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From fun to insight: Problem-based learning with wordwall e-worksheets to enhance critical thinking and learning engagement in ecosystem topics

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Abstract

Critical thinking skills are increasingly vital in contemporary education, yet effective strategies to foster them remain underexplored. This study addressed this gap by examining the impact of problem-based learning supported by digital worksheets developed with an interactive platform on junior high school students' critical thinking skills and learning activities in the context of ecosystem topics. A quantitative approach with a quasi-experimental non-equivalent control group design was applied, using cluster random sampling. Data were collected through questionnaires, observations, tests, and documentation. Findings revealed that the experimental group demonstrated greater improvement in both critical thinking skills and learning engagement compared to the control group, with statistical analyses confirming significant differences between groups. The results indicate that integrating problem-based learning with interactive e-worksheets can enhance both cognitive and participatory aspects of learning. This approach offers a practical model for enriching science education and promoting higher-order thinking skills in secondary education.

Keywords: Critical thinking; digital learning; ecosystem education; problem-based learning; student engagement.

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1. INTRODUCTION

Critical thinking skills are essential for today's generation, especially in countries like Indonesia, where recent PISA (Programme for International Student Assessment) scores have highlighted the need for educational improvement. In 2023, Indonesia's reading, mathematics, and science performance was below the OECD average, placing it in the lower ranks globally. Indonesia has an average science score of 398, which is relatively low. With the rapid advancement of technology and science, students must have critical thinking skills to face future challenges. (Sapitri et al., 2022). Asmara & Septiana (2024) and Andreucci-Annunziata et al., (2023) stated that critical thinking skills in learning can provide opportunities for students to make discoveries and construct their knowledge. The PISA score reveals gaps in problem-solving abilities and analytical skills, which are crucial in the modern world. The PISA results reflect how well students can apply knowledge in real-life situations, emphasizing the need for skills like critical thinking and reasoning. Without these, students may struggle to comprehend complex issues, solve problems, or adapt to changes in the workforce. Critical thinking helps learners engage with content, analyze information, and make informed decisions.

Developing a strong foundation in critical thinking from a young age is essential (Çavuş et al., 2025). Early education must go beyond rote memorization to encourage questioning, reflection, and analysis. It builds the intellectual capacity to understand and solve real-world problems, thus equipping students with the tools needed for future challenges. By focusing on critical thinking in fundamental education, Indonesia can nurture a better-prepared generation for complex global issues and competitiveness in the job market. However, according to Nabila et al., (2022), many teachers dominate during science learning. It may cause students to be passive and not actively carry out learning activities. Student learning activities are fundamental and useful for honing the potential of each student so that specific behavioral changes can occur in the learning process (Besare, 2020). To effectively instill critical thinking in students, education must shift to more interactive and student-centered approaches, such as problem-based learning to help present real-world problems and encourage students to explore solutions, foster analytical thinking and creativity; inquiry-based learning to encourage students to ask questions, investigate, and reflect promotes more profound understanding and critical reasoning; collaborative learning to help them work in a group that encourages discussion, debate, and the development of multiple perspectives; and also a teacher training for nurturing critical thinking (Anggraeni et al., 2023). Providing professional development opportunities that equip educators with strategies to teach these skills is essential. Focusing on critical thinking will help Indonesia address its educational challenges, leading to higher student achievement and better preparedness for the future. However, the critical thinking of most Indonesian students still needs to be improved since many students tend to be passive during learning activities.

Some research results revealed that teachers can implement learning models that involve active learning. Indonesia has been implementing *Kurikulum Merdeka* and suggesting active learning models, including project-based learning (PjBL), problem-based learning (PBL), inquiry, and discovery learning. The problem-based learning model links learning with real problems as a context and facilitates students to improve their critical thinking skills and to obtain essential concepts and knowledge. PBL might improve critical thinking skills by engaging students in solving real-world problems that require analysis, inquiry, and reflection (Chen et al., 2024; Anyaehie et al., 2025). It encourages active problem-solving, where students break down complex issues, gather relevant information, and explore various solutions. Students are exposed to diverse perspectives through collaboration, promoting deeper analysis and argumentation. PBL also connects theory

with practical application, helping students apply knowledge in real-world contexts while fostering self-directed learning. This hands-on, inquiry-driven approach nurtures curiosity, adaptability, and reflective thinking, all essential components of critical thinking. Students can solve authentic problems to compile their knowledge, develop inquiries, improve their high-level thinking skills, and increase students' self-confidence and independence. PBL is a learning model based on the constructivist paradigm, which is oriented towards the student-centered learning process. Problems are used as a stimulus and the main focus in guiding the teaching and learning process, while the teacher acts as a guide and facilitator (Mayasari et al., 2022; Sharma et al., 2023).

