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The Effect of Wordwall-Assisted Discovery Learning on Grade XI Students' Critical Thinking Skills

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Abstract: This study aimed to determine the effect of Wordwall-assisted discovery learning on the critical-thinking skills of Grade XI students at SMAN 01 Montong Gading in the topic of the human reproductive system. A quantitative quasi-experimental approach with a pretest–posttest control-group design was employed. The sample comprised two classes selected through purposive sampling: Class XI-F.1 as the experimental group and Class XI-F.2 as the control group. The instruments consisted of an essay test of critical-thinking skills and an instructional implementation observation sheet. The data were analyzed using tests of normality and homogeneity followed by one-way ANOVA. The results indicated that Wordwall-assisted discovery learning had a statistically significant effect on students' critical-thinking skills, $p < .001$; therefore, H0 was rejected and Ha was accepted. The findings suggest that Wordwall-assisted discovery learning may be used as an alternative instructional approach to promote student engagement, conceptual understanding, and critical-thinking skills in the topic of the human reproductive system.

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Introduction

Biology education is part of science and encompasses facts, laws, and principles derived through scientific processes. It also requires problem-solving abilities supported by critical-thinking skills (Afriadi & Yuni, 2018). A range of strategies and methods can be used to help teachers present biological concepts and assist students in understanding them. These approaches include lectures, discussions, question-and-answer activities, laboratory work, expository teaching, and inquiry-based learning (Marsaoly et al., 2023).

Based on observations and an interview with a biology teacher at SMAN 01 Montong Gading, laboratory activities were frequently used to help students understand biological concepts in more concrete and contextual ways. However, their implementation was constrained by limited teaching aids, outdated laboratory equipment, and insufficient practical materials. These conditions prevented experiments from being implemented optimally and potentially hindered the development of students' critical-thinking skills and academic achievement.

The initial observation involved four classes: XI-F.1, XI-F.2, XI-F.3, and XI-F.4. The summative scores recorded for these classes were 15, 16, 61, and 61, respectively. These results indicated that students' conceptual understanding and mastery of the subject matter had not yet reached an optimal level. This condition may have been influenced by several factors, including instructional strategies and learning models that had not fully supported the development of students' critical-thinking skills.

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In the school context, critical thinking refers to students' ability to examine information thoroughly, evaluate arguments objectively, and make decisions based on careful consideration (Ngatminiati et al., 2024). It also involves investigating, connecting, and evaluating different aspects of a situation or problem, including the ability to collect, organize, recall, and analyze information (Tutiliana et al., 2025).

One possible response to these problems is to shift the instructional paradigm toward a more student-centered learning process. Such a shift requires the use of learning models that position students as active participants. One model that may support the development of critical-thinking skills is discovery learning combined with engaging instructional media.

According to Haeruman et al. (2017), discovery learning can improve critical-thinking skills because students are not provided with concepts in their final form. Instead, they are guided to discover concepts through the stages of stimulation, problem identification, data collection, data processing, verification, and conclusion drawing. These stages actively engage students in mental processes such as analysis, evaluation, and logical and systematic problem solving, thereby providing greater opportunities for critical-thinking development than conventional instruction.

Instructional media can also contribute to the development of students' critical-thinking skills. Instructional media include teaching aids and other means used to convey messages from learning resources to students. Web-based instructional media represent a form of e-learning that has become increasingly common in educational institutions; Wordwall is one example of such media (Hapsari & Pamungkas, 2019).

Wordwall is an engaging browser-based application designed as a learning resource, instructional medium, and enjoyable assessment tool. It enables teachers to create interactive quiz-based games and present learning material in a more engaging manner. Such activities may reduce monotony during instruction and support the development of students' critical-thinking skills (Saptaaji et al., 2023).

Research Method

Research Design

This study employed a quantitative approach and a quasi-experimental design. It involved an experimental group and a control group and aimed to determine the effect of Wordwall-assisted discovery learning on students' critical-thinking skills.

