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The Effectiveness of a Digital Encyclopedia in Enhancing Scientific Literacy

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ABSTRACT

This study aims to examine the effectiveness of using a digital encyclopedia to enhance students' scientific literacy. In line with the rapid advancement of technology, the integration of digital media in the learning process has become increasingly relevant and essential. This research employed a quantitative experimental method using a one-group pre-test–post-test design. The sample was randomly selected from three classes, resulting in one experimental group. Data were collected through classroom observations and scientific literacy tests that had been previously validated. Data analysis involved a paired sample t-test to assess differences in scores before and after the intervention, and an effect size analysis using Cohen's d to measure the magnitude of the impact. The results indicate that the use of a digital encyclopedia had a significant positive effect on improving students' scientific literacy. The engaging and interactive presentation of instructional materials proved effective in increasing students' learning interest, which in turn fostered a culture of literacy. This study recommends further development of contextual digital learning media tailored to students' educational levels.

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Introduction

In the 21st century, Indonesian society has entered an era shaped by rapid technological and informational advancements across all aspects of life, including education. The swift development of science and technology demands innovation within the education sector, particularly in the use of learning media to support teachers in the instructional process. In the era of Industry 4.0, the growth of information technology and the entertainment industry has been exponential, with today's children considered digital natives—individuals who grow up immersed in digital environments [1]. This technological progress has significantly influenced education systems and positioned schools within the framework of globalization [2]. Information technology can serve as an integral component of educational tools, enhancing the learning experience. The emergence of engaging digital media helps accommodate students' diverse characteristics, interests, and talents, thereby fostering motivation and improving academic performance. Learning is increasingly conducted virtually through gadgets and internet access, offering broader and more interactive access to educational resources [3] . Moreover, digital media act as platforms for accessing materials, facilitating communication between teachers and students, and serving as tools, methods, and resources that support the development of knowledge, skills, motivation, and attitudes among learners [4].

In Indonesia, efforts to foster literacy have been institutionalized through initiatives such as the School Literacy Program launched in 2016 by the Ministry of Education and Culture. Scientific literacy, in particular, plays a crucial role in enabling students to apply scientific knowledge to everyday decision-making and problem-solving. However, fostering scientific literacy remains a challenge, especially when instructional approaches rely heavily on conventional methods that lack contextualization and interactivity [5].

Hands-on learning, particularly through observation, enables students to connect theoretical concepts with real-world contexts, thereby strengthening their critical thinking skills [6],[7]. This approach does not merely aim for content mastery but also encourages learners to recognize the practical relevance of scientific principles in daily life. When students engage directly with scientific phenomena, they are more likely to see the value of their education beyond the confines of the classroom. This practical engagement fosters the development of problem-solving abilities and cultivates a mindset that values inquiry, creativity, and innovation [8],[9]. Moreover, by narrowing the gap between abstract theory and real-life application, hands-on science learning empowers students with transferable skills essential for navigating an increasingly complex world [10]. It also deepens their appreciation for the learning process and encourages a lifelong pursuit of knowledge.

Despite these recognized benefits, science instruction in many educational contexts remains limited to traditional, text-based methods that may fail to engage students

meaningfully. To address this gap, there is a growing interest in leveraging digital learning media that not only deliver content but also promote exploration, critical thinking, and contextual application [6]. One such medium is the digital encyclopedia, which integrates multimedia elements with structured, curriculum-aligned content. While research has generally demonstrated the benefits of digital media in education, few studies have specifically explored the role of digital encyclopedias in improving elementary students' scientific literacy—especially within Indonesian classrooms.

This study aims to address that gap by examining the effectiveness of digital encyclopedias in enhancing scientific literacy among fifth-grade students. Through the integration of multimedia-rich content and experiential learning activities, digital encyclopedias offer a promising strategy for making science learning more engaging, contextual, and meaningful for young learners.

Material and Methods

This study employed a quantitative approach with a quasi-experimental design, specifically using the One-Group Pre-test–Post-test model. This design was chosen to evaluate the impact of using a digital encyclopedia on students' scientific literacy by comparing test scores before (pre-test) and after (post-test) the intervention. Such an approach enables a direct assessment of learning gains resulting from the implementation of the digital learning media.

The research was conducted at Muhammadiyah Pendowoharjo Elementary School, located in Dusun Pendowo, Pendowoharjo, Sewon, Bantul, Special Region of Yogyakarta, from March to November 2024. The population consisted of all fifth-grade students across three classes at the school. Using a Simple Random Sampling technique, one class was selected as the experimental group, comprising 33 students. This sampling method was employed to ensure each class had an equal chance of being selected and to enhance the representativeness and validity of the research findings.