In the "*Kurikulum Merdeka" (*Independent learning curriculum) of junior high school, one of the main topics in science learning related to problems in the daily life environment is the material on the influence of humans on ecosystems. The importance of studying this material is that students can understand and position themselves as part of living things that have a role in maintaining the balance of the ecosystem. The facts in the field related to the material on the influence of humans on ecosystems show that teachers dominate more during learning, and students are not used to problem-solving, finding ideas, and solving problems. Thus, the information obtained in learning is not optimal. In addition, students tend to be accustomed to memorizing when studying science concepts and materials, so the knowledge gained will only be momentary and quickly forgotten. If learning is not optimal, it can hinder critical thinking skills and learning activities. Therefore, innovation is needed in the implementation of science learning on the material on the influence of humans on ecosystems, which can be used to train students' critical thinking skills and learning activities. The implementation of problem-based learning as a learning model in the material on the influence of humans on ecosystems is expected to train critical thinking skills and learning activities because there are activities, including compiling knowledge, so that students can solve problems that exist in real life. It has been proven by research by Yarmalinda & Sineri (2020) that the results of students' critical thinking skills by implementation of the PBL model during learning activities on the material on the influence of humans on ecosystems result in higher results when compared to the results of students' critical thinking skills who do not apply the learning model. Students can improve their life skills, increase their understanding of the material, and be able to conduct analysis and evaluation based on the problems solved.

Implementing the PBL could be optimally achieved by assisting the learning process using student worksheets. The integration of e-worksheets in the PBL model enhances its effectiveness by providing structured tasks that guide students through the problem-solving process. E-worksheets can include a variety of multimedia elements, interactive questions, and reflection prompts that stimulate critical thinking. Research shows that digital worksheets make learning more interactive and help scaffold student understanding in PBL activities (Chen et al., 2020). The guided structure helps students organize their thoughts, track their progress, and reflect on their learning, all essential for developing critical thinking skills. Meanwhile, Wordwall is an interactive platform that allows educators to create engaging educational activities such as quizzes, matching games, and fill-in-the-blank exercises. It promotes active engagement, which is key to fostering critical thinking. Studies show that digital tools like WordWall enhance student motivation and engagement, leading to improved learning outcomes (Mahasneh & Alwan, 2021).

Wordwall's gamified approach makes learning enjoyable, allowing students to interact with content dynamically and receive immediate feedback, encouraging deeper thinking and problem-solving. Electronic worksheets or E-Worksheets with a Wordwall can be used as an alternative to the many types of interactive

learning media that can make learning activities more enjoyable, and students and educators since the Wordwall focuses more on learning styles that require students to take part in participate competitively with their friends while learning is taking place. (Ulfa et al., 2023). Wordwall-based E-Worksheets include learning activities by playing games on smartphones or other electronic devices. The games played follow critical thinking aspects to improve critical thinking skills and train students' learning activities. Aini et al. (2023) stated that Wordwall-based E-Worksheets could train the students' potential. Wordwall can provide stimulation to students in the form of play stimulation. Through playing, students are not only invited to be involved in the learning process, but while playing, students can gain knowledge and problem-solving mindsets in the form of ideas and behavior.

Several classroom-based studies demonstrate that combining PBL with E-Worksheets, especially using platforms like Wordwall, significantly improves critical thinking in junior high students. For example, a study by Yunita & Wahyudi (2021) found that students who engaged in PBL activities with E-Worksheets showed better problem-solving skills and were more adept at reasoning and analysis than those in traditional learning environments. Wordwall, in particular, was highlighted as an effective tool for creating interactive e-worksheets that engage students in critical thinking tasks. Research by Muzaini et al., (2023) shows that students exposed to PBL combined with digital tools like Wordwall demonstrated higher levels of engagement, curiosity, and cognitive development directly tied to critical thinking.

The gamified activities provided immediate feedback and allowed students to explore multiple solutions, fostering flexibility in thinking. Using Wordwall combined with e-worksheets allowed students to structure their thoughts better and approach problems methodically. While the PBL model with E-Worksheets and digital tools like Wordwall has successfully improved critical thinking, some challenges remain. Only a few research studies have been found to highlight the improvement of students' critical thinking skills and learning activities in the concept of the ecosystem by PBL and applying Wordwall-based E-Worksheet. Additionally, some educators reported that balancing guided instruction and independent learning can be difficult when relying on digital worksheets. Therefore, this current study was conducted to help improve students' critical thinking skills and learning activities by applying PBL with Wordwall E-Worksheet.

1.1. Purpose of study

This study aimed to analyze the implementation of problem-based learning supported by an electronic worksheet (E-Worksheet) utilizing Wordwall in developing students' critical thinking skills, as well as to examine its effectiveness in enhancing students' learning activities.