Experimental Design

The study used a pretest–posttest control-group design involving two intact classes that were selected non-randomly according to specific considerations. The experimental group completed a pretest to measure initial critical-thinking skills and then received instruction through Wordwall-assisted discovery learning. After the instructional treatment, the group completed a posttest to assess changes in critical-thinking skills. The control group also completed a pretest, received conventional instruction, and then completed a posttest. The research design is presented in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental	O1	X1	O3
Control	O2	X2	O4

Notes:
O1 : Pretest for the experimental group
O2 : Pretest for the control group
O3 : Posttest for the experimental group
O4 : Posttest for the control group
X1 : Treatment using the discovery learning model *assisted by Wordwall*
X2 : Treatment using conventional instruction

Population and Sample

The population consisted of Grade XI students at SMAN 01 Montong Gading in the 2025/2026 academic year. The sample was selected using purposive sampling. According to Lenaini (2021), purposive sampling is a method used to select participants according to criteria that are relevant to the research objectives. Two classes were included in the sample: XI-F.1 and XI-F.2. Class XI-F.1 consisted of 32 students and served as the experimental group, whereas Class XI-F.2 also consisted of 32 students and served as the control group. The classes were selected based on their mean summative scores, which indicated that they had relatively comparable initial abilities and were therefore appropriate for inclusion in the study.

Table 2. Number of Students and Mean Scores

Class	Number of Students	Mean Score
XI-F.1	32	15
XI-F.2	32	16
XI-F.3	34	61
XI-F.4	31	61

Research Setting and Time

The study was conducted at SMAN 01 Montong Gading in May 2026 during regular school hours.

Research Instruments

The instruments used to collect data on the effect of Wordwall-assisted discovery learning on students' critical-thinking skills were as follows.

1) Test

Critical-thinking skills were measured using 10 essay items administered before the treatment (pretest) and after the treatment (posttest). The items were developed based on critical-thinking indicators and the cognitive levels of Bloom's taxonomy, particularly C4–C6.

2) Observation

An observation sheet was used to monitor the implementation of Wordwall-assisted discovery learning. The observations were conducted by a teacher or research assistant during the learning process.

3) Instrument Validation

A validation form was used to evaluate the feasibility of the instructional materials and research instruments before data collection. The validated components included the teaching

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module (lesson plan), test instrument, and instructional implementation observation sheets. The validation was conducted by lecturers from the Biology Education Study Program, Universitas Pendidikan Mandalika. The criteria used to interpret the validation results are presented in Table 3.

Table 3. Validation Criteria

Percentage	Category
81%–100%	Very Valid
61%–80%	Valid
41%–60%	Moderately Valid
≤ 40%	Less Valid

The validity percentage was calculated using the following formula: Validity score = (total score obtained / maximum possible score) × 100%. The validation results for the instructional materials and research instruments are presented in Table 4.

Table 4. Validation Results

No	Validated Instrument	Validator 1	Validator 2	Decision
1	Teaching Module (Lesson Plan)	90%	75%	Suitable for Use
2	Test Instrument	90%	82.5%	Suitable for Use
3	Experimental-Group Implementation Observation Sheet	90%	87.5%	Suitable for Use
4	Control-Group Implementation Observation Sheet	87.5%	82.5%	Suitable for Use

As shown in Table 4, all instructional materials and research instruments, including the teaching module (lesson plan), test instrument, and instructional implementation observation sheets for the experimental and control groups, were considered suitable for use. The assessments provided by the two validators indicated that all components met the feasibility criteria in terms of content, construction, language, and presentation. Therefore, the materials and instruments were considered appropriate for guiding instruction and collecting research data.

Data Collection Techniques

1) Test

The test instrument was used to measure critical-thinking skills in relation to cognitive learning outcomes. It was administered before instruction (pretest) and after instruction (posttest) in both groups to identify differences in the improvement of critical-thinking skills between the experimental group, which received Wordwall-assisted discovery learning, and the control group, which received conventional instruction.

