

Effect of Problem-Based Learning Model Assisted by Wordwall on Student Learning Outcomes in Ecology Material for Junior High School

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Abstract: Problem-based learning is important for promoting meaningful learning through interactive, collaborative, and technology-enhanced learning activities. This study aims to determine the effect of the Problem-Based Learning (PBL) model, assisted by Wordwall, on the learning outcomes of seventh-grade students in ecology at UPT SMP Negeri 37 Medan. This study used a quasi-experimental method with a Nonequivalent Control Group Design. The research sample consisted of two classes: class VII-B, the experimental class, taught using the PBL model with Wordwall assistance, and class VII-E, the control class, taught using the PBL model without Wordwall assistance. The research instrument was a 30-question multiple-choice test that had been found to be valid and reliable. Data were analyzed using normality tests, homogeneity tests, and Independent Sample t-test hypothesis tests with the help of SPSS 21 for Windows. The results showed that the average post-test score of the experimental class was 82.09, higher than that of the control class (71.74). The results of the hypothesis test showed a significance value (2-tailed) of $0.000 < 0.05$ with a t value = -9.272, so that H_0 was rejected and H_a was accepted. Thus, it can be concluded that the PBL learning model, assisted by Wordwall, has a significant effect on improving student learning outcomes in ecology at UPT SMP Negeri 37 Medan.

Keywords: Ecology; Learning Outcomes; Problem-Based Learning, Wordwall.

Introduction

Education is an organized effort to create an environment that supports the development of students' potential [1]. Education as a system consists of various elements or components that are functionally interconnected in their implementation [2]. 21st-century education is an approach to learning that integrates skills and innovation, information literacy, and the use of digital media and technology [3]. In the 21st century, education emphasizes not only knowledge acquisition but also critical thinking skills, creativity, collaboration, and problem-solving [4].

In learning natural sciences, particularly biology, students are required not only to memorize concepts but also to understand and be able to relate theory to real-world phenomena in their environment. Biology learning emphasizes not only conceptual mastery but also requires students to be able to connect theory to phenomena occurring in their environment. One subject very close to students' daily lives is ecology, which examines the reciprocal relationship between living things and their environment. [5] Ecology material discusses the reciprocal relationship between living things and their environment, including interactions between ecosystem components, energy flow, food chains, and environmental balance. Through learning ecology, students are expected to understand the importance of maintaining environmental sustainability and to develop ecological awareness in everyday life.

However, ecology instruction in many schools remains conventional, dominated by lectures and teacher-centered methods, resulting in students being passive and having difficulty understanding the material [6]. Teachers tend to deliver material through lectures, while students simply listen and take notes. This situation leads to low student engagement in the learning process and results in poor learning outcomes [7]. Monotonous learning also lowers student motivation, leading to suboptimal learning outcomes.

Based on observations and interviews with science teachers at UPT SMP Negeri 37 Medan on September 25, 2025, student learning outcomes in ecology remained relatively low. Students experienced difficulty understanding the relationships between organisms and classifying living things in their environment. During the learning process, student engagement in asking and answering questions and expressing opinions remained low. Most students tended to wait for the teacher's explanations rather than explore and discover concepts independently. This situation indicates that learning has not fully encouraged students to actively construct their knowledge.

The low learning outcomes of students are also evident in the daily ecology test scores for grade VII D. Of the 34 students, 20 (59%) scored below the school's Minimum Completion Criteria (KKM), which is 75. Only 14, or 41%, completed learning. This data indicates that learning completion has not been achieved in a classical manner. The low learning outcomes are influenced by

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various factors, including the use of less varied learning models, minimal student involvement in the learning process, and the suboptimal use of engaging and interactive learning media.

These problems need to be addressed by implementing learning models that actively engage students in the learning process. One learning model that can be applied to address these issues is Problem-Based Learning (PBL). The Problem-Based Learning model emphasizes student-centered learning through the presentation of contextual problems as stimuli in the learning process [8]. In its application, students are directed to identify problems, seek information, discuss, and find solutions independently or in groups. This model can train students' critical thinking, collaboration, communication, and problem-solving skills, thus making learning more meaningful.

The implementation of the Problem-Based Learning model will be more effective when supported by engaging, interactive learning media. One digital learning platform that can support PBL implementation is Wordwall [9]. Wordwall is a web-based platform that offers a variety of educational games and interactive quizzes for use in learning. Wordwalls are web-based media that offer a range of interactive activities and educational games, thereby increasing student motivation and engagement in learning [10]. Furthermore, Wordwalls also help teachers present material in a more varied and innovative way.

