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The Effect of Blended Learning on Student Learning Outcomes in Biology FMIPA State University of Makassar

Pengaruh Blended Learning terhadap Hasil Belajar Mahasiswa Jurusan Biologi FMIPA Universitas Negeri Makassar

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Abstract. Student learning outcomes are still a challenge in higher education, especially in a learning system that is still teacher-centered and lack interactivity. Therefore, it is necessary to improve the quality of learning through more responsive and flexible approaches, such as blended learning. This study aims to analyze the effect of implementing blended learning on the learning outcomes of biology students in the Faculty of Mathematics and Natural Sciences (FMIPA) at the University of Makassar (UNM). This study employed a quasi-experimental design with random sampling. The study population consisted of all Biology Department students at FMIPA UNM enrolled in the Cell and Molecular Biology course. The sample comprised 75 students divided into three classes: two experimental classes and one control class. The assessment instrument used was a learning outcome test in the form of multiple-choice questions. Data analysis was conducted descriptively and inferentially using a one-way ANOVA test. The results showed that Experimental Class 1, which implemented blended learning, achieved a higher average learning outcome score compared to Experimental Class 2 and the control class. The ANOVA test indicated a significant difference between the groups ($p < 0.05$). Thus, blended learning has a significant effect on student learning outcomes.

Keywords: biology; blended_learning; learning_outcomes; students

Abstrak. *Hasil belajar mahasiswa masih menjadi tantangan dalam pendidikan tinggi, khususnya pada sistem pembelajaran yang cenderung berpusat pada dosen (teacher-centered) dan kurang interaktif. Oleh karena itu, diperlukan peningkatan kualitas pembelajaran melalui pendekatan yang lebih responsif dan fleksibel, seperti blended learning. Penelitian ini bertujuan untuk menganalisis pengaruh penerapan blended learning terhadap hasil belajar mahasiswa Biologi FMIPA UNM. Penelitian ini menggunakan desain kuasi eksperimen dengan teknik pengambilan sampel secara acak. Populasi penelitian adalah seluruh mahasiswa Jurusan Biologi FMIPA UNM yang mengikuti mata kuliah Biologi Sel dan Molekuler. Sampel penelitian berjumlah 75 mahasiswa yang terbagi ke dalam tiga kelas, yaitu dua kelas eksperimen dan satu kelas kontrol. Instrumen yang digunakan berupa tes hasil belajar dalam bentuk soal pilihan ganda. Analisis data dilakukan secara deskriptif dan inferensial menggunakan uji ANOVA satu jalur. Hasil penelitian menunjukkan bahwa kelas eksperimen 1 yang menerapkan blended learning memperoleh nilai rata-rata hasil belajar lebih tinggi dibandingkan kelas eksperimen 2 dan kelas kontrol. Uji ANOVA menunjukkan adanya perbedaan signifikan antar kelompok ($p < 0,05$). Dengan demikian, blended learning berpengaruh signifikan terhadap hasil belajar mahasiswa.*

Kata Kunci*: biologi; blended_learning; hasil_belajar; mahasiswa.*

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1. Introduction

Improving student learning outcomes remains a significant concern in higher education, particularly within instructional systems that are predominantly lecturer-centred. Traditional face-to-face teaching methods often fall short in fostering deep conceptual understanding, especially when students are expected to engage in independent learning and apply concepts to real-life contexts (1). Several factors contribute to this challenge, such as limited student engagement, the passive nature of lecturer-dominated instruction, and the complexity of content that requires more interactive and technologically supported learning approaches (2), (3), (4), (5). Previous studies have also shown that low student participation in learning activities can lead to suboptimal learning outcomes, as students are not actively engaged in the process of knowledge construction (6). One pedagogical strategy proposed to address these issues is blended learning.

Blended learning integrates in-person instruction with online educational activities in a structured manner(7), (8), (9). This approach affords learners greater flexibility in accessing content while simultaneously promoting active engagement in the learning process. It has been increasingly recognised as a valuable method for enhancing the quality and effectiveness of teaching and learning in tertiary education (10), (11), (12), (13). Fundamentally, blended learning aims to harmonise the use of digital technologies with direct human interaction between lecturers and students. This combination is expected to foster meaningful involvement in learning tasks(14), (15), (16), particularly through the support of Learning Management Systems (LMS).

