teaching materials have various advantages in supporting the learning process, such as making learning activities easier to carry out, increasing students' activeness and interest in discussing learning materials, making it easier to monitor learning progress, supporting communication through internet services without being limited by distance and time, and facilitating discussions and interactions more effectively through various features available on the internet. In addition, Siringoringo (2024) explaining that integrating technology into learning can improve the effectiveness of the learning process while also encouraging a shift in the education paradigm towards a more innovative and student-centered approach. Therefore, using digital learning resources, like electronic student worksheets, becomes one of the potential alternatives to improve the quality of physics learning more effectively.

One of the digital learning resources that has gained considerable attention is the Electronic Student Worksheet. E-Student Worksheet is a digital adaptation of conventional worksheets that can integrate various multimedia elements, including images, videos, animations, simulations, and interactive activities. Such features enable students to engage more actively in the learning process and support independent learning. Suryaningsih & Nurlita, (2021) argued that E-Student Worksheet can enhance learning interactivity and facilitate conceptual understanding. Furthermore, Ahzari et al (2024) reported that interactive digital learning materials positively affect student engagement and academic achievement. Similarly, Anisah et al (2021) found that technology-supported learning resources contribute to improved learning outcomes by providing more meaningful learning experiences. This finding shows that the Electronic Student Worksheet has great potential to optimally improve the quality of physics learning.

Despite its advantages, the effectiveness of E-Student Worksheet depends not only on the digital features it offers but also on the learning model that guides its implementation. The integration of digital learning materials with appropriate pedagogical approaches is essential to ensure that students actively construct knowledge rather than merely consume information (Siringoringo, 2024). One learning model that aligns with this objective is Dual Space Inquiry. Dual Space Inquiry integrates online and offline learning environments into a unified inquiry-based learning process. Through the online space, students are encouraged to explore learning resources, investigate phenomena, and formulate preliminary ideas independently. Subsequently, the offline learning space provides opportunities for discussion, experimentation, verification, and reflection, enabling students to deepen their conceptual understanding through direct interaction and scientific inquiry (Novitra et al., 2025).

Previous studies have demonstrated the effectiveness of inquiry-based learning and digital learning resources in improving students' learning outcomes. For example, inquiry-based instruction has been shown to enhance conceptual understanding and scientific reasoning skills, while E-Student Worksheet has been reported to increase student engagement and academic performance. However, most existing studies have focused either on the development and validation of E-Student Worksheet products or on the implementation of inquiry learning models separately. Research examining the integration of E-Student Worksheet with the Dual Space Inquiry model, particularly in physics learning, remains limited. Furthermore, studies investigating the effect of E-Student Worksheet based on Dual Space Inquiry on students' learning outcomes in temperature and heat topics at the senior high school level are still scarce. This gap highlights the need for further investigation regarding the effectiveness of integrating digital learning materials with Dual Space Inquiry to improve physics learning outcomes.

The topic of temperature and heat was chosen because it is one of the basic physics concepts that students often find difficult to understand. Previous research shows that misunderstandings frequently occur in concepts related to temperature, heat, thermal expansion, and heat transfer because of their abstract nature and the complex relationships between these concepts (Sari & Marlina, 2022). Therefore, a learning approach that facilitates active exploration, experiments, and concept reconstruction is needed to help students understand this topic more deeply. In addition, learning about temperature and heat doesn't just require students to memorize concepts, but also to understand the relationships between various phenomena that happen in everyday life. The difficulty in connecting these concepts often leads to students having low ability to solve contextual physics problems. Using interactive and technology-based learning media can help visualize abstract concepts so they're easier for students to understand. Therefore, the application of an Electronic Student Worksheet based on Dual Space Inquiry is expected to create a more meaningful learning experience and support the improvement of students' learning outcomes on the topic of temperature and heat more deeply.

