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Analysis of the Effect of Digital Media Use on Students' Conceptual Understanding of Global Warming

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Abstract

This study aims to analyze the effect of digital media use on students' conceptual understanding of global warming. The research method used a quantitative approach with a quasi-experimental design and comparative research type, involving two 10th grade classes at SMAN 3 Kota Serang, namely an experimental class with 36 students who received learning using digital media in the form of interactive PPT, videos, and educational games based on Canva, and a control class with 35 students who learned using conventional methods. Data analysis was conducted through normality tests, homogeneity tests, and Mann-Whitney U non-parametric tests. The Mann-Whitney test results showed an Asymp. Sig. (2-tailed) value of 0.000 < 0.05, confirming a significant difference between the experimental class and the control class. Descriptively, the experimental class obtained a higher average score (87.67) with a median of 100 and a more consistent distribution of scores compared to the control class (63.46 with a median of 75). These findings indicate that digital media can visualize abstract concepts, reduce cognitive load, and increase student engagement in learning. The practical impact of this study recommends that teachers integrate digital media into science learning to reduce misconceptions and increase learning motivation, while theoretically strengthening the constructivism and cognitive load theory frameworks in explaining how educational technology supports concept understanding.

Keyword: Conceptual Understanding, Digital Media, Global Warming, Mann-Whitney U-test

INTRODUCTION

Science knowledge (science) is science knowledge about phenomena nature obtained through a process called scientific method (Kamalia & Hisan, 2023). Physics is one branch of science. Physics, in essence, is a collection of knowledge, ways of thinking, and investigations. Science as a collection of knowledge can take the form of facts, concepts, principles, laws, theories, and models (Astuti, 2015) . Therefore, physics is closely related to the phenomena around us. As a science that is closely related to real phenomena, physics requires students to understand visual representations, analyze cause-and-effect relationships, and connect abstract concepts with real phenomena. Physics learning in high school still relies on conventional methods. Teachers tend to use a lecture approach and present material through laptops without actively involving students, causing students to feel bored and passive in the learning process (Tarigan, 2017) .

Based on research Liza (2021) , there was a significant decline in students' physics scores before the implementation of innovative learning media. In one study, the average physics test score for 10th grade students was only 45, with only 4 out of 35 students (11%) completing their studies, while the other 31 students did not reach the minimum passing grade. This phenomenon is often caused by conventional teaching methods dominated by teacher lectures. As a result, students become passive, uninterested, and find it difficult to understand abstract physics concepts, causing their overall learning outcomes to decline sharply. This situation shows that the use of innovative learning media is urgently needed to improve students' physics learning outcomes.

The ideal physics learning process involves media that can clarify concepts and help students build a deeper understanding. Learning media are tools that facilitate the teaching and learning process by making the messages conveyed clearer. With this media, learning objectives can be achieved more effectively. In addition, learning media can also attract attention, trigger enthusiasm, and create psychological effects that make students more motivated to learn (Azmi *et al*., 2024) . Various studies show the effectiveness of learning media in supporting the learning and teaching process (Widiastuti & Sagoro, 2017) . One of the learning media that is widely used in the current era is digital media.

Several studies confirm that the use of digital media can facilitate the delivery of abstract concepts and increase student engagement during the learning process, thereby improving student learning outcomes in the classroom. Research conducted by Fauziyyah *et al*., (2024) shows that the use of interactive E-LKPD-based digital media has a positive effect on student learning outcomes in physics. In this study, learning was designed using interactive digital LKPD combined with instructional videos, allowing students to learn independently while receiving immediate feedback. The results showed an improvement in learning outcomes after the use of digital media, with most students achieving scores above the Minimum Passing Criteria (KKM).

Research conducted by Halmuniati *et al*., (2022) found that animated videos can have a positive impact on physics learning outcomes in mechanical wave material. An N-Gain value of 0.69 indicates a fairly effective category, and statistical test results show a significant difference between classes with animated videos and those using conventional learning methods. Adrian *et al*., (2023) also showed that the use of interactive PowerPoint can improve students' physics learning outcomes. Research conducted by Pangga *et al*., (2020) shows that the application of Microsoft PowerPoint-based media/videos on the subject of "Equilibrium of rigid bodies" is very effective in improving the physics learning outcomes of 11th grade students at MA Al-Istiqomah NW Bedus with a gain value of 71% in the high category. The use of digital media such as animated videos can also facilitate students in actively solving problems, thereby supporting the development of critical thinking skills, which is the main objective of learning with the *Problem-Based Learning* (PBL) model (Nafingah *et al*., 2024) .