2. METHODS AND MATERIALS

2.1. Participants

This research was conducted at SMPN 2 Gabus in Karangrejo, Gabus, Grobogan, Central Java, Indonesia. The population used in this research was students of SMPN 2 Gabus Class VII for the 2023/2024 academic year, totaling 158 students. In this research, sampling was carried out using cluster random sampling, and the samples used were 32 students from class VII C as the experimental class and 32 students from class VII E as the control class. The students were asked by their teachers if they wanted to participate in this study because participation in this study was voluntary. All students from two classes agreed to participate and voluntarily signed active and informed consent forms.

2.2. Research design

The research design used in this study is a quasi-experiment with a non-equivalent control group design implemented in the classroom. The students learned the Science Subject on the topic of the Ecosystem. In this study, a pretest was conducted to determine the initial conditions and differences between the control class and the experimental class. Then, each class was given a different learning treatment. In the experimental class, treatment was given for the implementation of the problem-based learning model assisted by an E-Worksheet using Wordwall, and in the control class, treatment was given for the implementation of problem-based learning assisted by an E-Worksheet without Wordwall implementation. Furthermore, at the end of the meeting, a posttest was conducted on the control and experimental classes. The research design is presented in Table 1.

Table 1

Research design

Class	Pretest	Treatment	Posttest
Experimental class	O_1	X	O_2
Control class	O_3	Y	O_4

Source: Sugiyono (2014).

Description:

X : experimental class
Y : control class
O_1 : pretest experimental class
O_2 : posttest experimental class
O_3 : pretest control class
O_4 : posttest control class

2.3 Data collection instruments

Data collection techniques included questionnaires, observation, tests, and documentation. Questionnaire methods and observation methods were used to measure student learning activities. Test methods were used to measure students' critical thinking skills. Documentation methods were used to obtain data related to population size, sample size, and research documentation.

This research was conducted on March 4-29, 2024, at SMPN 2 Gabus, Central Java, Indonesia. The research was conducted in four meetings in experimental and control classes. Students in the experimental class and control class took a pretest before being given treatment and took a posttest after being given treatment. Students' critical thinking abilities were measured from the pretest and posttest results. Meanwhile, a questionnaire sheet and observation sheet were used to obtain learning activity data, and the results were calculated using the Likert Scale. Students filled out the questionnaire sheet independently, and the researcher filled out the observation sheet during the research.

This study used test and non-test instruments. The test instruments used were pretest and posttest questions. The pretest and posttest questions consisted of 10 descriptive questions based on indicators of critical thinking skills on the material on human influence on ecosystems. The test instrument was used to measure students' critical thinking skills. The non-test instruments used in this study were questionnaire

sheets and observation sheets. The questionnaire and observation sheets were made based on indicators of student learning activities to measure student learning activities during the learning process (Table 2).

Table 2

Critical thinking skills and learning activities indicators measured in the application of problem-based learning by Wordwall-based e-worksheet

Problem-Based Learning assisted by E-Worksheet using Wordwall	Indicators	
	Critical Thinking Skills	Learning Activities
1. Orientation of students to the problem (YouTube videos and news information boxes on E-Worksheet)	Analysis	Learning independency
2. Organizing students for learning (Wordwall barcode link)		Participation
3. Guide individual and group investigations (Wordwall game at each meeting)	Inference Analysis Interpretation Explanation Evaluation Self-regulation	Participation Learning Creativity
4. Developing and presenting results (presentation of E-Worksheet work results)	Explanation	Participation Courage
5. Analyze and evaluate the problem-solving process (reflection box on E-Worksheet)	Evaluation Self-regulation	Participation

2.4. Data analysis technique

The research results obtained from the experimental class and control class were (1) pretest and posttest data, (2) data on students' learning activity questionnaire, and (3) data on students' learning activity observation. Data analysis to measure students' critical thinking skills included the N-gain, Related T-test, and ANOVA tests. The Likert Scale was used to measure students' learning activities.