The novelty of this research lies in the integration of E- Student Worksheet with the Dual Space Inquiry model in physics learning. Unlike previous studies that examined E- Student Worksheet and inquiry-based learning separately, this study combines both through the use of complementary online and offline learning spaces. This approach gives students the chance to carry out the inquiry process both inside and outside the classroom. As a result, learning is expected to become more meaningful, boost student engagement, and have a positive impact on learning outcomes in the topic of temperature and heat.

Based on the background that has been explained, this study aims to analyze the effect of using E-Student Worksheets based on Dual Space Inquiry on students' learning outcomes in the topic of temperature and heat at SMA Negeri 1 Pancung Soal. This research is expected to contribute theoretically to the development of technology-based physics learning, as well

as practically to serve as an innovative learning alternative for teachers to improve the quality of the learning process and students' learning outcomes. Therefore, the hypothesis proposed in this study is that the application of Dual Space Inquiry E-Student Worksheets has a significant effect on students' learning outcomes in the topic of temperature and heat.

METHODS

This study uses a quantitative approach because the research data is presented in the form of numbers and analyzed using statistical techniques (Sugiyono, 2019). The method used is a quasi-experiment, which is a development of the true experimental design. This design was chosen because it allows researchers to examine the effect of a treatment in conditions where full control over all experimental variables is not possible. Through this design, researchers can compare learning outcomes between the group that received treatment using E-Student Worksheet based on Dual Space Inquiry and the group that participated in conventional learning, so the effect of the treatment can be determined more objectively.

The design used in this study is a Posttest-only Control Design. According to Sugiyono (2019), this research design involves two groups: an experimental group and a control group that are not chosen randomly. The experimental group is given treatment in the form of using Dual Space Inquiry E-Student Worksheet, while the control group uses conventional Student Worksheet in the learning process. After the entire learning process is completed, both groups are given a final test (posttest) to see the differences in learning outcomes obtained as a result of the treatment given.

Table 1. Design of Research

Group	Range	Posttest
Experiment	X	O_1
Control	-	O_2

(Sugiyono, 2019)

This study was conducted at SMA Negeri 1 Pancung Soal in the 2025-2026 academic year. The research procedure involved three stages: planning, implementation, and completion. In the planning stage, the researcher prepared research instruments in the form of objective questions on the topic of temperature and heat, which were used to measure students' learning outcomes. Next, in the implementation stage, the two sample classes were given different treatments. The experimental class participated in learning using Dual Space Inquiry E-Student Worksheet, while the control class used Inquiry-based Student Worksheet. After the entire learning process was completed, students in both classes were given a posttest to measure their learning outcomes. At the final stage, the posttest data was analyzed to see the effect of using the Dual Space Inquiry E-Student Worksheet on student learning outcomes. This analysis was done by comparing the learning results between the experimental class and the control class from the data that had been collected.

The population in this study consisted of all 11th-grade students at SMA Negeri 1 Pancung Soal who took physics lessons in the 2025/2026 academic year, totaling 209 students spread across 6 classes. The research sample was determined using purposive sampling, which is a sampling technique based on certain considerations or criteria (Sugiyono, 2019). The criteria used in selecting the sample included classes that had relatively similar average scores and were taught by the same teacher. Based on these criteria, class XI F1 was chosen as

the experimental class to receive learning using E-Student Worksheet based on Dual Space Inquiry, while class XI F2 was designated as the control class to receive learning using inquiry-based Student Worksheet. With that sample selection, it is hoped that both classes have relatively equal initial characteristics so that the differences in learning outcomes obtained can better reflect the effect of the treatment given.

Data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were employed to describe students' learning outcomes in both the experimental and control groups through measures of central tendency and data distribution. Prior to hypothesis testing, prerequisite analyses were conducted, including the normality test and homogeneity test. The normality test was done using the Shapiro-Wilk test to see if the data obtained was normally distributed. The calculation for the Shapiro-Wilk test is done using the following formula (Uyanto, 2009).