The use of Wordwalls in ecology learning is considered relevant because ecological material requires visualization, conceptual reinforcement, and activities that connect the material to the students' surroundings. By combining the Problem-Based Learning model with Wordwalls, students not only gain a more active learning experience but are also encouraged to think critically as they solve environmental problems. Thus, learning is expected to improve conceptual understanding and student learning outcomes.

Several recent studies have demonstrated the effectiveness of PBL and Wordwall in improving science learning. PBL has been reported to improve students' learning outcomes, critical thinking skills, and learning engagement through problem-solving activities [11]. Similarly, Wordwall has been shown to enhance students' motivation, participation, and conceptual understanding through interactive, game-based learning activities [12]. These findings suggest that both PBL and Wordwall contribute positively to improving the quality of science learning.

Despite these promising findings, several research gaps remain. Most previous studies have investigated the effectiveness of PBL and Wordwall separately or have focused on science learning in general. In addition, studies integrating PBL with Wordwall have predominantly been conducted at the elementary and senior high school levels, whereas evidence regarding their implementation in junior high school biology learning remains limited, particularly in ecology. Furthermore, previous studies have mainly evaluated improvements in learning outcomes and motivation without emphasizing students' ability to relate ecological concepts to authentic environmental problems. Since ecology requires conceptual understanding as well as the ability to apply biological knowledge to real-world

contexts, further investigation into integrating PBL and Wordwall into ecology learning is needed.

This study addresses these gaps by investigating the effect of PBL assisted by Wordwall on students' learning outcomes in ecology at the junior high school level. The integration of a student-centered problem-based learning approach with interactive digital game-based media is expected to promote active learning, strengthen conceptual understanding, and enhance students' critical thinking and problem-solving skills in ecology. The findings of this study are expected to provide empirical evidence on the effectiveness of integrating PBL and Wordwall in biology instruction and to inform the development of innovative instructional strategies for junior high school science education.

Research Methods

This research was conducted at the UPT SMP Negeri 37 Medan, located at Jalan Timor No. 36 B, Gaharu Village, East Medan District, Medan City, North Sumatra 20234, during the even semester of the 2025/2026 academic year. This research used a quantitative, quasi-experimental design and employed a Nonequivalent Control Group Design [13]. It argues that a population is a generalised area comprising objects or subjects with specific quantities and characteristics that researchers can determine for study and the drawing of conclusions. The population in this study were all 251 seventh-grade students. The sample was selected using purposive sampling, resulting in two classes: class VII-B, the experimental class taught using the Problem-Based Learning (PBL) model with the aid of Wordwall, and class VII-E, the control class taught using the PBL model without the aid of media. The research instrument was a multiple-choice learning achievement test comprising 30 items that had undergone validity testing; the validity test results showed an r -table value of 0.355 (for $N = 31$ at a 0.05 significance level). An item was considered valid if r -count $>$ r -table. Of the 50 prepared test items, 30 were deemed valid, and 20 were invalid. A reliability test was subsequently conducted, yielding an r -count of 0.934, compared to an r -table value of 0.355 (for $N = 31$ at a 5% significance level). Items were considered reliable if r -count $>$ r -table; the results indicated that the items fell into the "very high" reliability category. Next, a difficulty level test was performed, revealing varying levels of difficulty among the items: out of the 50 tested items, 15 were categorized as easy and 35 as medium. Finally, a discrimination power test was conducted, identifying 30 items as "very good" and 20 as "poor." This instrument is used in the pre-test and post-test to measure students' cognitive learning outcomes on ecology [14].

The study began by administering a pre-test to both classes to assess students' initial proficiency, followed by implementing specific learning models: the experimental class received instruction using the PBL model supported by Wordwall, while the control class received instruction using the PBL model without media support. The PBL framework comprised five stages: student orientation to the problem, organization for learning, guidance during group inquiry, development and presentation of work, and analysis and evaluation of the problem-solving process, with the experimental class undergoing a Wordwall-based evaluation

during this final stage. Upon completion of the instruction, both classes took a post-test to determine the impact of the respective treatments on student learning outcomes. The collected data were subsequently analyzed using IBM SPSS Statistics version 21 at a significance level of 0.05. The analysis techniques included the Shapiro-Wilk test to assess data normality, Levene's test to assess homogeneity of variance, and an independent-samples t-test to determine the effect of the Wordwall-assisted PBL model on student learning outcomes.

