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The Effect of Problem-Based Learning Assisted by Animated Video on Biology Students' Creativity

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Abstract

Creativity is a key competency that needs to be developed through Biology learning to meet the demands of twenty-first-century education. This study aims to determine the effect of Problem-Based Learning (PBL) assisted by animated video on students' creativity in Biology learning. The study employed a quantitative quasi-experimental design with a nonequivalent control group design, involving 50 Grade XI students divided into experimental and control classes. Data were collected using pretest and posttest instruments based on four creativity indicators, fluency, flexibility, originality, and elaboration, and analyzed using ANCOVA with pretest scores as covariates. The results show that students' creativity in the experimental class increased significantly compared to the control class, with ANCOVA indicating a significant treatment effect ($p < 0.05$) and a large effect size. It can be concluded that PBL, assisted by animated video, is more effective than conventional learning at enhancing students' creativity. These findings suggest that integrating problem-based learning with interactive digital media can be an effective strategy for fostering creativity and supporting the implementation of innovative, student-centered Biology learning.

Keywords: animated video; biology learning; creativity; problem based learning; quasi-experimental design

INTRODUCTION

Students' creativity is one of the essential competencies required in twenty-first-century education and has become increasingly important in Biology learning. Biology requires students not only to memorize concepts but also to analyze living phenomena, interpret relationships among biological systems, propose explanations, and solve contextual scientific problems (Ramanda et al., 2022; Seragih & Sirait, 2023). Therefore, students need creativity to build meaningful understanding and respond adaptively to scientific challenges. In this study, creativity is measured using four indicators: fluency, flexibility, originality, and elaboration. Fluency refers to the ability to generate many relevant ideas, flexibility refers to the ability to examine problems from different perspectives, originality refers to the ability to produce uncommon or unique responses, and elaboration refers to the ability to develop ideas in greater detail. The development of these dimensions is important because it contributes to deeper conceptual understanding, active participation, and better scientific problem-solving in Biology classrooms (Lockwood & Mooney, 2017; Wu, T. T., *et al.,* 2024).

Because creativity is highly important, instructional approaches that actively involve students are needed. One relevant model is Problem-Based Learning (PBL), which emphasizes authentic problem-solving, collaborative inquiry, and active knowledge construction. Through PBL, students are encouraged to identify problems, seek relevant information, discuss alternative explanations, and present solutions. These learning stages are closely related to the development of creativity (Herawadini et al.). The problem orientation stage can foster fluency by encouraging students to generate many initial ideas. Investigation and discussion activities can foster flexibility by prompting students to compare problems from various viewpoints. The stage of developing and presenting solutions can foster originality by challenging students to propose unique and meaningful responses. Reflection and refinement activities can stimulate elaboration, as students are expected to expand and explain their ideas in greater detail. Therefore, PBL has strong theoretical potential to improve students' creativity in Biology learning (Napitupulu & Syahputra, 2023).

Previous studies have shown that PBL and digital learning media provide positive contributions to Classroom learning. Maslinawati (2021) reported that animated videos

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had a positive effect on students' creativity in science learning. Trisnawati *et al.* (2024) found that PBL assisted by animation media improved students' learning outcomes, while Malkan *et al.* (2023) showed that PBL supported by animated video contributed positively to students' science literacy. These findings indicate that PBL and animation media have strong educational benefits. However, several problems remain. First, many previous studies focused on learning outcomes, literacy, motivation, or general academic performance rather than on creativity itself. Second, studies that discussed creativity often did not explicitly measure it through the indicators of fluency, flexibility, originality, and elaboration. Third, despite the theoretical advantages of active learning, Classroom practice is still often dominated by conventional teacher-centered instruction that limits students' opportunities to explore ideas, express opinions, and solve problems creatively (Jainab, 2025; Husna *et al.,* 2025). In the specific context of Grade XI at Senior High School 10 Mataram, Biology instruction was also found to be lecture-based, leading to students being passive, less confident, and less engaged in learning activities. This condition indicates that students' creativity in Biology learning has not yet been optimally developed.

