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Implementation of an educational game (Wordwall) to determine student learning outcomes on the material of biodiversity

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Article

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Abstract

Biology instruction in educational institutions is still often conducted using conventional methods that emphasize the teacher's role, resulting in suboptimal student engagement and cognitive outcomes. With advancements in educational technology, the use of interactive game-based educational media (Wordwall) has emerged as an attractive new alternative for improving student learning outcomes. This study aimed to determine the difference in learning outcomes between students taught using Wordwall-based educational games and those taught using conventional instruction. This study employs a quantitative approach using a true experimental design. The research design utilized is a randomized pretest-posttest control group design. The study subjects consisted of 50 tenth-grade students at MA Al-Ihsan Kalijaring, divided into an experimental group and a control group. Data collection was conducted through learning outcome tests in the form of pretests and posttests. The data were analyzed to determine improvements in student learning outcomes and to identify differences between the experimental and control groups using N-Gain analysis, normality tests, homogeneity tests, and an independent samples t-test. The results show that the average N-Gain score in the experimental class was 0.54, which falls into the moderate category, while in the control class it was 0.29, which is classified as low. The independent samples t-test revealed a statistically significant difference between the two groups ((t=-4.765), (df=48), ($p<0.001$)). These findings indicate that students receiving Wordwall-based instruction experienced greater improvement in learning outcomes than those receiving conventional instruction. Therefore, Wordwall-based educational games may serve as an alternative learning medium for teaching biodiversity in biology.

INTRODUCTION

Education is one of the fundamental aspects in improving the quality of human resources, especially in facing the challenges of scientific and technological development in the era of globalization. Education not only functions as a means of transferring knowledge but also as a process of shaping students' character, values, and morals comprehensively [1]. In the learning process, especially in biology lessons, students are not only required to master concepts but also to be able to carry out scientific processes such as observing, questioning, and analyzing natural phenomena [2]. However, in practice, biology learning in schools is still largely dominated by conventional teacher-centered methods, such as lectures, which causes students to tend to be passive and less actively involved in the learning process. This condition results in a lack of understanding of concepts and students' learning outcomes [3].

Along with the development of information and communication technology, various innovations have emerged in the world of education. One approach that is growing is Digital Game-Based Learning (DGBL), which is rooted in constructivist theory and multimedia learning. In this perspective, students build knowledge through active interaction with the learning environment,

including through digital media [4]. Game-based learning can also stimulate higher-order thinking skills such as problem-solving and decision-making through structured challenges and immediate feedback [5]. One digital learning platform that can be integrated into this approach is Wordwall, an interactive platform that offers various game-based activities for presenting learning materials and assessing students' understanding. Wordwall was selected for this study because it allows teachers to transform biology questions into interactive game activities, provides a variety of activity formats, and creates opportunities for students to participate actively in answering questions and receiving feedback. These features make Wordwall a relevant alternative to conventional teacher-centered instruction, particularly for reinforcing students' understanding of biological concepts through structured practice and evaluation**.** Previous studies have also indicated that educational games can combine entertainment with instructional objectives, support formative assessment, and create more engaging learning experiences [6]. In addition, educational games are able to create a fun learning experience and increase students' active involvement in the learning process [7].

The urgency of this research is based on the importance of improving student learning outcomes. The topic of biodiversity is a fundamental topic in biology and possesses a high level of complexity, encompassing various concepts such as genetic diversity, species diversity, and ecosystems. Student learning outcomes are a key indicator of learning success, demonstrating the extent to which students are able to understand and apply the material they have learned [8]. However, learning still uses conventional methods, resulting in less-than-optimal student learning outcomes.

Several previous studies have shown that the use of educational game-based learning media can improve student learning outcomes. Ali et al. [9] shows that game-based learning can significantly improve students' cognitive learning outcomes. Furthermore, Oktafadilla et al. [10] shows that the use of WordWall has a positive effect on students' learning outcomes with a significant increase in scores compared to conventional methods. Similarly, Habibi et al. [11] It also shows that the Wordwall game educational can significantly improve students' learning outcomes and digital literacy.