Results and Discussion

Student learning outcomes were measured using a pretest and a posttest, both containing 30 multiple-choice questions. The pretest assessed students' initial abilities before the learning intervention, while the posttest measured their abilities after it. A comparison of students' cognitive learning outcomes in the experimental and control classes before and after learning is presented in Table 1.

Table 1. Mean and Standard Deviation of Learning Outcomes

Class	Pre-test Mean	SD	Post-test Mean	SD
Experiment	39.16	6.24	82.09	5.57
Control	38.80	4.34	71.72	3.80

Based on Table 1, the average pre-test score in the experimental class was 39.16 and in the control class 38.80. These results indicate that the initial abilities of students in both classes were relatively equal. After the learning process, learning outcomes improved in both classes, but the experimental class using Problem-Based Learning with word walls showed greater improvement than the control class using Problem-Based Learning without media.

The average post-test score in the experimental class was 82.09, while in the control class it was 71.72. This difference indicates that students who participated in the Problem-Based Learning model with word walls achieved better learning outcomes than those who participated in learning without media. Furthermore, the level of student learning completion in the experimental class was also higher than in the control class, indicating that the majority of students had achieved the established completion criteria.

A normality test was conducted to determine whether the pre-test and post-test data obtained in this study were normally distributed. Data normality testing was performed using the Shapiro-Wilk test in Statistical Package for the Social Sciences (SPSS) version 21 for Windows, with a significance level of 0.05. Data are considered normally distributed if the significance value is greater than 0.05 (sig.>0.05). The normality test results for student learning outcomes are shown in Table 2 below.

Table 2. Shapiro Wilk Normality Test Results

Variable	Class	Statistic	df	Sig	Ket.
Pre-test	Control	0.937	31	0.066	Normal
Post-test	Control	0.945	31	0.111	Normal
Pre-test	Experiment	0.938	31	0.073	Normal
Post-test	Experiment	0.947	31	0.130	Normal

Based on the analysis results presented in Table 2, the significance value of the pre-test learning outcomes in the experimental class (grade 3) was 0.073, while the significance value of the post-test (grade 4) was 0.130. Both values exceed the significance level (0.05), so the pre-test and post-test learning outcome data in the experimental class are normally distributed. In the control class, the significance value for the pre-test learning outcomes (grade 1) was 0.066, and for the post-test (grade 2) was 0.111. These values are also greater than the significance level of 0.05, indicating that the pre-test and post-test learning outcome data in the control class meet the assumption of normal distribution. Based on these test results, it can be concluded that all learning outcome data from both the experimental and control classes are normally distributed. With the fulfillment of this normality assumption, the research data are suitable for further analysis using parametric statistical tests, namely the homogeneity test and hypothesis testing (t-test).

A homogeneity test was conducted to determine whether the data obtained from the research sample groups had the same variance. In this study, the homogeneity test was conducted using SPSS version 21 for Windows, with the Levene test for the Homogeneity of Variance Test.

Table 3. Results of Levene's Homogeneity Test

Data	Levene Statistic	Sig.	Taraf Sig.	Information
Pre-test	0.768	0.189	> 0.05	Homogenous
Post-test	0.005	0.944	> 0.05	Homogenous

The results of the Levene test for homogeneity in cognitive abilities indicated that the p-value was greater than 0.05. Based on Table 3, the post-test significance value for both classes was 0.944, which is greater than the 0.05 significance level. This indicates that the data variance in the experimental and control classes is homogeneous, or the data distribution is uniform across groups.

Table 4. Results of the Independent Sample T-Test in the Post-test

Class	Average	Sig (2-tailed)	Taraf Sig
Experiment	71.71		
Control	82.10	0.000	> 0.05

Based on the results of the hypothesis test calculations in Table 5, significant data (2-tailed) of 0.000 was obtained. So it can be stated that $0.000 < 0.05$, the decision was taken that H_0 was rejected and H_a was accepted. Thus, it was concluded that the use of the Problem-Based Learning model, assisted by Wordwalls, influenced student learning outcomes in the ecology material for class VII at UPT SMP Negeri 37 Medan.