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

Homogeneity testing is done to find out whether the variances of the two sample groups used in the study have the same level of variation or are homogeneous. This test is important because variance homogeneity is one of the requirements for using parametric statistical tests. In this study, homogeneity testing was carried out using Levene's Test with the help of IBM SPSS Statistics 25 to compare the variances between the experimental class and the control class. The results of this test are used as a basis to determine whether the data meet the homogeneity assumption before further hypothesis testing is conducted. The formula for Levene's Test used to check data homogeneity in this study is as follows.

$$W = \frac{(N-k)\sum_{i=1}^{k} N_i(\overline{Z}_\iota - \bar{Z})^2}{(k-1)\sum_{i=1}^{k}\sum_{j=1}^{N_i}\left(Z_{ij} - \overline{Z}_\iota\right)^2}$$

After the prerequisite assumptions were met, hypothesis testing was conducted using the independent samples t-test to determine whether there was a significant difference in learning outcomes between students who learned using the Dual Space Inquiry E-Student Worksheet and those who learned using the Inquiry-based Student Worksheet. All statistical analyses were performed using IBM SPSS Statistics 25. The decision criterion was based on a significance level of 0.05. If the significance value (Sig.) was less than 0.05, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted, indicating a significant effect of the Dual Space Inquiry E-Student Worksheet on students' learning outcomes. The t-test is calculated using the following formula.

$$t = \frac{\overline{X_1} - \overline{X_2}}{S_{gab}\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

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

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

RESULTS AND DISCUSSION

Results

This research was carried out over five weeks with a total of five meetings for each sample class. The research activities aimed to obtain information about the learning outcomes of students who participated in learning using Dual Space Inquiry E-Student Worksheet, as well as the learning outcomes of students using inquiry-based Student Worksheet. During the learning process, both classes were treated according to the research design that had been set. The measurement of students' learning outcomes was done once through a final test (posttest) given after all treatments and learning activities were completed.

Table 2. Posttest Results of the Experiment and Control

Statistical Data	Class	
	Experiment	Control
Number of Students (N)	36	36
Ideal Score	90	86
Highest Score	100	100
Lowest Score	76	67
Average	87.69	83.46
Variance	47.085	66.078
Standard Deviation	6.861	8.128

Based on Table 2, the maximum score a student can get is 100 if all questions are answered correctly. Data analysis results show that the average learning outcomes of students in the experimental class are higher compared to the control class. The average difference of 4.23 points indicates that using the Dual Space Inquiry-based E-Student Worksheet leads to better learning outcomes than learning using the Inquiry-based Student Worksheet. In addition, the lowest score in the experimental class, which is 76, is higher than the lowest score in the control class, which is 67, showing that students with lower abilities in the experimental class are still able to achieve better learning outcomes. These findings show that students who studied using the Dual Space Inquiry E-Student Worksheets got better learning outcomes compared to those who used Inquiry-based Student Worksheets. In addition, the variance in the experimental class was lower than in the control class. This indicates that the distribution of learning outcomes in the experimental class was more even or closer to the average score. Accordingly, the standard deviation in the experimental class was also smaller than in the control class. This suggests that the students' learning results in the experimental class had less variation and tended to be closer to the average compared to the control class.

The distribution of post-test scores of students in the experimental class is shown in Figure 1. The data is presented in the form of a histogram and frequency polygon to give an overview of the spread of scores in each class interval as well as the variation in student learning outcomes after participating in learning using the Dual Space Inquiry E-Student Worksheet. Presenting the data in a graphical form makes it easier to identify patterns in score distribution, trends in learning achievement, and the frequency distribution of students in each score category. The information obtained from this visualization serves as a basis to give an initial picture of students' learning outcomes before further analysis is carried out in more depth during the discussion stage.