Data were collected using two primary techniques: observation and testing. Observations were conducted to monitor classroom learning activities during the implementation of the digital media. Meanwhile, tests were administered to measure students' scientific literacy on the topic of the Human Respiratory System before and after the use of the digital encyclopedia. The test consisted of multiple-choice questions, each with four answer options and one correct response. The test instrument had undergone both validity and reliability testing prior to its use in the study.

Data analysis was conducted using the Statistical Product and Service Solutions (SPSS) version 27 software. The analysis included descriptive statistics (mean, standard deviation,

and data categorization), prerequisite tests (normality and homogeneity tests), and a paired sample t-test to determine significant differences between the pre-test and post-test scores. In addition, the effect size was calculated using Cohen's d to measure the magnitude of the digital encyclopedia's impact on students' scientific literacy.

Results and Discussion

In this study, the observed learning process began with the initial activities, followed by the main activities, and concluded with the closing activities. Additionally, the researcher observed students' conditions during the learning process, both when using learning media and during discussions. This observation process was carried out from before the pre-test until after the post-test. Before conducting the pre-test, the researcher observed several shortcomings, such as students paying less attention to the material being explained, low interaction between teachers and students, resulting in a one-way communication process, and the use of a single learning resource, namely textbooks. Following this, students were given treatment related to the provided material. After obtaining students' scientific literacy scores from both the pre-test and post-test, the researcher aimed to compare the scores from these two assessments.

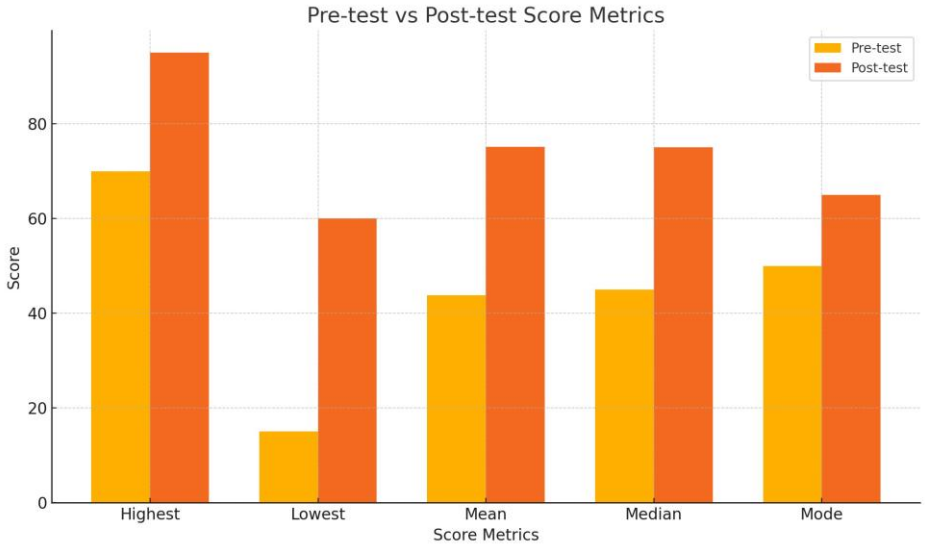


Fig. 1. Comparison of Pre-test and Post-test Data

Based on Fig. 1, the results indicate a significant difference between the pre-test and post-test scores. The average pre-test score is 43.79, while the average post-test score is 75.15. This demonstrates a substantial gap, with the post-test scores being significantly higher than the pre-test scores.

Data categorization refers to the classification of data into various groups, categories, or segments. In this study, the researcher categorized the data into three groups: low, medium, and high. Fig. 2 shows this categorization.



Fig. 2. Bar Chart of Pre-test and Post-test Data Categorization

Based on the bar chart above, the blue bars represent the pre-test data, while the green bars represent the post-test data. The normality test was conducted to determine whether the sample data came from a normally distributed population, with the results obtained from the pre-test and post-test scores. The decision-making guidelines for the normality test state that if the sig. value (probability) < 0.05, the distribution is not normal, whereas if the sig. value (probability) > 0.05, the distribution is normal. Table 1 presents the normality test results.

Table 1. Normality Test Results

	Kolmogorov-Smirnova			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test Scientific Literacy	.110	33	.200*	.973	33	.577
Post-test Scientific Literacy	.090	33	.200*	.964	33	.342

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on the results presented at Table 1, the normality test yielded a significance value of 0.200, which exceeds the threshold of 0.05. Therefore, it can be concluded that the data are normally distributed since the significance value is > 0.05. The homogeneity test was conducted using SPSS version 27, with the decision-making criteria stating that if the sig. value > 0.05, the data variance is homogeneous, meaning the homogeneity assumption is met. Conversely, if the sig. value < 0.05, the data variance is not homogeneous, meaning the homogeneity assumption is not met. Table 2 presents the homogeneity test results.