Based on these gaps, this study aimed to analyze the effect of Problem-Based Learning assisted by animated video on the creativity of Grade XI students in Biology learning at Senior High School 10 Mataram. The novelty of this study lies in three aspects. First, it integrates PBL with animated video as an innovative instructional strategy, whereas previous studies mostly examined PBL or animation media separately (Rahayu, 2023; Sofyan & Komariah, 2016). Second, it specifically evaluates students' creativity through four measurable indicators: fluency, flexibility, originality, and elaboration. Third, it provides empirical evidence from a local senior high school context that has received limited scholarly attention. Unlike previous studies that mainly emphasized learning outcomes, literacy, or broader academic achievement, this study focuses directly on the development of creativity in Biology learning. The expected scientific implication is to strengthen theoretical and practical understanding that creativity can be fostered more effectively through problem-oriented instruction supported by interactive digital media (Nasution *et al*., 2024). In addition, the findings are expected to offer teachers an alternative learning strategy that is more active, meaningful, and relevant to the demands of twenty-first-century education.

MATERIALS AND METHODS

Time and Place

This research was conducted at Senior High School 10 Mataram, located at Jl. Dr. R. Soedjono, Lingkar Selatan, Jempong Baru, Sekarbela District, Mataram City, West Nusa Tenggara, Indonesia. The school was selected because it represents a senior high school context in which Biology learning is still required more innovative instructional approaches to enhance students' creativity, particularly through active and technology-supported learning. In addition, the school provided accessible classes and learning conditions relevant to the objectives of this study (Nurasiah *et al.,* 2024).

The study was carried out during the first semester of the 2025/2026 academic year, specifically in September 2025. The research implementation consisted of three meetings in the experimental class and three in the control class. Each meeting followed the regular school schedule for Biology instruction. The learning material used in this study focused on regulatory processes in plants, as this topic contains conceptual and process-based content suitable for problem-oriented learning and visual explanations through animated video.

Research Design

This study employed a quantitative quasi-experimental design with a nonequivalent control group. This design was considered appropriate because the existing school classes could not be randomly reassigned for research purposes, so intact classes were used as the experimental and control groups (Darna & Herlina, 2018; Sari *et al.,* 2017). Both groups were given a pretest and a posttest, but only the experimental group received the treatment in the form of Problem-Based Learning assisted by an animated video, while the control group received comparison instruction based on the regular teaching practice applied at school.

Because no random assignment was conducted, potential selection bias may occur. To minimize this risk, the researcher selected two parallel Grade XI classes with relatively similar academic characteristics, as indicated by school records, class level, and comparable prior Biology learning conditions. In addition, students' initial equivalence was assessed using pretest scores administered before the treatment was implemented. The descriptive results showed that the mean pretest creativity score in the experimental class was 58.52, while the control class obtained 58.84, indicating that both groups had relatively similar baseline conditions. Furthermore, pretest scores were treated as covariates in the ANCOVA analysis to statistically control initial differences between groups and to ensure that posttest differences more accurately reflected the treatment effect.

Thus, the use of a non-equivalent control group design in this study was methodologically relevant because it allowed comparison between two naturally existing classes while still controlling potential bias through baseline matching, pretest measurement, and covariate adjustment.

Population and Sample

The population of this study consisted of all Grade XI students of Senior High School 10 Mataram in the first semester of the 2025/2026 academic year. The sample comprised 50 students: 25 in the experimental class and 25 in the control class. The sample was selected using purposive sampling because the classes were not randomly assigned, and the selection was based on specific research considerations (Hasanah et al., 2018). The experimental and control classes were selected from parallel Grade XI classes with similar academic characteristics, not special classes, and comparable initial Biology learning conditions, based on school considerations and pretest results. The independent variable in this study was Problem-Based Learning assisted by an animated video, while the dependent variable was students' creativity. Data were collected through pretest and posttest administration to determine students' initial and final creativity levels after treatment. The instrument used was a validated creativity checklist with a scoring scale of 1–4, supported by learning tools in the form of teaching modules, animated videos, and learning materials on regulatory processes in plants. The creativity checklist was based on four indicators: fluency, flexibility, originality, and elaboration. Fluency refers to students' ability to generate many relevant ideas, flexibility refers to the ability to propose different perspectives or alternative solutions, originality refers to the ability to produce unique or uncommon responses, and elaboration refers to the ability to develop ideas in greater detail. These indicators served as the primary basis for measuring students' creativity in both the experimental and control classes (Jainab, 2025).

Research Procedure

The research procedure was carried out in three main stages: preparation, implementation, and data analysis. In the preparation stage, the researcher developed lesson plans, teaching modules, animated video media, and creativity assessment instruments. All research instruments were validated before implementation. Afterward, two parallel Grade XI classes were determined as the experimental and control groups based on the established sampling criteria.