The findings on the effectiveness of digital media and the PBL model in improving student learning outcomes and critical thinking are increasingly relevant given the high level of misconceptions about global warming among high school students, thus requiring innovative learning media interventions that can effectively address these misconceptions. The study identified a fairly high level of misconceptions among students on global warming material, with percentages reaching 75.86% on the sub-topic of global warming, 72.41% on ozone layer depletion, 41.37% on the greenhouse effect, and significantly on climate change, based on diagnostic analysis using a two-level test on high school students (Pranantya, 2025) . Another study found misconceptions on the subconcept of global warming averaging 41.54%, with details on the process of occurrence at 42.86%, the greenhouse effect at 39.28%, reduction solutions at 35.69%, daily events 44.64%, and impacts 45.21%, caused by a lack of internal understanding, invalid learning resources, and conventional teaching (Simamora *et al*., 2022).

Based on these conditions and findings, further research is needed to specifically examine how the use of digital media can support students' conceptual understanding, especially in materials related to real phenomena such as global warming. Therefore, this study aims to analyze the effect of digital media use on students' conceptual understanding of global warming material, so that the results are expected to provide a clearer picture of the benefits and role of digital media in improving the quality of physics learning.

METHODE

This study uses a quantitative approach with a comparative research type and **a** quasi-experimental design**.** The study aims to determine the difference in Physics learning outcomes on Global Warming material between students who participate in learning using digital media and students who participate in learning without digital media. The quantitative data analysis method is a computational and statistical method that focuses

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on statistical, mathematical, or numerical analysis of data sets (Sofwatillah *et al.*, 2024) . The comparative quantitative research method is used to examine the differences and similarities in characteristics between two or more groups or conditions based on quantitative data.

This research was conducted at SMAN 3 Kota Serang, classes X-11 and X-12. The research objects were student learning outcomes using digital media and students who participated in learning without digital media. This study used an independent sample t-test to compare the averages of the two classes with different treatments.

a. Normality Test

A normality test is a step used to test whether the collected data follows a normal distribution or not (Isnaini *et al.*, 2025) . A normality test is used to determine whether the analyzed data follows a normal distribution or not. There are various methods that can be used to test data normality, including the Kolmogorov-Smirnov, Shapiro-Wilk, Lilliefors, Chi-Square, and Jarque-Bera tests. In this study, the normality test serves as the basis for selecting the subsequent data analysis technique, whether to use parametric or nonparametric statistics. The normality test applied in this study is the Shapiro-Wilk test with the following testing hypothesis:

H_0: the data is normally distributed

H_1: the data is not normally distributed

b. Mann-Whitney U-test

The Mann-Whitney U test is a nonparametric statistical technique used to test for significant differences between two independent groups, especially when the data is on an ordinal, interval, or ratio scale but does not meet the assumption of normal distribution (Deswan *et al.*, 2025) . This test is often applied as an alternative to the *independent t-test* when the normality assumption is not met. In its application, the Mann-Whitney U test is performed by comparing the median or average rank of each group being analyzed, making it very suitable for data from two unrelated groups. The hypotheses in the Mann-Whitney U test are as follows:

H_0: there is no significant difference between the two groups

H_1: There is a significant difference between the two groups.

Data analysis was performed using the Mann-Whitney U nonparametric statistical test to determine the difference in understanding of Global Warming material between two groups of independent students. This test was selected based on the results of the prerequisite test, which showed that the data was not normally distributed and the variance was not homogeneous. Hypothesis testing was conducted at a significance level of 0.05, with the criterion that a significance value of less than 0.05 indicated a significant difference between the two groups.

c. Descriptive Analysis

Descriptive analysis is a form of data analysis used to provide an overview of the sample used. This descriptive analysis was conducted through descriptive hypothesis testing. The results are seen from the mean, standard deviation ( ), variance, maximum, minimum, sum, range, kurtosis, and skewness (distribution skewness) (Sari, 2014) . The results of the descriptive analysis will be displayed in a table comparing the two groups. Interpretation of the skewness value will be used as one consideration for how the data is distributed.