However, a gap remains between findings from previous research and actual conditions in the field. A needs analysis conducted at MA Al-Ihsan Kalijaring reveals that biology instruction is still dominated by lecture-based methods relying on limited media, such as textbooks, whiteboards, and LCD projectors. Furthermore, Wordwall had not yet been utilized in biology instruction at the school. This situation indicates an opportunity to introduce interactive digital learning media that can complement existing teaching practices and encourage greater student participation. Given its variety of game-based activities and its potential to support question-based practice and assessment, Wordwall was considered a relevant medium to investigate in the context of teaching the diversity of living things.

Based on this background, this study aimed to determine whether there was a significant difference in the improvement of students' learning outcomes between those taught using Wordwall-based educational games and those taught using conventional instruction on the topic of the diversity of living things. The comparison was conducted using students' N-Gain scores calculated from pre-test and post-test results in the experimental and control classes.

RESEARCH METHOD

This study employs a quantitative approach aimed at determining the impact of using educational games (wordwall) on student learning outcomes in an objective and measurable manner. The quantitative approach was selected because it enables the collection of numerical data that can be statistically analyzed to test the research hypotheses [12]. A quantitative method employing a true experimental design was used specifically, a randomized pretest-posttest control group design. This design involved two groups selected at random: an experimental class and a control class. Both groups underwent a pretest to assess baseline proficiency; subsequently, the experimental class received instruction using an educational game medium (wordwall), while the control class was taught using

conventional methods. Following the intervention, both groups took a posttest to measure changes in learning outcomes [13].

The subjects of this study were 50 Grade X students from MA Al-Ihsan Kalijaring, divided into two groups: an experimental class consisting of 25 students and a control class consisting of 25 students. A random sampling technique was used to select the subjects, ensuring that every student had an equal chance of being assigned to a research group [12].

The research procedure consists of three stages: preparation, implementation, and final analysis. In the preparation stage, learning materials and research instruments are prepared, and learning activities for both classes are organized. In the implementation stage, a pre-test is given to the experimental class and the control class to assess the students' initial learning outcomes. The experimental class then receives learning using Wordwall-based educational games for 3 sessions, with each session lasting 60 minutes. Wordwall activities include quizzes designed to strengthen students' understanding of the diversity of living things. During each session, the teacher introduces the learning materials, guides students through the Wordwall activities, and provides feedback on their answers. Meanwhile, the control class received instruction using conventional teaching methods with the same number of sessions and duration. After the teaching treatment was completed, both classes took a post-test to measure their learning outcomes. In the final stage, the pre-test and post-test scores were processed and analyzed using descriptive statistics, N-Gain calculations, tests of normality and homogeneity, as well as independent samples t-tests to examine the differences in learning outcome improvements between the two classes.

The research instrument used in this study was a student learning achievement test consisting of 20 multiple-choice questions developed based on learning indicators related to the topic of the diversity of living things. Before being used for data collection, the instrument was tested for validity. Instrument validity assesses the extent to which the tool measures what it is intended to measure [14]. The data collection techniques in this study include testing and documentation. Tests are used to measure student learning outcomes through pre-tests and post-tests, while documentation is used to obtain supporting data, such as student rosters and information regarding the learning conditions.

Data analysis was conducted in several stages: 1) calculating the N-Gain value to determine the improvement in student learning outcomes; 2) performing a normality test using the Shapiro-Wilk test to assess the data distribution; 3) conducting a homogeneity test using ANOVA (Analysis of Variance) to determine the equality of variances across groups; and 4) performing a hypothesis test using the Independent Sample t-test to determine the difference in learning outcomes between the experimental and control classes. The hypothesis test was conducted at a significance level of 0.05 [12].

RESULTS AND DISCUSSION

This study aims to determine whether there is a significant difference in students' learning outcomes between those taught using educational games (Wordwall) and those taught using conventional instruction on the topic of the diversity of living things. Learning outcome data were obtained from pretest and posttest scores in both the experimental and control classes, and subsequently analyzed using descriptive statistics, N-Gain calculations, and parametric statistical tests. The descriptive statistics of students' learning outcomes are presented in Table 1.