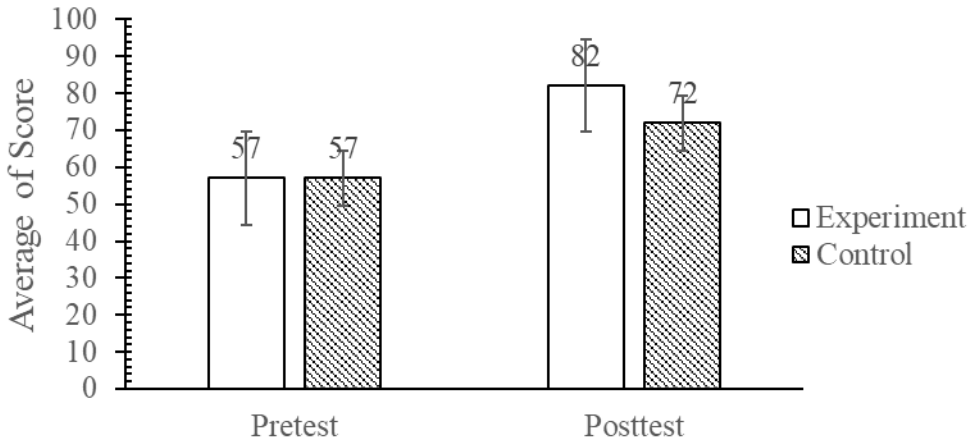
3. RESULTS

3.1. Critical thinking skills

Students' critical thinking abilities were measured using pretest and posttest data. The pretest was carried out at the beginning of learning before treatment was given. The pretest results showed that the experimental and control classes had the same average score (57). It can be concluded that students' initial critical thinking abilities in the two classes were homogeneous at the beginning of the research. The posttest was carried out after the experimental class and control class were given different treatments, i.e., the experimental class was given treatment by implementing the problem-based learning model assisted by Wordwall-based E-Worksheet, and the control class was given treatment by implementing the problem-based learning model assisted by only E-Worksheet. The posttest results showed a difference in average scores; the experimental class had an average score of 82, and the control class had an average score of 72. The results of the pretest and posttest data can be seen in Figure 1.

Figure 1

Pretest and posttest results of the experiment and control classes



The data results from the pretest and posttest were tested using a normality test to determine whether the data were normally distributed or not normally distributed. The normality test was also carried out to determine the type of data analysis that can be used at the next stage. The results of the pretest normality test are presented in Table 3, and the posttest normality test in Table 4.

Table 3

Pretest normality test

Data	Class	X^2_{count}	X^2_{table}	Criteria
Pretest	Experiment	3.257	11.07	Normally distributed
	Control	9.366		Normally distributed

Table 4

Posttest normality test

Data	Class	X^2_{count}	X^2_{table}	Criteria
Posttest	Experiment	7.154	11.07	Normally distributed
	Control	1.939		Normally distributed

The data in Tables 3 and 4 show that the results of the normality test of the pretest and posttest data in the experimental class and control class are all normally distributed because $X^2_{count} < X^2_{table}$. The pretest and posttest data showed a normal distribution, meaning that the N-Gain test was then carried out to determine the increase in students' critical thinking abilities. The results of the analysis of the increase in students' critical thinking skills can be seen in Table 5.

Table 5

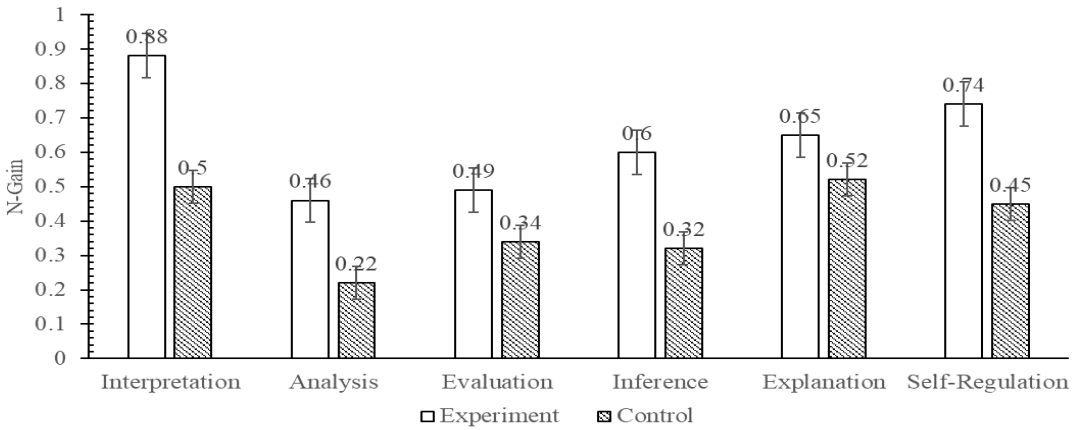
N-Gain Test Results

Data	Experiment		N-Gain	Control		N-Gain
	Pretest	Post-test		Pretest	Post-test	
Average	57	82	0.57 (Medium)	57	72	0.33 (Medium)

Based on Table 5, it can be seen that there is an increase in students' critical thinking abilities in the experimental class, with N-Gain test results of 0.57 with medium criteria, and in the control class with N-Gain test results of 0.33 with medium criteria. These results show that the experimental class had a higher increase in critical thinking skills than the control class, so it can be stated that implementing the problem-based learning model, assisted by using an E-Worksheet, with Wordwall, improved students' critical thinking skills. The N-Gain Test results also show an increase in each indicator of critical thinking ability. N-Gain on critical thinking ability indicators is presented in Figure 2.