In the implementation stage, both classes were first given a pretest to measure students' initial creativity. The same Biology teacher taught both the experimental and control classes to minimize teacher-related bias and to ensure consistency in Classroom management, learning objectives, and content delivery. The experimental class received treatment through Problem-Based Learning, assisted by an animated video, over three meetings. At the beginning of each meeting, students were introduced to contextual biological problems related to plant regulatory processes. The animated video was then played on the Classroom projection system for approximately 10–15 minutes in each meeting. The video was used to visualize biological processes, stimulate students' curiosity, and provide problem contexts for discussion. During and after the video presentation, students were encouraged to note key information, identify problems, ask questions, discuss ideas in groups, and formulate solutions based on evidence from the material. Each group then presented its findings, followed by guided activities on feedback, reflection, and conclusion.

Meanwhile, the control class received comparison instruction in line with the regular teaching practice commonly used in schools. The teacher explained the material through lectures, question-and-answer sessions, and textbook-based discussions, without using Problem-Based Learning syntax or animated video media. Students in the control class mainly received explanations, answered teacher questions, and completed learning tasks individually or in a conventional Classroom discussion.

After all treatments were completed over three meetings, both classes were given a posttest to measure students' creativity. The final stage of the procedure involved scoring the collected data, conducting statistical analysis, interpreting the findings, and drawing research conclusions.

Data Analysis Techniques

The research data were analyzed quantitatively using descriptive and inferential statistics with SPSS Statistics 22. Descriptive analysis was first conducted to determine the mean scores, score improvement, and distribution of students' creativity in both groups. To facilitate qualitative interpretation, creativity scores were classified into three categories: low, moderate, and high. Scores below 60 were categorized as low, 60–79 as moderate, and 80–100 as high. This categorization was used to provide a clearer description of students' creativity levels before and after treatment.

Before hypothesis testing, prerequisite tests were conducted to ensure that the data met the assumptions of parametric statistics. The normality of the data was tested using the Shapiro–Wilk test, while the homogeneity of variance between groups was tested using Levene's Test. The data were considered normally distributed and homogeneous when the significance value was greater than 0.05.

After the assumptions were fulfilled, the hypothesis was tested using Analysis of Covariance (ANCOVA) with pretest scores as covariates. This analysis was used to control for students' initial differences in creativity, so that posttest differences between the experimental and control groups more accurately reflected the treatment effect. Statistical significance was determined at the 0.05 level.

To strengthen the interpretation of findings, effect size analysis was also considered. In this study, Partial Eta Squared (η^2) obtained from ANCOVA was used to determine the magnitude of the treatment effect. The effect size was interpreted as small ($\eta^2 < 0.06$), moderate ($0.06 \leq \eta^2 < 0.14$), and large ($\eta^2 \geq 0.14$). Therefore, the statistical results were interpreted not only based on significance values, but also based on the practical magnitude of the treatment effect on students' creativity (Sukestiyarno dan Agoestanto, 2017; Cohen, 1988).

RESULTS AND DISCUSSION

Result

Descriptive Results of Students' Creativity

The descriptive analysis showed that the initial creativity levels of students in the experimental and control classes were relatively similar. In the experimental class, the mean pretest score was 58.52, with a standard deviation of 5.19, and scores ranged from 50 to 68. In the control class, the mean pretest score was 58.84, with a standard deviation of 6.65, and scores ranged from 47 to 71. These results indicate that, before treatment, both classes had comparable initial creativity levels and remained in the low category.

After the treatment, the mean posttest score of the experimental class increased to 83.52, with a standard deviation of 5.19; scores ranged from 75 to 93. In contrast, the control class reached a mean posttest score of 63.72, with a standard deviation of 6.76, ranging from 50 to 76. Based on the score classification used in this study, the experimental class's posttest creativity was in the high category, whereas the control class's was in the moderate category. These findings indicate that the increase in creativity in the experimental class was substantially higher than that in the control class.

To provide a clearer comparison of students' creativity before and after treatment, the results are presented in Figure 1.