Table 1. Descriptive Statistics of Student Learning Outcomes

Class	N	Minimum Value	Maximum Value	Average Pre-test Score	Average Posttest Score	N-Gain value	Description
Control	25	30	65	39,8	57,2	0,29	Low
Experiment	25	40	90	49,2	76,6	0,54	Medium

Based on Table 1, both groups showed an improvement in learning outcomes following the instructional process. However, the improvement observed in the experimental class was greater than

that in the control class. The average post-test score for the experimental class reached 76.60, whereas the control class achieved only 57.20. This difference is also reflected in the N-Gain scores: 0.54 (medium category) for the experimental class and 0.29 (low category) for the control class. These results indicate that the use of educational games (wordwall) is more effective in enhancing learning outcomes compared to conventional instruction.

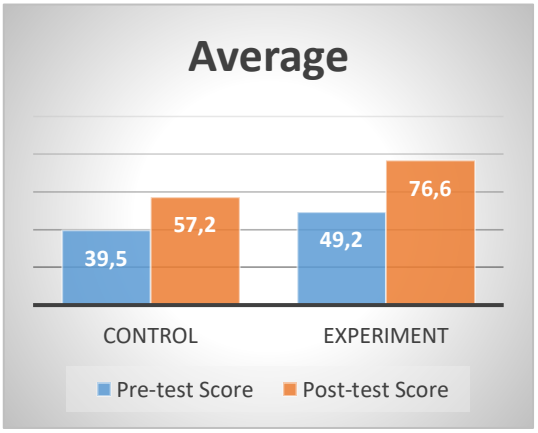


Figure 1. Comparison of Pre-test and Post-test Averages

The graph in Figure 1 shows an increase in scores from the pretest to the posttest in both classes. However, the magnitude of this increase was greater in the experimental class than in the control class. This is evident from the larger difference between the pretest and posttest scores in the experimental class. A statistical test was conducted to determine the significance of the difference in learning outcomes between the two classes.

The Shapiro-Wilk normality test results indicate that the N-Gain data for both the control class ($p = 0.259$) and the experimental class ($p = 0.231$) are normally distributed, as the significance values exceed $\alpha = 0.05$. Furthermore, the homogeneity test (Levene's Test) yielded a significance value of 0.256 (>0.05), indicating that the variances of the two groups are homogeneous. Finally, the independent-samples t-test results showed a significance value of 0.000 (<0.05), indicating a significant difference in student learning outcomes between the control class and the experimental class. The detailed results can be seen in Table 2.

Table 2. Statistical Test Results

Statistical Test	Analyzed Data	Statistical Value	Sig. (p-value)	Description
Shapiro-Wilk	N-Gain of the control class	-	0,259	Normal
Shapiro-Wilk	N-Gain of the experimental class	.	0,231	Normal
Homogenitas (Levene's Test)	N-Gain of the control and experimental classes	F = 1,321	0,265	Homogeneous
Independent Sample t-Test	N-Gain of the control and experimental classes	t = -4,765 df = 48	0,000	There is a significant difference

The research findings indicate that the use of Wordwall-based educational games resulted in greater improvements in student learning outcomes than conventional instruction. The experimental class achieved a mean N-Gain score of 0.54, which falls into the moderate category, whereas the control class obtained a mean N-Gain score of 0.29, categorized as low. This difference suggests that Wordwall-based learning provided a more supportive learning environment for improving students' cognitive understanding of the diversity of living things. However, the effectiveness of Wordwall in this context should be understood not only in terms of the difference in N-Gain scores but also in

relation to the characteristics of the learning material and the learning activities facilitated by the platform. The topic of the diversity of living things involves several interconnected concepts, including the characteristics of living organisms, classification, and the relationships among different groups of organisms. For students at the Madrasah Aliyah (MA) level, understanding these concepts requires more than memorizing biological terms; students also need to compare characteristics, recognize patterns, and apply classification principles. Wordwall can support these learning demands by presenting questions and activities in an interactive game format that encourages students to retrieve information, distinguish between concepts, and receive immediate feedback. These features may help students identify misunderstandings and reinforce their understanding during the learning process. In contrast, conventional instruction may provide fewer opportunities for repeated interactive practice, depending on how the lessons are implemented. Thus, the greater improvement observed in the experimental class may be associated with the opportunities for active participation, repeated practice, and immediate feedback provided by Wordwall [15]. Nevertheless, these mechanisms represent plausible explanations for the findings rather than effects that were independently measured in this study.