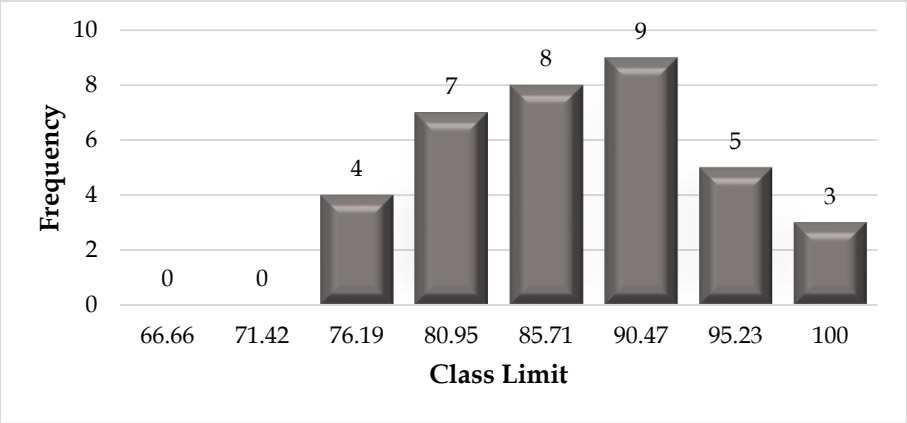

Figure 1. Histogram and Polygon of Posttest Scores for the Experimental Class

Based on Figure 1, the distribution of posttest scores for students in the experimental class after participating in learning using the Dual Space InquiryE-Student Worksheet shows that the scores tend to fall into the high category. The students' scores ranged from 76.19 to 100, indicating that there were no students with low learning outcomes after the lessons. The highest frequency was at a score of 90.47, achieved by 9 students, followed by 85.71 with 8 students, and 80.95 with 7 students. Additionally, 5 students scored 95.23, while 4 students each scored 76.19 and 100. The absence of students in the 66.66 and 71.42 score intervals shows that all students scored above these ranges. This distribution pattern indicates that most students were able to achieve good to very good learning outcomes after using the Dual Space Inquiry E-Student Worksheet.

Most of the students' scores were in the range of 80.95 to 100, which shows that the majority of students achieved high learning outcomes after participating in the lessons. The absence of students scoring in the lowest range, along with some students achieving perfect scores, indicates that students' understanding of the material on temperature and heat is quite good. This situation shows that the Dual Space Inquiry E-Student Worksheet can help students understand the concepts being taught more effectively through structured, student-centered learning activities. Overall, the score distribution dominated by the high category suggests that using the Dual Space Inquiry E-Student Worksheet has a positive impact on students' learning outcomes in the experimental class.

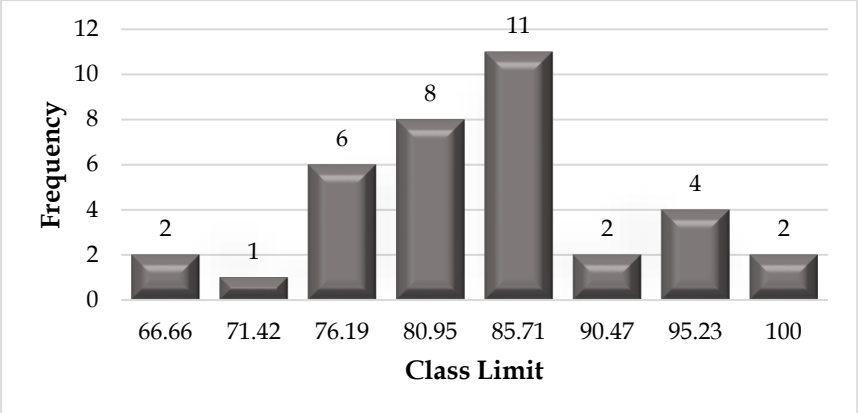

Figure 2. Histogram and Polygon of Posttest Scores for the Control Class

Figure 2 shows the distribution of students' posttest scores in the control class after learning the material on temperature and heat. Based on the histogram, the posttest scores range from 66.66 to 100, with the highest frequency at 85.71 achieved by 11 students, followed by 80.95 with 8 students, 76.19 with 6 students, 95.23 with 4 students, 66.66, 90.47, and 100 with 2 students each, and 71.42 with 1 student. The dominant score range of 76.19–85.71 indicates that most students achieved fairly good learning outcomes after the lesson. However, there are still some students who scored in the low category, so the level of material mastery in the control class hasn't been completely even. Overall, the control class posttest results show that students have achieved good learning outcomes, even though the score distribution is still more varied compared to the experimental class.