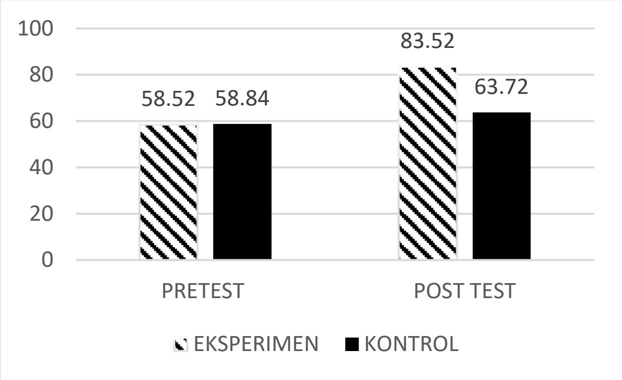

Figure 1. Mean pretest and posttest scores of students' creativity in the experimental and control classes.

Figure 1 shows that both classes improved after learning, but the increase in the experimental class was greater than that in the control class. The mean scores of students' creativity are presented in Table 2.

Table 2. Descriptive Statistics of Students' Creativity Scores

Group	Test	Mean	SD	Min	Max	Category
Experimental	Pretest	58.52	5.19	50	68	Low
Experimental	Posttest	83.52	5.19	75	93	High
Control	Pretest	58.84	6.65	47	71	Low
Control	Posttest	63.72	6.76	50	76	Moderate

Based on Table 2, the experimental class showed an absolute gain of 25.00 points, whereas the control class increased by only 4.88 points. In relative terms, the normalized gain (N-gain) of the experimental class was 0.60, falling into the moderate category, whereas the control class had an N-gain of 0.12, categorized as low. These findings indicate that Problem-Based Learning assisted by animated video not only improved students' creativity in absolute terms, but also produced a stronger relative increase toward the maximum score.

Prerequisite Test Results

Before conducting hypothesis testing, prerequisite tests were performed to determine whether the data met the assumptions of parametric analysis, namely normality and homogeneity of variance. The normality test results are presented in Table 3

Table 3. Summary of Shapiro–Wilk Normality Test for Creativity Scores

Variable	Statistic	df	Sig.
Pretest Experimental	0.969	25	0.545
Posttest Experimental	0.969	25	0.545
Pretest Control	0.967	25	0.526
Posttest Control	0.962	25	0.450

Based on Table 3, all significance values were greater than 0.05, indicating that the pretest and posttest creativity scores in both classes were normally distributed. Then, the homogeneity test results are presented in Table 4. The table label was revised to refer specifically to creativity rather than computational thinking to avoid inconsistency with the variable being analyzed.

Table 4. Summary of Levene's Homogeneity Test for Creativity Scores

Variable	Levene Statistic	df1	df2	Sig.
Pretest Creativity	0.747	1	48	0.392
Posttest Creativity	1.143	1	48	0.291

Based on Table 4, the significance values for pretest and posttest were both greater than 0.05. Therefore, the variances of the two groups were homogeneous, and the assumptions required for ANCOVA were fulfilled

Hypothesis Testing Results

After the prerequisite assumptions were satisfied, hypothesis testing was conducted using Analysis of Covariance (ANCOVA), with pretest scores as covariates. This analysis was used to control students' initial creativity levels so that posttest differences between the two groups could be interpreted more accurately as the effect of the treatment. The ANCOVA results are presented in Table 5.

Table 5. Summary of ANCOVA Results for Students' Creativity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4900.500	1	4900.500	134.932	0.000	0.738
Intercept	270995.220	1	270995.220	7461.665	0.000	0.994
Class	4900.500	1	4900.500	134.932	0.000	0.738
Error	1743.280	48	36.318			
Total	277639.000	50				

Based on Table 5, the significance value for the class factor was 0.000 ($p < 0.05$), indicating that Problem-Based Learning assisted by animated video had a significant effect on students' creativity. The Partial Eta Squared value of 0.738 indicates a large effect size, showing that the treatment had a strong practical effect on creativity development. In addition, the covariate analysis indicates that pretest scores functioned to control initial differences between groups, so that the posttest differences can be interpreted as primarily associated with the treatment rather than merely reflecting students' baseline characteristics.

Discussion

Discussion of Descriptive Results

The substantial improvement in the experimental class indicates that Problem-Based Learning, assisted by animated video, was more effective than conventional learning at fostering students' creativity. Referring to Table 2, the increase from the low category at pretest to the high category at posttest in the experimental class reflects a meaningful development of creativity. This increase can be interpreted more concretely using the four indicators measured in this study: fluency, flexibility, originality, and elaboration. During the problem orientation stage, students were encouraged to generate many initial ideas, which reflects fluency. During the investigation and group discussion, students examined problems from different viewpoints, reflecting flexibility. When presenting solutions, students were required to produce more unique and meaningful answers, which reflects originality. Finally, when refining responses and drawing conclusions, students were encouraged to expand and detail their ideas, which reflects elaboration.