Despite the higher N-Gain score, the experimental class achieved only a moderate level of improvement (0.54), rather than a high level. This finding suggests that although Wordwall supported learning, its use alone may not have been sufficient to produce substantial gains for all students. One possible explanation is that the topic of biodiversity requires conceptual understanding and the application of classification principles, which cannot always be fully developed through game-based quizzes alone. Students may also need additional explanations, concrete examples, visual representations of organisms, and opportunities to connect biological concepts with observations of living things in their surroundings. Furthermore, differences in students' prior knowledge, learning pace, and ability to interpret biological concepts may have influenced the extent of improvement. These factors are possible explanations, as the present study did not directly measure their individual contributions. Therefore, integrating Wordwall with teacher-guided explanations, contextual examples, and other inquiry-based learning activities may help deepen students' understanding and potentially improve learning outcomes.

The distribution of N-Gain scores provides additional insight into the findings. The majority of students in the experimental class were reported to fall into the moderate category, whereas the control class was dominated by the low category. This pattern suggests that the benefits of Wordwall were not limited to an increase in the class mean but were also reflected in the learning-gain categories achieved by individual students. However, the distribution of N-Gain categories alone does not establish that Wordwall produced a more equitable improvement in student abilities. Such a claim would require additional evidence, including an analysis of score variability and differences in learning gains among students with different initial achievement levels. Accordingly, the findings support the potential of Wordwall to facilitate improved cognitive learning outcomes, while further investigation is needed to determine whether its benefits are distributed equally among students.

Several limitations should be considered when interpreting these findings. First, the study involved 50 students from a single school, Madrasah Aliyah Al-Ihsan Kalijaring, which may limit the generalizability of the results to students in other schools with different learning environments and characteristics. Second, the intervention focused on the diversity of living things, so the findings cannot automatically be generalized to other biology topics that may require different learning approaches. Third, the study primarily assessed cognitive learning outcomes through pretests and posttests; therefore, it did not directly establish whether Wordwall improved students' motivation, engagement, or long-term knowledge retention. Future research should involve larger samples from multiple schools, extend the intervention period, and examine the effectiveness of Wordwall across different biology topics. Further studies could also investigate students' motivation, engagement, and long-term retention, as well as compare Wordwall-supported instruction with approaches that

combine digital games, contextual biological examples, and inquiry-based activities. Such research would provide a more comprehensive understanding of how Wordwall can be integrated effectively into biology education.

This improvement in learning outcomes can be attributed to the characteristics of the educational game (Wordwall) as a game-based learning medium. This medium offers interactive learning activities, provides immediate feedback, and encourages active student participation throughout the learning process. These factors boost student motivation to understand the material, making information easier to process and retain. The results of this study are consistent with the findings [16], which state that game-based learning using Wordwall has a positive impact on student learning outcomes during the learning process. These findings are also supported by research [17] demonstrating that the use of educational games (Wordwall) is effective in improving learning outcomes in science education, as it creates an interactive and enjoyable learning atmosphere while fostering active student participation.

The successful use of the educational game (Wordwall) in this study is further reinforced by statistical test results that satisfy the assumptions of parametric analysis. The Shapiro-Wilk normality test indicates that the data from both groups are normally distributed, with significance values exceeding 0.05. This suggests that the data distribution does not deviate significantly, thereby ensuring the reliability of the analysis results [18]. These results also reinforce the view [19] which states that the normality test aims to ensure the data originates from a normally distributed population, thereby enabling hypothesis testing to yield more valid and reliable conclusions. This finding is supported by [20] This indicates that the Shapiro-Wilk test performs better than several other normality tests for small to medium sample sizes, making it highly suitable as a basis for parametric statistical analysis.

Furthermore, the Levene's test results indicate that the variances of both groups are homogeneous, as the significance value exceeds 0.05. This equality of variance suggests that the initial conditions of the experimental and control classes were relatively comparable prior to the intervention; consequently, the differences in learning outcomes observed after instruction more accurately reflect the impact of using the educational game (Wordwall) rather than pre-existing characteristic differences between the two groups. These findings align with the view [21] which states that homogeneity of variance is needed to minimize bias due to differences in initial ability between groups. This statement is also supported by [22], which explains that the homogeneity test aims to ensure the samples originate from populations with equal variances, thereby allowing comparative analysis to be conducted objectively, accurately, and reliably.