After the posttest data from the experimental class and the control class were obtained, prerequisite analysis tests were carried out, including normality and homogeneity tests. The normality test was conducted using the Shapiro-Wilk test at a significance level greater than $\alpha = 0.05$ to find out whether the research data were normally distributed. The results of the normality test are presented in Table 3. Next, the homogeneity test was carried out to determine the similarity of variance between the experimental class and the control class. The results of the homogeneity test are shown in Table 4. Based on the results of these prerequisite tests, the posttest data of both classes were found to be normally distributed and have homogeneous variance. After meeting the analysis requirements, the hypothesis test was conducted using an independent samples t-test. The results of the hypothesis test analysis are shown in Table 5, while the t-test calculations at a significance level of $\alpha < 0.05$ show that there is a difference between the experimental class and the control class, so H_1 is accepted and H_0 is rejected, which means there is a difference in learning outcomes. This is shown in more detail in Table 6 below.

The results of the posttest data normality test for the experimental class and the control class are presented in Table 3. The normality test was conducted to find out whether the learning outcome data in both classes were normally distributed, which is one of the requirements for parametric statistical analysis. Through this test, the characteristics of the data distribution obtained during the study can be understood more clearly. The results of this normality test serve as the basis for determining the appropriate statistical analysis technique to test the research hypothesis.

Table 3. Results of Shapiro-Wilk Normality Test

Class	Statistics	df	Sig.	Information
Experiment	0.940	36	0.051	Normal
Control	0.952	36	0.118	Normal

Based on the data in Table 3, the normality test using Shapiro–Wilk shows that the learning outcome data in both the experimental and control classes are normally distributed. This is indicated by the significance values (Sig.) of 0.051 for the experimental class and 0.118 for the control class, both of which are higher than the 0.05 significance level. These values suggest that there are no significant deviations from a normal distribution in either group of data. Additionally, the Shapiro–Wilk statistics for the experimental class (0.940) and the control class (0.952), which are close to 1, indicate a good fit of the data to a normal distribution. The similarity in distribution characteristics between the two classes indicates that the learning outcome data are relatively stable and don’t show any significant skewness. With the normality assumption being met, the learning outcome data from both groups can

be analyzed using parametric statistical tests, like the t-test, to examine the effect of using Dual Space Inquiry E-Student Worksheet on students' learning outcomes.

After it was found that the learning outcome data in both classes were normally distributed, the next step is to test the homogeneity of variance as one of the requirements for parametric statistical analysis. The homogeneity test is conducted to find out whether the variances of learning outcomes in the experimental class and the control class have the same level of variation. This test uses Levene's Test with a significance level of 0.05. The results of the homogeneity test for both data groups are presented in Table 4. The results of this test are used to determine the suitability of the data for the next stage of analysis. In addition, the homogeneity test also helps ensure that the comparison of learning outcomes between the two classes can be done accurately.

Table 4. Results of levene's Homogeneity Test

Class	N	Sig.	Information
Experiment	36	0.447	Homogeneous data
Control	36		

Based on Table 4, the results of the homogeneity test using Levene's Test showed a significance value of 0.447. This value is higher than the set significance level of 0.05, so the null hypothesis (H_0) is accepted. Therefore, it can be concluded that the variance of learning outcomes in the experimental and control classes is homogeneous or has a relatively similar level of variability. This condition indicates that the difference in score distribution between the two groups is not significant, so both classes can be considered to come from populations with equivalent variance characteristics. Variance homogeneity is one of the important requirements for using parametric statistical tests because it ensures that comparisons of learning outcomes between the two groups are made under fair and comparable conditions. Meeting this homogeneity assumption, along with the previously met normality assumption, shows that the research data has fulfilled the requirements to carry out hypothesis testing using a t-test. Therefore, further analysis can be done to find out whether using E-Student Worksheet based on Dual Space Inquiry has a significant effect on students' learning outcomes in the topic of temperature and heat.