Figure 2

N-gain results for critical thinking ability indicators in experiment and control classes



The N-Gain test was also carried out on each indicator of critical thinking ability to determine the increase in students' critical thinking ability on each indicator. Based on Figure 2, indicator 1 (interpretation), which is the ability to express and understand the meaning and intent of data, situations, rules, assessments, procedures, and various criteria, measured from question number 10, shows the N-Gain results in the experimental class of 0.88 (high) and control class 0.5 (medium) with a difference of 0.38. In indicator 2 of the analysis, namely the ability to clarify conclusions based on the relationship between concepts and information with questions contained in the problem, as measured by questions number 1 and 2, the N-Gain results in the experimental class were 0.46 (medium) and the control class 0.22 (low). Hence, it has a difference of 0.24. In indicator 3 of evaluation (the ability to be able to assess the credibility of a representation or other statement of opinion or provide an assessment of a conclusion based on the relationship between concepts and information), with questions contained in the problem measured from

questions number 2 and 4, showing the N-Gain results. In the experimental class, it is 0.49 (medium), and in the control class, 0.34 (medium), with a difference of 0.15. In indicator 4, the inference identifies the elements needed to draw rational conclusions by considering information relevant to the problem and its consequences based on the data presented, measured from questions 3, 5, and 9. The results indicate that the N-Gain in the experimental class is 0.6 (medium), and the control class is 0.32 (medium). Thus, there is a difference of 0.28. In indicator 5, the explanation is the ability to give a reasoning statement when providing a reason for justifying a concept, evidence, methodology, and logical criteria based on existing data or information, where reasoning is made in the form of an argument measured from question number 7 shows The N-Gain result in the experimental class is 0.65 (medium) and the control class is 0.52 (medium) with a difference of 0.13. Indicator 6 of self-regulation is the ability to have awareness to carry out checks on one's cognitive activities, the elements used in activities, and the results of these activities by utilizing the ability to analyze and evaluate to confirm, validate, and correct the results of the reasoning that has been implemented before. Indicator 6, measured from question number 6, shows the N-Gain result in the experimental class is 0.74 (high) and the control class is 0.45 (medium) with a difference of 0.29. The average difference in N-Gain for each indicator is 0.245. The highest N-Gain difference was obtained by indicator 1 and the lowest by indicator 5.

The post-test data, which had been tested for normality and the N-Gain test, were then analyzed using a related T-test comparative test to determine whether there were significant differences in the implementation of the problem-based learning model assisted by E-Worksheet using Wordwall on the critical thinking abilities of junior high school students. The results of the T-test related to the posttest scores for the experimental and control classes can be seen in Table 6.

Table 6

Related T-Test results

Class	Average	Df	t_{count}	t_{table}	Information
Experiment	25.03	62	5.47	1.67	Significant
Control	15.00				

The ANOVA test was used to determine whether there was a difference in implementing the problem-based learning model assisted by E-Worksheet using Wordwall on students' critical thinking abilities. The differences in the ANOVA test can be seen if the significance value (p-value) is lower than 5% (0.05), then Ho is rejected and Ha is accepted. The results of the significance value (p-value) from the ANOVA test on the posttest scores for the experimental and control classes can be seen in Table 7. It shows a significant value, meaning there is a difference in the posttest average for experimental and control class students. Therefore, learning in the experimental class used the implementation of the problem-based learning assisted by E-Worksheet using Wordwall, which shows an effect compared to the control class, which was treated with the implementation of the problem-based learning model assisted by E-Worksheet only.

Table 7

ANOVA test results

Class	Number of Students	*P-value*
Experiment	32	0.00
Control	32	

Based on the description above, it can be concluded that the differences in treatment given can influence students' critical thinking abilities. Students in the experimental class who had been treated with the implementation of problem-based learning assisted by E-Worksheet using Wordwall had a higher increase in critical thinking skills compared to the control class, which had been treated with the implementation of problem-based learning assisted by E-Worksheet. Following research by Fajriani et al., (2023), Wordwall effectively improved the critical thinking skills of Generation Z students. The differences obtained are quite significant because the use of Wordwall media contains activities that follow indicators of critical thinking skills, and students became more active because the Wordwall game used includes critical thinking skills (interpretation, analysis, evaluation, inference, explanation, and self-regulation).

3.1.1. Interpretation

Interpretation is the ability to express the meaning or meaning of a problem and understand it. This interpretation ability was improved by doing the following Wordwall game:

Figure 3

Wordwall for the interpretation skill

(A)

(B)

Figure 3A is the Wordwall that the experimental class must work on at the second meeting, and Figure 3B is the Wordwall that must be worked on at the fourth meeting. It was aimed to train in improving critical thinking skills in the interpretation aspect because, in working on Wordwall, students can interpret, analyze, synthesize, and also describe relevant information to determine answers following research by Widowati & Yonata (2023) that Wordwall quizzes are suitable for improving students' critical thinking skills in science learning.