Cognitive learning outcomes are variables measured after implementing the PBL learning model, assisted by Wordwalls, for ecology material in the experimental and control classes. Providing pre-test questions to students in the experimental and control classes resulted in low scores. The resulting low scores because students did not yet have an overview of the material to be taught and discussed. After the material was delivered, post-test questions were administered to students to assess improvements in their cognitive learning outcomes. Based on Table 4.2, the class using the PBL model, assisted by Wordwalls, experienced a

greater increase in learning outcomes than the control class using the PBL learning model alone. Learning using the PBL model, supported by Wordwall media, showed progress in cognitive aspects such as conceptual understanding and application, affective interest and motivation to learn, as well as psychomotor classwork and higher-order thinking skills [15]. The results of data analysis using the hypothesis test "independent sample t-test" showed differences in significance values in the two samples, as evidenced by the increase in students' cognitive abilities after being taught with the PBL learning model assisted by Wordwalls.

Research shows that the PBL learning model, supported by Wordwall, can influence student learning outcomes in ecology. The PBL learning model, assisted by Wordwall, can make students more active and joyful in the learning process. This can be seen from several steps in the PBL learning model that are taught, namely (1) orientation, namely students are given pictures or videos of problems that are in accordance with the topic of ecology, namely regarding polluted river water that changes color to pitch black due to household waste and factory waste to identify ways to overcome river or environmental pollution contained in the Student Worksheet, here students may answer and provide arguments as freely as possible that have been provided in the LKPD. Students may answer correctly or incorrectly. Then, students are required to be more active in identifying problems related to river pollution and its impacts on organisms. This stage makes students more active, as evidenced by the seriousness and cohesion among groups. At this stage of formulating the problem, some students can understand how to formulate problems based on the problems presented (2) Organizing for learning, in this process, students join groups that have been determined by the teacher. (3) Guiding students in group investigations, at this stage, the author sees and guides students actively in discussing and answering each question by observing problems from the LKPD on ecological material, such as what the characteristics of life and ecosystems are suitable for fish in rivers, and then what are the general causes of river pollution. The activeness of students can be seen from the seriousness and cohesiveness between groups so that students can find answers to the problems that have been given, to obtain information, students are given the freedom to explore knowledge through various sources aimed at better understanding the material (4) Developing and presenting the results of the work, at this stage each group comes forward and presents the results of their discussion about "how the environment influences an organism" here other groups are free to ask or provide responses to the group that is presenting. Then after all groups have finished their presentations, the teacher provides reinforcement of the material and discusses each question in the LKPD together, and students are free to ask the teacher about anything they don't understand. (5) Analyze and evaluate the problem-solving process, at this stage invite students to put forward arguments or opinions from each group about the work that has been done to get the actual conclusion. First, the teacher directs students to complete an evaluation by closing all books and displaying Wordwall media to assess how much students understand of today's learning. At the evaluation stage, each student is required to answer every question displayed on the projector screen. After that, students are

required to provide conclusions related to the completed learning material.

The results of the study indicate that implementing the PBL model, integrated with Wordwall media, has a significant impact on student learning outcomes. This is indicated by the difference in learning outcomes between the group that participated in PBL learning with Wordwall support and the group that only implemented PBL without media support. The average post-test score in the experimental class was 82.09, higher than that of the control class (71.72), indicating a significant difference. Furthermore, the results of the Independent Samples t-test ($p < 0.05$) indicate that the use of Wordwalls in PBL learning significantly improves learning outcomes. Theoretically, this finding relates to the characteristics of PBL, which are oriented towards contextual problem-solving, active student involvement, and the development of higher-order thinking skills, with implications for improving cognitive learning outcomes. Suggest that PBL encourages students to analyze problems and find solutions independently, resulting in a deeper understanding of concepts. In line with this [16], emphasized that the discussion and inquiry processes in PBL enable students to actively construct knowledge [17]. Also stated that direct involvement in problem-based learning contributes to improved conceptual understanding, but without adequate media support, PBL implementation is often unable to optimally accommodate the participation of all students [18].

The use of word walls as supporting media has been shown to strengthen PBL implementation, especially in interactive and game-based learning evaluation activities. Stated that word walls can provide variation in the presentation of questions so that evaluation activities are not monotonous and more interesting for students [19]. Furthermore, revealed that the use of word walls can increase motivation to learn through elements of competition and enjoyable learning experiences [20]. From a cognitive engagement perspective, explained that interactive digital media allows for more intense interaction between students and learning materials [21]. This is reinforced by studies showing that providing immediate feedback helps students identify errors and improve their understanding, thereby positively impacting cognitive learning outcomes [22]. Conversely, PBL learning without interactive media tends to proceed conventionally, especially during the evaluation stage, resulting in less-than-optimal student participation. Stated that limited use of media in learning can hinder the active involvement of students, especially in the process of reflection and strengthening concepts [23].