The independent sample t-test results show a significance value of $p < 0.000$ (<0.05), indicating a statistically significant difference in learning outcomes between the experimental and control classes based on their N-Gain scores. The mean N-Gain score was 0.54 in the experimental class, categorized as moderate, compared with 0.29 in the control class, categorized as low. These findings indicate that the improvement in learning outcomes was greater in the experimental class, which used Wordwall-based educational games, than in the control class, which received conventional instruction. This difference may be related to the interactive features of game-based learning, which can encourage student participation through challenging activities and immediate feedback. Such features may help students engage more actively with the learning material and reinforce their understanding of biological concepts. The results of this study support the view of [23], which emphasizes that the implementation of game-based learning media needs to be designed systematically to provide sustainable benefits in the learning process. In addition, the study in [24] explains that the application of gamification elements in learning can enhance students' motivation, engagement, and learning performance.

A synthesis of the research findings indicates that the implementation of an educational game (Wordwall) positively contributes to improving student learning outcomes regarding the topic of the Diversity of Living Things. The higher N-Gain scores in the experimental group, supported by the

fulfillment of normality and homogeneity assumptions and independent-samples t-test results showing a significant difference, provide empirical evidence that the educational game (Wordwall) is an effective learning medium for enhancing student learning outcomes. The novelty of this study lies in the application of the educational game (Wordwall) to the topic of the Diversity of Living Things at the Madrasah Aliyah (Islamic senior high school) level using a true experimental design, thereby offering stronger empirical evidence regarding the effectiveness of game-based learning media in boosting academic achievement. The use of the educational game (Wordwall) proved effective in transforming passive instruction into a more dynamic learning experience, while simultaneously increasing student motivation and academic performance [25]. These findings are also consistent with research [26], which states that the implementation of educational games (Wordwall) can enhance learning activities, student engagement, and learning outcomes through a more interactive and learner-centered learning environment.

CONCLUSION

Based on the research findings and discussion, it can be concluded that there was a difference in student learning outcomes between the experimental and control classes. The experimental class achieved a mean N-Gain score of 0.54, which falls into the medium category, whereas the control class obtained a mean N-Gain score of 0.29, categorized as low. The preliminary assumption tests indicated that the data met the requirements for parametric statistical analysis. The Shapiro–Wilk normality test yielded a significance value of 0.259 (> 0.05), indicating that the data were normally distributed, while the homogeneity test yielded a significance value of 0.265 (> 0.05), indicating homogeneous variances between the two classes. Furthermore, the independent-samples t-test revealed a statistically significant difference in learning outcomes between the experimental and control classes ($p < 0.05$). These findings suggest that the use of Wordwall-based educational games was more effective than conventional instruction in improving students' cognitive learning outcomes on the topic of the diversity of living things.

However, this study has several limitations. First, the research was conducted at only one school, with a relatively small sample of 50 students, which may limit the generalizability of the findings to other educational contexts. Second, the intervention focused on a specific learning topic, and the study primarily assessed students' cognitive learning outcomes. Therefore, the findings may not fully reflect the potential effects of Wordwall on other aspects of learning, such as motivation, engagement, and long-term knowledge retention. Future research is recommended to involve students from multiple schools with larger sample sizes, extend the intervention period, and investigate the effects of Wordwall on other learning outcomes, including learning motivation, student engagement, and knowledge retention. Further studies could also compare Wordwall with other digital learning media to provide a more comprehensive understanding of its effectiveness in biology education.

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AUTHOR CONTRIBUTIONS

The first author is a student in the Biology Education Study Program who conducted this research as part of the requirements for an undergraduate thesis. The first author was responsible for developing the research concept, designing the methodology, collecting and analyzing data, visualizing results, and drafting the manuscript. The second and third authors served as supervisors, providing

guidance on research design, instrument validation, and result interpretation, as well as reviewing and editing the manuscript. The second author provided input on concept development, research methodology, and manuscript preparation, while the third author offered insights regarding scientific aspects and result interpretation, and assisted in refining the manuscript for publication. All authors have read, reviewed, and approved the final version of the manuscript for publication.

CONFLICTS OF INTEREST

All authors declare that there are no conflicts of interest regarding the research or the publication of this article. All stages of the research from proposal development, data collection and analysis, to the writing of the scientific article were conducted objectively and voluntarily, without pressure or influence from any party that could affect the research findings.

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