Table 2. Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.
Value	Based on Mean	2.057	1	64	.156
	Based on Median	1.685	1	64	.199
	Based on the Median and with adjusted df	1.685	1	53.801	.200
	Based on trimmed mean	2.061	1	64	.156

The results of the homogeneity test (Table 2) indicate a significance value (sig.) of 0.156, which exceeds the 0.05 threshold. This suggests that the data variance is homogeneous, fulfilling the assumption of homogeneity. After conducting both the normality test and the homogeneity test, confirming that the data are normally distributed and homogeneous, the next step is to perform a paired sample t-test. See Table 3 for the results.

Table 3. Paired Sample T-Test Results

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pre-test Pre-test Scientific Literacy - Post-test Scientific Literacy	-31.36364	12.32837	2.14609	-35.73509	-26.99219	-14.614	32	.000

Based on the SPSS output (Table 3), the Sig. (2-tailed) value is 0.000, which indicates that since the significance value is < 0.05, H1 is accepted, and H_0 is rejected. This means that the hypothesis stating that there is a difference in test results before and after the treatment is supported. Based on the obtained data, the researcher aimed to assess the effect size derived from the pre-test and post-test scores. Cohen's d was utilized to compare the effect of a variable using SPSS version 27. The effect size classifications are as follows: small (d = 0.2), medium (d = 0.5), and large (d ≥ 0.8). Table 4 presents the Cohen's d results.

Table 4. Cohen's d Effect Size Results Paired Samples Effect Sizes

		Standardize[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Pre-test Scientific Literacy - Post-test Scientific Literacy	Cohen's d	12.51821	-2.505	-3.233	-1.778
	Hedges' correction	12.66733	-2.476	-3.195	-1.757

a. The denominator used in estimating the effect sizes.

Cohen's d uses the sample standard deviation of the mean difference adjusted by the correlation between measures. Hedges' correction uses the sample standard deviation of the mean difference adjusted by the correlation between measures, plus a correction factor.

The SPSS output shows a Cohen's d value of 2.50, indicating a very large effect size (≥ 0.8). This result suggests that the use of the digital encyclopedia on the human respiratory system has a substantial positive impact on the scientific literacy of fifth-grade students at SD Muhammadiyah Pendowoharjo. The digital encyclopedia employed in this study integrates various multimedia elements such as structured texts, illustrative images, and interactive animations. These features support the development of the four key indicators of scientific literacy examined: (1) the ability to explain scientific phenomena, (2) evaluate and design scientific investigations, (3) interpret data and evidence scientifically, and (4) demonstrate awareness of the impact of science on society and the environment.

The content of the encyclopedia provides students with systematic and contextual explanations of the human respiratory system, enabling them to comprehend scientific concepts more holistically and apply them meaningfully. Interactive elements within the digital resource further encourage students to analyze information, observe patterns, and make scientifically grounded conclusions. In addition, the visually engaging and accessible format promotes students' awareness of the relevance of scientific knowledge to personal health and environmental well-being [11].

By bridging theoretical knowledge with real-life applications, the digital encyclopedia functions as an effective learning tool that nurtures critical thinking, conceptual understanding, and reflective inquiry. This finding aligns with prior studies asserting that engaging digital media can enhance students' motivation, critical thinking skills, and scientific reasoning [12],[13]. When students are exposed to contextualized learning experiences, they are better equipped to face scientific and health-related challenges in everyday life [14],[15]. The implementation of a multimedia-rich digital encyclopedia significantly contributes to strengthening elementary students' scientific literacy in the digital era by fostering inquiry-based learning, contextual understanding, and lifelong health awareness [16],[17].

Conclusion

This study found that a digital encyclopedia significantly improved scientific literacy among 5th-grade students, as indicated by higher post-test scores and a strong effect size (Cohen's d = 2.50). The results confirm that interactive digital media enhances students' understanding and retention of scientific concepts. Integrating digital learning tools in science education can help teachers create engaging and student-centered learning environments. Schools with limited physical resources can benefit from technology-driven educational materials to support scientific literacy development. Policymakers should consider incorporating digital resources into curricula to enhance learning outcomes. Future research should investigate long-term effects and broader applications of digital encyclopedias across

different subjects and demographics. Ultimately, embracing digital learning innovations can help students develop critical thinking and problem-solving skills essential for the 21st century.

Conflict of Interest

The authors declare that there is no conflict of interest.

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