3.1.2. Analysis

Analysis is concluding and identifying relationships between questions, statements, descriptions, concepts, or other forms. This analytical ability was trained by playing the following Wordwall game:

Figure 4

Wordwall for analysis skill

(A)

(B)

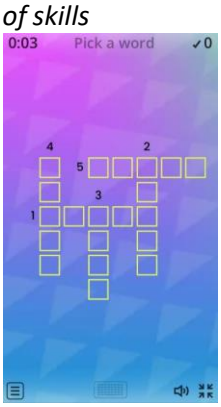
Figures 4A and B are the Wordwalls the experimental class must work on at the first meeting. Wordwall quiz game in this research only used two answer choices to improve critical thinking skills in the analytical aspect because, when working on Wordwall, students can analyze information to understand it well and draw conclusions to determine the right answer according to research. Ma'rifah & Mawardi (2022) Studied that Wordwall quizzes could improve students' critical thinking skills because there are analysis activities to determine answers.

3.1.3. Evaluation

Evaluation is an ability in the form of being able to assess the credibility of a representation or question and logically think about the relationships that exist between descriptions, statements, questions, and concepts. This evaluation ability was trained by doing the following Wordwall game:

Figure 5

Wordwall for evaluation of skills



(A)

(B)

Figure 5A is the Wordwall used in the experimental class at the first meeting, and Figure 5B is the Wordwall for the fourth meeting. Wordwall is a form of crossword game used to improve critical thinking skills in the evaluation aspect because, when working on Wordwall, students can access the credibility of a statement based on the relationship between information and concepts to find the correct answer. Hapsari

et al. (2023) stated that the use of one of the Wordwall games that can improve students' critical thinking skills is the crossword puzzle game because students can find ideas and abilities independently, and are more active in solving problems, and the teacher only acts as a facilitator.

3.1.4. Inference

Inference is obtaining the elements needed to draw conclusions and identify them. This inference ability was trained by doing the following Wordwall game:

Figure 6

Wordwall for inference skill

(A)

(B)

Figure 6A is the Wordwall used at the third meeting, and Figure 6B is for the second meeting. The Wordwall used in this phase is a matching game used to improve critical thinking skills in the inference aspect because, when working on the Wordwall, students can pay attention to the elements presented to identify and draw conclusions. According to Rohman & Khaliza's (2024) statement, they can put the correct answer that Wordwall questions are structured like a matching game, using problems that require students to think logically, analyze information, make the right decisions, and improve critical thinking skills.

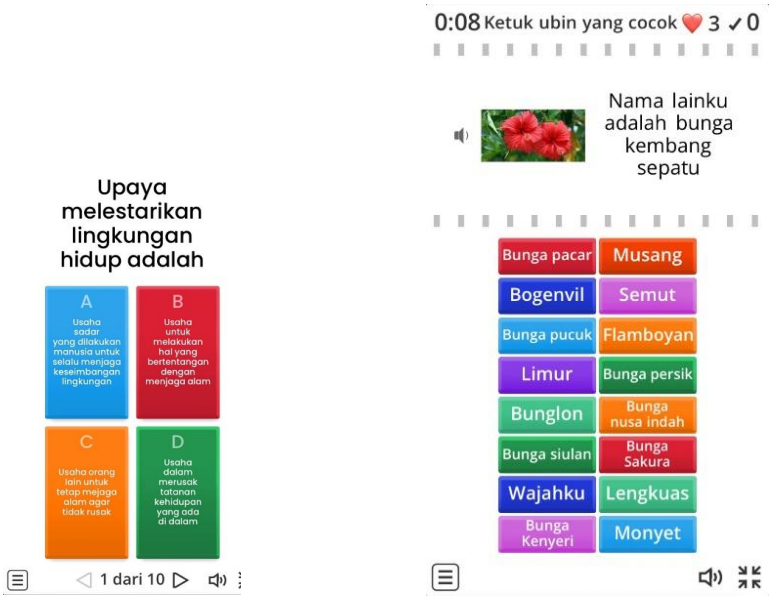
3.1.5. Explanation

Explanation is the ability to provide and establish logical reasons based on the results obtained. Explanation skill was trained by doing the following Wordwall game:

Figure 7A shows the Wordwall used in the third meeting, namely a quiz game with long answer choices used to train to improve critical thinking skills in the explanation aspect. Using this Wordwall form, students can train their ability to determine answers and reason logically by establishing reasons for choosing the correct answer. Figure 7B is a Wordwall that the experimental class worked on at the fourth meeting, in the form of a game, in the form of questions explaining a living thing's characteristics. Thus, in this form, students must determine the correct answer based on the explanation. According to Rohman & Khaliza (2024), a competitive Wordwall can stimulate student motivation and help strengthen information. Wordwall quizzes and matching personalize the learning so that teachers can adjust learning materials according to students' needs and difficulty levels to improve critical thinking skills.