2) Observation

Observation sheets were used to collect data during the learning process in both the experimental and control groups. Observations were conducted at each meeting to determine the extent to which the planned learning activities were implemented.

3) Documentation

Documentation was used to complement the research data by collecting evidence related to the learning process and outcomes in both groups. The collected materials included students'

test results, notes recorded during instruction, and photographs or video recordings of the learning activities. These materials were used to strengthen the research evidence and provide a more concrete description of classroom implementation.

Data Analysis Techniques

The data analysis procedures were used to determine the effect of Wordwall-assisted discovery learning on students' critical-thinking skills. The analyzed data consisted of pretest and posttest scores from the experimental and control groups. Before hypothesis testing, prerequisite analyses were conducted to assess normality and homogeneity.

1) Normality Test

The normality test was used to determine whether the critical-thinking scores were normally distributed. The Shapiro–Wilk test was selected because the number of students in each group was fewer than 50. The pretest and posttest scores of the experimental and control groups were analyzed using SPSS.

The decision criteria were as follows:

a. If Sig. > .05, the data are normally distributed.
b. If Sig. ≤ .05, the data are not normally distributed.

The Shapiro–Wilk test is frequently used in educational research because it has good statistical power for relatively small samples.

2) Homogeneity Test

The homogeneity test was conducted to determine whether the variances of the experimental and control groups were equal. This test was performed as a prerequisite for parametric hypothesis testing. Levene's and Bartlett's tests are commonly used to assess homogeneity of variance; Levene's test is generally more robust when the data deviate from normality. In this study, Levene's test was applied to the pretest and posttest scores using SPSS.

3) One-Way ANOVA

Hypothesis testing was conducted using one-way analysis of variance (ANOVA). This test was used to determine whether statistically significant differences existed among the group means. The assumptions of normality and homogeneity were assessed before the analysis. A significance value below .05 indicated a statistically significant difference among the groups, leading to rejection of H0 and acceptance of Ha. Conversely, the significance value above .05 indicated no statistically significant difference, leading to acceptance of H0 and rejection of Ha. Thus, one-way ANOVA was used to examine the effect of the treatment on students' critical-thinking scores by comparing the group means.

Result and Discussion

This study examined the effect of Wordwall-assisted discovery learning on the critical-thinking skills of Grade XI students at SMAN 01 Montong Gading in the topic of the human reproductive system. It was conducted during the second semester of the 2025/2026 academic year and involved Class XI-F.1 as the experimental group and Class XI-F.2 as the control group.

The study began with a pretest to assess students' initial critical-thinking skills. The experimental group then participated in Wordwall-assisted discovery learning, whereas the

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control group received conventional instruction. After the instructional period, both groups completed a posttest to measure their critical-thinking skills following the treatment.

The pretest and posttest data were analyzed using normality and homogeneity tests followed by one-way ANOVA in SPSS to determine the effect of Wordwall-assisted discovery learning on students' critical-thinking skills.

Implementation of Learning

The implementation of learning was observed in both the experimental and control groups. The observation sheet was aligned with the planned instructional procedures. The results are presented in Table 5.

Table 5. Instructional Implementation Results

Group	Meeting 1	Meeting 2	Mean	Criterion
Experimental	95.24%	95.24%	95.24%	Very Good
Control	90.00%	90.00%	90.00%	Very Good

As shown in Table 5, the instructional implementation score was 95.24% in the experimental group and 90.00% in the control group. Both groups were classified as very good, indicating that the learning activities were implemented in accordance with the planned procedures.

Pretest and Posttest Scores

Table 6. Mean Pretest and Posttest Scores

Group	Mean
Control Pretest	27.48
Control Posttest	69.81
Experimental Pretest	31.54
Experimental Posttest	73.93

As shown in Table 6, the control group's mean score increased from 27.48 on the pretest to 69.81 on the posttest, representing an increase of 42.33 points. The experimental group's mean score increased from 31.54 to 73.93, representing an increase of 42.39 points. Both groups therefore demonstrated improvements in critical-thinking skills after instruction. However, the experimental group obtained a higher posttest mean than the control group. This result suggests that Wordwall-assisted discovery learning produced better outcomes than the instruction provided to the control group. The mean pretest and posttest scores are also displayed in Figure 1.