The use of animated video also strengthened this process. In the topic of regulatory processes in plants, concepts such as tropism, nastic movement, and hormonal regulation are relatively abstract when explained only verbally. Through animated video, students were able to observe more concrete visual representations of how plants respond to stimuli and how internal regulatory mechanisms operate. This visual support helped students understand the problem context more easily, compare alternative explanations, and develop more detailed scientific responses. Thus, animated video did not merely function as supporting media, but as a stimulus that enriched the creative process during PBL. This interpretation is consistent with previous studies reporting that animated video can positively influence creativity and that animation-supported learning improves students' engagement and understanding (Maslinawati, 2021; Jannah *et al.,* 2023; Trisnawati *et al.,* 2024).

Discussion of Prerequisite Test Results

The normality and homogeneity results indicate that the creativity data met the assumptions required for parametric analysis. This is important because if the assumptions had not been fulfilled, the comparison between groups using ANCOVA would have been less reliable and alternative non-parametric procedures might have been needed. Therefore, the fulfillment of these assumptions strengthens the validity of the subsequent statistical interpretation. This explanation can be presented briefly because the main technical information is already clearly shown in Tables 3 and 4.

Discussion of Hypothesis Testing

The ANCOVA results confirmed that Problem Based Learning assisted by animated video had a significant and strong effect on students' creativity after controlling for pretest scores. This point is important because the study used a quasi-experimental design without full randomization. By including pretest as a covariate, the analysis reduced the influence of initial differences between groups, so the posttest differences can be interpreted more confidently as the effect of the treatment. In other words, the higher creativity achievement in the experimental class was not merely due to differences in students' initial characteristics but was mainly associated with the learning intervention implemented during the study.

The large effect size ($\eta^2 = 0.738$) indicates that the treatment had substantial practical value. This finding supports previous research indicating that problem-based learning and animation-based instruction positively affect student learning outcomes (Masriah *et al.,* 2019). However, the present study extends earlier findings by showing that the combination of PBL and animated video specifically supports students' creativity in Biology learning through the indicators of fluency, flexibility, originality, and elaboration (Kotimah *et al*., 2024). More specifically, students in the experimental class were challenged to solve contextual problems related to regulatory processes in plants, such as explaining why plants bend toward light, why roots grow downward, and how plant hormones regulate movement responses. The animated video helped visualize these processes more clearly, while the PBL stages guided students to analyze the problems collaboratively and to construct varied, meaningful, and detailed scientific explanations. This combination appears to be one of the main reasons why the treatment produced a strong effect on students' creativity.

CONCLUSION

Based on the results of this study, it can be concluded that Problem-Based Learning assisted by animated video had a significant effect on the creativity of Grade XI students in Biology learning at Senior High School 10 Mataram. The experimental class showed higher creativity scores than the control class, as indicated by the ANCOVA results (Sig. = 0.000; $p < 0.05$) and a large effect size (Partial Eta Squared = 0.738). Thus, the objective of this study was achieved: to determine the effect of Problem-Based Learning assisted by animated video on students' creativity, as measured by fluency, flexibility, originality, and elaboration. Therefore, this learning model can serve as an innovative and effective alternative for improving creativity in Biology learning.

These findings imply that combining student-centered learning models with interactive digital media can be an effective strategy to foster creativity in Biology education. However, this study is limited by its sample size and research scope within a single school context. Future research is recommended to involve larger and more diverse samples, as well as to explore the long-term impact of such interventions and their application in different subject areas. Additionally, further studies may investigate how specific components of Problem-Based Learning and multimedia integration contribute to the development of creativity.

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AUTHOR'S CONTRIBUTION

All authors made significant intellectual contributions to this work and approved the final version of the manuscript before submission.

Table of Author Contributions

Contribution Indicator	Author			
	1	2	3	4
Conceptualization	✓			
Literature Review	✓	✓		
Research Design / Methodology	✓	✓		✓
Instrument Development	✓			
Data Collection		✓	✓	
Data Curation		✓		✓
Formal Analysis	✓	✓		✓
Data Interpretation	✓	✓	✓	
Writing – Original Draft	✓			
Writing – Review & Editing	✓	✓	✓	
Visualization / Tables	✓			
Supervision	✓	✓	✓	✓

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