Figure 7

Wordwall for explanation skill



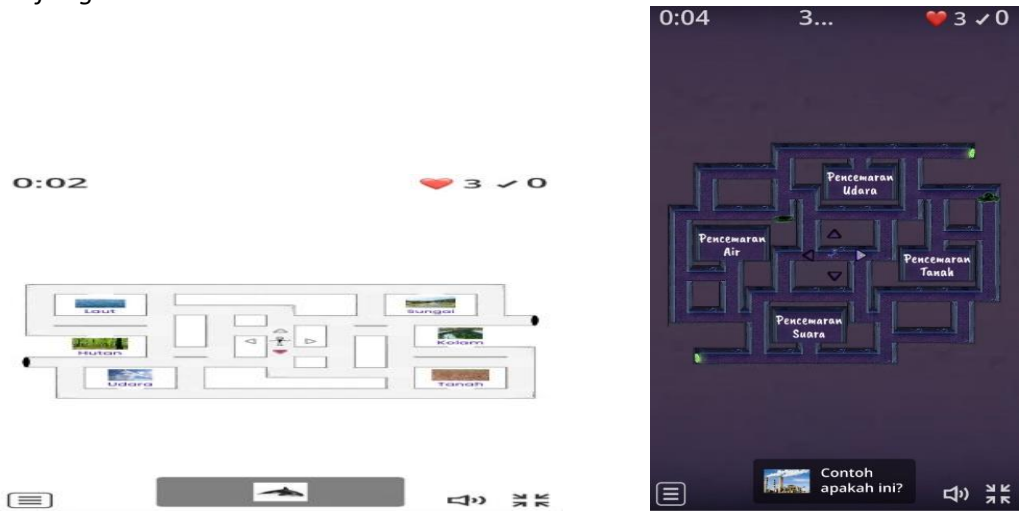
(A) (B)

3.1.6. Self-regulation

Self-regulation is the ability to monitor a person's cognitive activities and every element applied in activities to solve a problem, especially in the implementation of evaluating and analyzing abilities. This self-regulation ability was improved by playing the following Wordwall game:

Figure 8

Wordwall for Self-regulation Skill



(A) (B)

Figure 8A is the Wordwall used in the experimental class at the second meeting, and Figure 8B is the Wordwall used in the third meeting. The Wordwall was in the form of a chase game in a maze. The chase in the maze is to run to the correct answer zone by avoiding enemies. This Wordwall is used to improve critical thinking skills in the aspect of self-regulation because, when working on the Wordwall, students can check their cognitive activities by answering questions while having to run a maze chase. According to Rahmatika & Septiana (2024), maze chase games or chasing in a maze could improve critical thinking skills because students can concentrate on fun learning.

3.2. Learning activities

Student learning activities are activities that are both mental and physical. According to Yunis (2021), in learning activities, students must be more dominant and active in participating to develop their potential. Student learning activities are measured using questionnaires and observation sheets. After completing the entire learning sequence, students filled out the questionnaire at the last meeting. Observations were carried out by researchers in the experimental and control classes during the learning activities to understand the learning activities of students participating in the learning activities. The criteria for learning activities in this study were measured into 4 criteria (very good, good, fair, and not good). The questionnaire results and observation of learning activities were said to be complete if the percentage of indicators reached the good criteria. The results of the questionnaire sheet analysis showed that the learning activities of the experimental class students were 95.31% very good and 4.69% good, while the questionnaire sheet analysis of the learning activities of the control class students was 12.5% very good and 87.5% good. The results of the analysis of the observation sheet show that the learning activities of the experimental class students are 100% very good, while the results of the analysis of the observation sheet of the learning activities of the control class students are 28% very good and 72% good.

The results of learning activities based on questionnaire sheets and observation sheets were analyzed to obtain the average results of students' learning activities. The average results of student learning activities can be seen in Table 8. The results of learning activities were said to be complete if the percentage of indicators reached good criteria. The analysis of the average learning activity results shows that the experimental class learning activities were excellent (100% very good). In comparison, the control class showed that 18.75% were very good in each category and 81.25% were good. It can be seen that the experimental class had better learning activities compared to the control class. Students' learning activities from questionnaire sheets and observation sheets were analyzed based on learning activity indicators according to Ahmadi & Supriyono (2013), which can be seen in Figure 9.