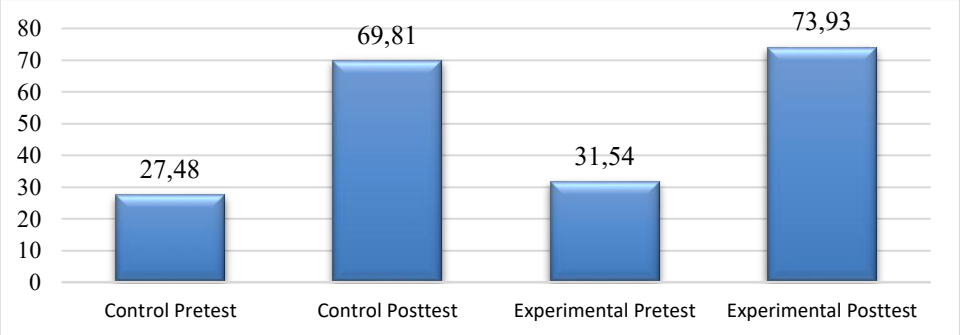

Figure 1. Mean Pretest and Posttest Scores of the Control and Experimental Groups

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Normality Test

The normality test was conducted to determine whether the data were normally distributed. The Shapiro–Wilk test was used because the number of students in each group was fewer than 50. Data were considered normally distributed when the significance value exceeded .05. The results are presented in Table 7.

Table 7. Normality Test Results

Group	Statistic	df	Sig.
Control Pretest	.935	27	.091
Control Posttest	.936	27	.099
Experimental Pretest	.966	28	.481
Experimental Posttest	.963	28	.419

Table 7 shows that the Shapiro–Wilk significance values were .091 for the control-group pretest, .099 for the control-group posttest, .481 for the experimental-group pretest, and .419 for the experimental-group posttest. Because all values were greater than .05, the pretest and posttest data for both groups were considered normally distributed.

Homogeneity Test

The homogeneity test was conducted to determine whether the variances of the experimental and control groups were equal. This assumption was assessed before hypothesis testing with one-way ANOVA. The data were considered homogeneous when the significance value exceeded .05. The results are presented in Table 8.

Table 8. Homogeneity Test Results

Basis	Levene Statistic	df1	df2	Sig.
Based on Mean	.661	3	106	.578
Based on Median	.489	3	106	.691
Based on Median and Adjusted df	.489	3	101.924	.691
Based on Trimmed Mean	.663	3	106	.577

Levene's test results in Table 8 show a significance value of .578 for the row based on the mean. Because this value was greater than .05, the variances were considered homogeneous. The homogeneity assumption was therefore satisfied, and the analysis could proceed using parametric hypothesis testing.

One-Way ANOVA

One-way analysis of variance (ANOVA) is a parametric statistical procedure used to determine whether statistically significant differences exist among two or more group means. In this study, it was used to examine the effect of Wordwall-assisted discovery learning on students' critical-thinking skills. The test was conducted after the assumptions of normality and homogeneity had been satisfied. The results are presented in Table 9.

Table 9. One-Way ANOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51368.886	3	17122.962	111.066	.000
Within Groups	16341.886	106	154.169		
Total	67710.773	109			

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The one-way ANOVA results in Table 9 yielded $F = 111.066$ and $p < .001$. Because the p-value was below .05, H0 was rejected and Ha was accepted. These results indicated statistically significant differences among the group means.

A post hoc analysis using Tukey's honestly significant difference (HSD) test was subsequently conducted to identify the pattern of differences among the groups. The results are presented in Table 10.