RESULT AND DISCUSSION

This study was conducted in two 10th grade classes at SMAN 3 Kota Serang, namely an experimental class with 36 students and a control class with 35 students. The

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experimental class received instruction using digital media in the form of interactive PPT, videos on global warming issues, and the educational game "snakes and ladders" based on Canva as an assessment tool, while the control class used conventional methods without digital media. The purpose of this study was to analyze the effect of digital media use on students' conceptual understanding of global warming material.

(a) **(b)**

Figure 1. (a) Learning using digital media; (b) Learning without digital media

a. Prerequisite Tests for Analysis

The initial step of the analysis was conducted with prerequisite tests, namely normality and homogeneity tests, to determine the appropriate type of statistical test. These tests are important because they determine whether the analysis can use parametric tests or must switch to non-parametric tests (Ghozali, 2016; Sugiyono, 2017) .

Table 1. Tests of Normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Understanding Global Warming	Through Digital Media	.299	36	.000	.709	36	.000
	Without Digital Media	.197	35	.001	.917	35	.011

a. Lilliefors Significance Correction

Based on the Tests of Normality output, it is known that the Sig. value in both classes is less than 0.05. This indicates that the data is not normally distributed. Thus, the basic assumption for using parametric tests such as the Independent Sample T-Test is not met.

Table 2. Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig
Understanding of Global Warming Material	Based on Mean	7.515	1	69	.008
	Based on Median	3,951	1	69	.051
	Based on Median and with adjusted df	3.951	1	68.940	.051
	Based on trimmed mean	7,237	1	69	.009

Based on the output of the Test of Homogeneity of Variance, it is known that the significance value in the calculation based on the mean is 0.008 < 0.05. This indicates that the variances of the two groups are not homogeneous. Since the conditions of normality and homogeneity are not met, the analysis is continued using the non-parametric Mann-Whitney U test (Ghozali, 2016; Sugiyono, 2017) .

b. Mann-Whitney U Test

The next step is hypothesis testing using the Mann-Whitney U test. The research hypothesis is tested to determine whether there is a difference in learning outcomes between the experimental class and the control class. The test is conducted using the

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Mann-Whitney U test because the data obtained is not normally distributed and the variance between groups is not homogeneous. According to Artaya, (2018) , the Mann-Whitney U test is one of the non-parametric tests that is appropriate to use in such conditions. This is in line with Quraisy & Madya, (2021) which emphasizes that the Mann-Whitney U test is widely used in educational research to compare the learning outcomes of two independent groups.

Table 3. Results of the Mann-Whitney U Test Statistics[a]

	Understanding of Global Warming Material
Mann-Whitney U	235
Wilcoxon W	865,000
Z	-4.606
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Class

Based on the "Test Statistics" output, it is known that the Asymp. Sig. (2-tailed) value is 0.000 < 0.05. Therefore, it can be concluded that "the hypothesis is accepted." Thus, it can be said that there is a difference in learning outcomes about Global Warming between classes that use digital media and classes that do not use digital media. Because there is a significant difference, it can be said that "there is an effect of the use of digital media on learning outcomes in Physics in Grade X with the subject of Global Warming. This difference can be explained by the characteristics of digital media, which are able to visualize the abstract concept of global warming in a more concrete way. According to constructivist theory, conceptual understanding is more easily formed when students interact with visual representations and exploratory activities (Piaget, 1972; Vygotsky, 1978) .

c. Comparison of Learning Outcomes

1. Rank Analysis

Rank analysis provides information on the mean rank and sum of ranks for each group. This analysis is important because it shows the distribution trend of students' concept understanding scores in the experimental and control classes.