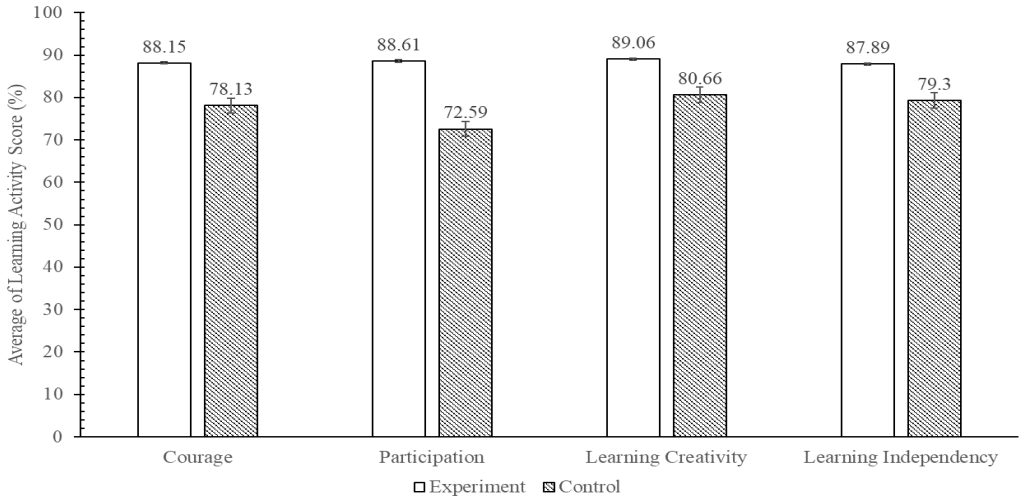
Table 8

Average results of student learning activities

No	Criteria	Average of Percentage (%)	
		Experimental Class	Control Class
1.	Very Good	100	18.75
2.	Good	-	81.25
3.	Fair	-	-
4.	Not Good	-	-

Figure 9

Learning activities score for each indicator



3.2.1. Courage

The courage aspect is the desire to express one's needs, interests, and problems. This indicator is based on when learning activities occur, where students dare to ask questions to the teacher, dare to be speakers during presentations, and dare to respond to other groups presenting. From the analysis, it can be concluded that the courage in the experimental class was better than in the control class. This result is due to the statement by Ma'rifah & Mawardi (2022) The use of internet media, one of which is Wordwall, can make students have the courage to learn new ideas and concepts.

3.2.2. Participate

The participation aspect is the desire to use the opportunity to participate in learning activities, including preparation, process, and evaluation. This indicator reflects the learning activities where students participate when the teacher gives apperception, answers the teacher's questions, does assignments and discussions, responds to ideas, and interacts with other friends regarding learning. The results of the questionnaire sheet on the participation indicator concluded that in the experimental class, the students were better at participating compared to the control class. According to Puspitarini (2023)Wordwall media can make students participate more actively in learning because Wordwall uses games to make learning more fun, and existing games can foster curiosity, encouraging students to get the best score.

3.2.3. Learning creativity

Learning creativity reflects the performance of various types of business, and learning creativity in carrying out and completing a series of learning activities to achieve success. This indicator shows that learning activities occur where students actively work on their tasks and have high self-confidence while participating in learning activities. The results of the questionnaire sheet on the learning creativity indicator concluded that in the experimental class, students had better learning creativity compared to the control

class. This result is from research by Novyanti et al. (2022) that Wordwall increased students' learning creativity, especially cognitive creativity, which can be seen from learning results.

3.2.4. Learning independence

Learning independence shows the freedom and independence of students in carrying out an activity without any pressure from the teacher or other parties. This indicator is reflected when learning activities occur, where students look for additional sources of information and feel enthusiastic about doing the pretest and posttest. The results of the questionnaire sheet on the Learning Independence Indicator concluded that in the experimental class, the students were better at independent learning than in the control class. According to research by Wardani et al., (2022), Wordwall can increase students' Learning independence because Wordwall makes students memorize the material provided by the teacher, and students can understand it directly through learning activities with their group.

4. CONCLUSIONS

Based on the research findings, the implementation of problem-based learning supported by a Wordwall-based electronic worksheet (E-Worksheet) enhanced students' critical thinking skills, as evidenced by improvements in N-Gain scores and the results of the t-test and ANOVA, which indicated significant differences between the experimental and control classes. The approach also improved students' learning activities, with the experimental class achieving higher average activity scores than the control class.

A project-based learning model incorporating a Wordwall-based E-Worksheet can be employed to further develop students' critical thinking skills and learning activities in ecosystem-related topics. When applying alternative learning models, the Wordwall activities should be adapted to align with the model's instructional syntax, and learning activities should be implemented by the prescribed sequence of the chosen model.

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