After all the analysis requirements are met, namely that the data is normally distributed and has homogeneous variance, the next step is to conduct a hypothesis test. The hypothesis testing is done using an Independent Sample T-Test to see if there is a significant difference in learning outcomes between the experimental class using Dual Space Inquiry E-Student Worksheet and the control class using conventional learning. This test is conducted at a 0.05 significance level by comparing the obtained significance value (Sig. 2-tailed). The results of this hypothesis test are presented in Table 5.

Table 5. Results of the Independent Sampel T-Test

Class	N	Sig (2- tailed)	Information
Experiment	36	0.047	H_1 is accepted and H_0 is rejected
Control	36		

Based on Table 15, the number of samples in the experimental class and the control class is 36 students each. The results of the Independent Sample T-Test show a significance value (Sig. 2-tailed) of 0.047. Since this significance value is smaller than the 0.05 significance level ($0.047 < 0.05$), H_0 is rejected and H_1 is accepted. This result indicates that there is a significant

difference between the learning outcomes of students in the experimental class and the control class. This difference suggests that the use of Dual Space Inquiry E-Student Worksheet has an effect on the learning outcomes of 11th grade students at SMA Negeri 1 Pancung Soal on the topic of temperature and heat. Therefore, Dual Space Inquiry E-Student Worksheet is proven to be more effective in improving learning outcomes compared to the inquiry-based Student Worksheet used in the control class.

Discussion

Research results show that using E-Student Worksheet based on Dual Space Inquiry has a positive effect on students' physics learning outcomes on the topic of temperature and heat. This effect is shown by the average posttest scores of students in the experimental class being higher compared to the control class after the learning process. This finding indicates that the application of E-Student Worksheet based on Dual Space Inquiry can help students build a better understanding of concepts. The integration of online and offline learning spaces through E-Student Worksheet encourages students to be more actively involved and learn independently. Therefore, learning that uses E-Student Worksheet based on Dual Space Inquiry has the potential to create a more meaningful learning experience compared to learning that only uses Inquiry-based Student Worksheet.

The improvement in learning outcomes in the experimental class can be explained by the characteristics of the Dual Space Inquiry model, which combines scientific investigation activities in two complementary learning spaces. In the offline space, students are directly involved in observation, simple experiments, and problem-solving activities related to the concepts of temperature and heat. Meanwhile, in the online space, students have the chance to access learning materials, complete assignments, and engage in reflection and discussion more flexibly. The integration of these two spaces allows students to build a deeper conceptual understanding because the learning process doesn't just happen during face-to-face sessions, but continues through independent and collaborative online learning activities.

The results of this study show that knowledge isn’t just passively received from teachers, but is built through learning experiences that involve exploration, observation, and reflection. The E-Student Worksheet designed based on inquiry principles encourages students to discover concepts through a series of scientific activities, making learning more student-centered. This idea aligns with Bruner's view that discovery-based learning can improve conceptual understanding and knowledge retention because students are directly involved in the process of finding knowledge.

The findings of this study are in line with research conducted by Noviwati et al (2023) which states that inquiry-based learning can improve learning outcomes, including teaching applied through blended learning so that students are more flexible in learning physics concepts related to temperature and heat. Research by Azizah et al (2025) also showed a significant need from both educators and students for engaging inquiry-based digital learning tools, like DSIF-based E-Student Worksheet, to improve the quality of physics learning. Likewise, research Novitra et al (2025) who found that an approach combining online and offline learning with a balanced integration of inquiry activities is recommended for optimal learning outcomes in physics education. In addition, Herayanti et al (2024) showed that inquiry-based blended learning is effective in improving physics problem-solving skills because it integrates face-to-face and online learning activities in a balanced way. These

findings support the results of this study, which applies the Dual Space Inquiry concept through the use of offline and online learning spaces.