Table 10. Tukey HSD Results

Group	N	Homogeneous Subset	Mean
Control Pretest	27	1	27.4815
Experimental Pretest	28	2	31.5357
Control Posttest	27	3	70.1852
Experimental Posttest	28	4	74.8214

The Tukey HSD results at $\alpha = .05$ showed that the control-group pretest (27.4815), experimental-group pretest (31.5357), control-group posttest (70.1852), and experimental-group posttest (74.8214) were located in different homogeneous subsets. This result indicated statistically significant differences among all four conditions. The experimental-group posttest had the highest mean, suggesting that the treatment provided to the experimental group produced better learning outcomes than the instruction provided to the control group.

Discussion

The prerequisite tests indicated that the data met the assumptions required for one-way ANOVA. According to Rahayu et al. (2025), ANOVA is a parametric statistical method used to compare more than two group means when the assumptions of normality and homogeneity of variance are satisfied. The hypothesis test indicated that Wordwall-assisted discovery learning had a statistically significant effect on students' critical-thinking skills.

This effect may be explained by the opportunities provided by discovery learning for students to construct knowledge through a sequence of learning activities. Rather than receiving information passively, students observed phenomena, identified problems, searched for relevant information, processed data, verified their findings, and drew evidence-based conclusions. Discovery learning has been reported to support critical-thinking development because it encourages students to explore, investigate, and observe biological phenomena actively (Ayu et al., 2025).

Each stage of discovery learning plays a role in developing students' critical-thinking skills. During stimulation, students encounter a phenomenon or problem related to the reproductive system, which is intended to arouse curiosity. During problem statement formulation, students identify and define the problem to be addressed. At the data-collection stage, they gather relevant information through discussions, learning materials, and other resources. The information is then examined during data processing so that students can connect the concepts they have learned. Verification encourages students to compare their analyses with relevant theories or scientific evidence, whereas generalization requires them to formulate conclusions based on the available evidence. Through these stages, students practice interpretation, analysis, evaluation, and inference, thereby supporting the development of critical-thinking skills (Cahyaningsih & Assidik, 2021).

In addition to the learning model, Wordwall supported interactive and game-based learning activities. Through anagram games and crossword puzzles, students appeared more

motivated to participate in the lesson, focused more closely on the material, and responded more actively to questions and problems. Interactive Wordwall activities have been reported to support student motivation and engagement (Prawiyata et al., 2025). Active and enjoyable learning may also help students construct knowledge and develop critical-thinking skills more effectively (Fitriana & Indriyani, 2024).

The control group also demonstrated an increase in critical-thinking scores from pretest to posttest. However, the increase in the experimental group was slightly greater. This difference suggests that combining discovery learning with Wordwall may provide additional support for critical-thinking development. A discovery-oriented learning process combined with interactive media can create a more engaging, challenging, and meaningful learning environment and encourage students to examine learning material more deeply (Suhenda et al., 2024).

Based on the analysis and discussion, Wordwall-assisted discovery learning had a statistically significant effect on the critical-thinking skills of Grade XI students at SMAN 01 Montong Gading in the topic of the human reproductive system. The effect was indicated by statistically significant differences among the group means, with $p < .001$. Wordwall-assisted discovery learning created an active, interactive, and student-centered learning environment that supported the development of interpretation, analysis, evaluation, and inference—key components of critical thinking.

Conclusion

Based on the one-way ANOVA results, Wordwall-assisted discovery learning had a statistically significant effect on the critical-thinking skills of Grade XI students at SMAN 01 Montong Gading in the topic of the human reproductive system. The p-value was below .001, indicating statistically significant differences among the groups. Therefore, Wordwall-assisted discovery learning may be considered as an alternative instructional approach for supporting students' critical-thinking skills.

Recommendation

The following recommendations are proposed:

1) Teachers are encouraged to use this learning model as an alternative approach in biology instruction, particularly for topics that require analysis and problem-solving skills. Wordwall may also be used to increase student engagement and motivation and to create a more interactive and meaningful learning experience.
2) Future researchers are encouraged to examine Wordwall-assisted discovery learning in different subject areas and educational levels to strengthen the evidence regarding its effectiveness in improving students' critical-thinking skills.

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