The results of this study align with previous studies confirming that integrating innovative learning models and interactive digital media yields better outcomes than using learning models alone. Stated that the combination of appropriate learning strategies and media can increase the effectiveness of the learning process by creating a more meaningful learning experience [24]. Also added that interactive media not only increases motivation but also strengthens students' conceptual understanding [25]. Found that the use of digital media in problem-based learning can improve learning quality because it can accommodate the diversity of students' learning styles [26].

From a theoretical perspective, the effectiveness of integrating Wordwall into the PBL model can be explained

through the constructivist learning theory, which emphasizes that students actively construct knowledge through meaningful learning experiences. In the PBL process, students develop conceptual understanding by identifying authentic problems, discussing various alternative solutions, conducting inquiries, and reflecting on their findings. Wordwall complements these activities by providing interactive formative assessments, immediate feedback, and a game-based learning experience (gamification) that helps reinforce students' understanding of ecological concepts. The role of interactive media in supporting each stage of PBL aligns with the findings of Selviana and Andriani, which indicate that PBL-based interactive multimedia can improve student learning outcomes by facilitating active engagement, concept visualization, and more meaningful interaction throughout the learning process [27]. Immediate feedback enables students to recognize misconceptions and correct their understanding while the learning process is still taking place, thereby strengthening conceptual change and long-term knowledge retention. Furthermore, the gamification features of Wordwall, including interactive quizzes, scoring systems, and instant responses, increase students' intrinsic motivation and sustain their engagement throughout the learning process. Consequently, Wordwall functions not only as an assessment medium but also as a cognitive scaffold that supports students in organizing, strengthening, and applying the concepts acquired during each stage of Problem-Based Learning.

Although the findings demonstrate that integrating PBL and Wordwall significantly improves students' cognitive learning outcomes, several limitations should be considered when interpreting these results. First, this study involved a relatively limited sample from a single school, which may limit the generalizability of the findings to different educational settings. Second, the study employed a quasi-experimental design using intact classes rather than random assignment; therefore, differences in students' prior knowledge, learning characteristics, and classroom environments may have influenced the results despite comparable pre-test scores. Third, the effectiveness of Wordwall may also have been influenced by students' access to digital devices and internet connectivity, as well as their level of digital literacy. In addition, teacher competence in implementing the PBL model and facilitating classroom discussions may have contributed to students' participation and learning outcomes, representing potential confounding factors that were not fully controlled in this study.

These limitations provide important directions for future research. Further studies are recommended to involve larger and more diverse samples, employ randomized experimental designs where feasible, and investigate the long-term effects of integrating Wordwall into PBL on students' conceptual retention and higher-order thinking skills. Future research may also examine additional variables, such as students' digital literacy, learning motivation, and teacher instructional competence, to provide a more comprehensive understanding of how interactive digital media support the effectiveness of Problem-Based Learning in science education.

Conclusion

Based on the data analysis, it can be concluded that the PBL model supported by Wordwall has a significant impact on students' cognitive learning outcomes regarding the ecology topic in Grade VII at UPT SMP Negeri 37 Medan. This is evidenced by a greater increase in pre-test and post-test scores in the experimental class compared to the control class. This improvement in learning outcomes was driven by students' active participation in each stage of the PBL process and the use of Wordwall, which provided immediate feedback during the evaluation phase, thereby helping students grasp ecological concepts more effectively. Hypothesis testing results further confirm that implementing the Wordwall-assisted PBL model significantly affects student learning outcomes. These findings indicate that integrating digital media such as Wordwall into PBL is an effective way to enhance the quality of science education, particularly for topics requiring conceptual understanding and real-world application. Consequently, teachers are encouraged to integrate digital learning media into PBL implementation to foster a more active, innovative, and student-centered learning environment. Future research should examine the effectiveness of the Wordwall-assisted PBL model across a wider range of educational levels, subject matter, and school characteristics, and investigate its impact on students' critical thinking, creativity, problem-solving abilities, motivation to learn, and collaboration skills.

Author's Contribution

S.R. Samosir: played a role in designing the research, collecting data, analysing data, and compiling the research article manuscript. A.S. Batubara: contributed by providing conceptual direction, guiding the implementation of the research methodology, and reviewing and revising the manuscript to ensure it complies with scientific writing standards. M. Sitepu played a role in assisting the data collection process and supporting the implementation of learning during the research.

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