Besides supporting research findings based on inquiry, this study also aligns with various studies on the use of E-Student Worksheet in physics learning. Developing E-Student Worksheet based on Live worksheet has been proven to improve students' learning outcomes because it provides an interactive, practical, and easily accessible learning media (Rachma et al., 2023). Other research shows that guided inquiry-based E-Student Worksheet has a positive impact on students' learning outcomes and interest in learning (Erni et al., 2024). In addition, the E-Student Worksheet developed using a scientific approach is said to be effective in improving learning outcomes (Laily & Wiyatmo, 2025). Therefore, the success of learning in this study is influenced not only by the Dual Space Inquiry approach, but also by the characteristics of the E-Student Worksheet that allow students to learn actively, independently, and continuously both in offline and online learning spaces. Even so, there's an important difference between this research and previous studies. Most earlier studies focused on the effectiveness of inquiry or E-Student Worksheet separately, whereas this study combines both in a Dual Space Inquiry framework that uses offline and online learning spaces at the same time. Previous research generally placed inquiry activities only in classroom or lab settings, while this study expands the learning space to digital environments, so the investigation process isn't limited by time or place. In other words, the improvement in learning outcomes comes not just from using E-Student Worksheet or the inquiry approach alone, but also from the synergy between face-to-face learning activities and online learning activities that support each other.

The difference in learning outcomes between the experimental class and the control class contributes to the development of more innovative and effective physics learning. This study shows that the Dual Space Inquiry approach can be one of the alternative learning strategies suitable for physics topics that require both conceptual understanding and investigative skills. Integrating online and offline learning spaces through E-Student Worksheet allows students to gain broader learning experiences, enabling them to explore concepts more deeply and continuously. (Putri et al., 2026) states that digital learning materials have a positive impact on high school students' physics learning outcomes. In addition, utilizing E-Student Worksheet based on Dual Space Inquiry encourages active student participation in the learning process through activities like observing, investigating, analyzing, and drawing conclusions based on the phenomena studied. This condition helps students build a stronger conceptual understanding compared to learning that focuses only on delivering information. Thus, the implementation of E-Student Worksheet based on Dual Space Inquiry has the potential to be one of the solutions to improve the quality of physics learning as well as students' learning outcomes on the topic of temperature and heat.

Overall, the results of this study reinforce that using Dual Space Inquiry E-Student Worksheet is an effective approach for improving students' physics learning outcomes on the topic of temperature and heat. The study found that students who learned using Dual Space Inquiry E-Student Worksheet achieved better learning outcomes compared to those using inquiry Student Worksheet. These results are consistent with various previous studies which stated that inquiry-based learning and the use of E-Student Worksheet can enhance student engagement and understanding of concepts. Additionally, this study contributes by integrating both offline and online learning activities into a single structured learning design. This integration allows students to have a more varied, active learning experience that is

centered on the process of scientific investigation. Therefore, Dual Space Inquiry has the potential to be one of the learning models that are relevant to use in physics learning. This model can also serve as an innovative alternative that can be developed for other physics topics as well as for science subjects with similar characteristics.

CONCLUSION

Based on the results of statistical data analysis, the use of E-Student Worksheet based on Dual Space Inquiry affects the improvement of students' learning outcomes on the topic of temperature and heat. The average learning outcomes of students using E-Student Worksheet based on Dual Space Inquiry were proven to be higher compared to students using conventional Student Worksheet. This shows that E-Student Worksheet based on Dual Space Inquiry is able to provide a more meaningful and interactive learning experience, which can enhance students' understanding of concepts. Through systematic learning stages, students can identify problems, conduct simple investigations, analyze observation results, and connect the concepts they learn to everyday life phenomena. This condition encourages students to be more active in building their own knowledge and increases their engagement during the learning process. Besides that, using E-Student Worksheet helps students get information and complete learning activities in a more structured way. Therefore, E-Student Worksheet based on Dual Space Inquiry is very relevant to be implemented as an effective alternative learning resource in physics learning. So, it can be concluded that using E-Student Worksheet based on Dual Space Inquiry has a positive and significant impact on students' learning outcomes in the material of temperature and heat, making it a useful reference for educators in efforts to improve teaching quality and student learning results.

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