Table 4. Ranks of Understanding of Global Warming Material

	Class	N	Mean Rank	Sum of Ranks
Understanding of Global Warming Material	Using Digital Media	36	46.97	1691.00
	Without Digital Media	35	24.71	865.00
	Total	71		

Based on the *Ranks* output, it is known that the class with digital media has a mean rank of 46.97 with a total rank of 1691.00. Meanwhile, the class without digital media only has a mean rank of 24.71 with a total rank of 865.00. This difference in mean rank values indicates that the students' concept comprehension scores in the experimental class are consistently higher than those in the control class. This reinforces the results of the Mann-Whitney U test, which previously showed a significant difference.

The higher mean rank results in the experimental class are consistent with the findings of(2020) , which show that the use of Physics learning videos improves junior high school students' conceptual understanding. This is also in line with Radiusman,(2020) , which emphasizes that conceptual understanding is an important indicator of success in mathematics learning. Thus, this study reinforces the evidence that digital media plays a significant role in improving the quality of science learning.

2. Descriptive Analysis

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Descriptive analysis was conducted by looking at the mean, median, standard deviation, and score distribution in both classes. This analysis provides an overview of student score trends and learning outcome consistency.

Table 5. Descriptives of Understanding of Global Warming Material

	Class			Statistic	Std. Error
Understanding of Global Warming Material	With Digital Media	Mean		87.67	3.146
		95% Confidence Interval for Mean	Lower Bound	81.28	
			Upper Bound	94.05	
		5% Trimmed Mean		89.69	
		Median		100.00	
		Variance		356.286	
		Standard Deviation		18.876	
		Minimum		34	
		Maximum		100	
		Range		66	
		Interquartile Range		20	
		Skewness		-1.490	.393
		Kurtosis		1.162	.768
	Without Digital Media	Mean		63.46	4,507
		95% Confidence Interval for Mean	Lower Bound	54.30	
			Upper Bound	72.62	
		5% Trimmed Mean		64.74	
		Median		75.00	
		Variance		710.903	
		Standard Deviation		26.663	
		Minimum		0	
		Maximum		100	
		Range		100	
		Interquartile Range		42	
		Skewness		-.709	.398
		Kurtosis		-.476	.778

Based on the *Descriptives* output, it is known that the average value of students' concept understanding in the experimental class is 87.67 with a median of 100, while in the control class it is only 63.46 with a median of 75. In addition, the standard deviation in the experimental class is lower than in the control class, which means that the distribution of scores in the experimental class is more consistent. The score distribution also shows that the experimental class tends to be concentrated on high scores (skewness -1.490), while the control class is more spread out with greater variation in learning outcomes (skewness -0.709). This confirms that students who learn with digital media have a better understanding of concepts than students who learn using conventional methods.

This study supports the *cognitive load* theory framework, which states that interactive visualization can reduce students' cognitive load in understanding abstract concepts (Sweller, 1994) . Thus, the use of digital media is not only practically relevant but also enriches the literature on the effectiveness of educational technology in improving conceptual understanding.

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The results of this study confirm that digital media has a significant effect on students' conceptual understanding. These findings are consistent with the research Aldila *et al.*, (2024) and Kareemulla *et al.*, (2021) , which emphasize the role of technology in improving critical thinking skills and learning motivation. The practical implication is that teachers can integrate digital media such as interactive PPTs, videos, and educational games to increase student engagement. The theoretical implication is that this study strengthens the literature on technology integration in science learning and supports constructivism and *cognitive load* theories in explaining how digital media facilitates concept understanding.

CONCLUSION

The use of digital media in the form of interactive PPTs, videos, and educational games based on Canva has been proven to have a significant effect on students' understanding of global warming concepts. This is demonstrated by the results of the Mann-Whitney U-test with an Asymp. Sig. (2-tailed) value of 0.000 < 0.05, which confirms that there is a significant difference between the experimental class and the control class. Students in the experimental class not only obtained higher average and median scores, but also showed a more consistent distribution of scores compared to the control class. These findings indicate that digital media can visualize abstract concepts, reduce cognitive load, and increase student engagement in the learning process. Practically, the results of this study recommend that teachers integrate digital media into science learning to reduce misconceptions and increase learning motivation, while theoretically, this study reinforces the constructivism and cognitive load theory frameworks in explaining how educational technology supports the formation of conceptual understanding. Further research is recommended to explore the application of digital media in other science topics and to examine the long-term impact on students' critical thinking skills and science literacy.

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