An LMS is a digital platform designed to facilitate the planning, delivery, and management of learning experiences (17). It provides infrastructure for conducting online training, managing course materials, hosting forums, and administering assessments (18). With the increasing ubiquity of LMS, it has become possible to deliver education through fully online, blended, or face-to-face modalities (19). LMS features such as forums, chat tools, and messaging functions allow learners to collaborate and interact, building communities of practice and fostering deeper engagement and peer learning (19), (20). These interactions enhance the teaching process by creating opportunities for knowledge sharing and collaborative reflection (22).

Previous studies indicate that blended learning improves student motivation, enriches the educational experience, and supports improved academic performance (23), (24). Nevertheless, the effectiveness of this approach particularly in the Indonesian higher education context continues to warrant further investigation. Although many institutions have begun to adopt blended learning, the extent of its application varies considerably, both in instructional design and its ability to foster student engagement and measurable learning outcomes. Accordingly, the present study seeks to explore how blended learning might optimise learning activity and outcomes among university students.

Research by Ceylan et al. (25) employing an experimental design found that blended learning significantly improved academic achievement at the secondary level. Similarly, a literature-based review conducted by Sun et al. (26)

highlighted the positive impact of blended learning on the academic performance of Business English majors in China. Another experimental study by Kang et al. (27), focusing on public healthcare education, concluded that this approach enhanced students' knowledge, problem-solving competencies, and satisfaction with the learning process.

The novelty of this study lies in its specific focus on the use of blended learning among biology students a topic that has received limited scholarly attention in Indonesia. The study explores how the implementation of this method influences student learning activity and outcomes in both online and face-to-face contexts. Through this dual-mode engagement, students are encouraged to construct knowledge actively, thus making the learning process more meaningful (28), (29), (30), (31), (32), (33)

This study aims to see the effect of blended learning on student learning activities and outcomes. Seeing these problems, it is necessary to investigate the contribution of blended learning implementation experiments to learning activities and outcomes. Based on the problem solving, it is expected to be one of the alternative solutions in improving the quality of education in higher education, especially in creating a learning experience that is more interactive and adaptive to the needs of students.

2. Methods

Time and Place of the Study

This study was conducted at the Faculty of Mathematics and Natural Sciences, Makassar State University (FMIPA UNM). The study involved students enrolled on the Cell and Molecular Biology course during that academic semester.

Research Design

This study adopted a quantitative This study employed a quantitative approach using a quasi-experimental design, specifically a control group design with post-treatment testing only, to examine the effect of blended learning on the academic achievement of Biology students at the Faculty of Mathematics and Natural Sciences, Makassar State University (FMIPA UNM). The study population consisted of all Biology programme students taking the Cell and Molecular Biology course. Three whole classes were randomly selected at the class level, comprising Class A and Class B from the Biology Education programme and one class from the Biotechnology programme.

Two classes were assigned as experimental groups, whilst one class served as the control group. Experimental Class 1 received blended learning activities, including a glossary, discussion forums, assignments, and in-class discussions. Experimental Class 2 received a similar treatment with the addition of lecturer-led explanations. Conversely, the control group was taught solely through conventional face-to-face instruction.

This study employed a post-test-only design without a pre-test, focusing on post-intervention outcomes. The independent variable was blended learning, defined as the integration of synchronous face-to-face learning activities and asynchronous online learning. The dependent variable was student learning outcomes, measured through cognitive achievement scores obtained from the post-test.

The research procedure comprised: (1) preparing teaching materials; (2) implementing blended learning for the experimental group and conventional learning for the control group over seven sessions; (3) conducting a final test; and (4) analysing the data using descriptive and inferential statistics. The research instrument used was a multiple-choice test to measure students' learning outcomes.

Technique of Data Collection

The data were collected via a multiple-choice test designed to measure pupils' learning outcomes. The test was administered as a post-intervention test following the implementation of the learning strategy.

Data Analysis Technique

The data were analysed using descriptive and inferential statistics. Prior to hypothesis testing, assumption tests were conducted to ensure the validity of the data. The normality of the data distribution was assessed using the Kolmogorov–Smirnov test, whilst the homogeneity of variances was evaluated using Levene's test.

Once these assumptions were met, a one-way Analysis of Variance (ANOVA) was conducted to determine whether there were significant differences in student learning outcomes between the experimental and control groups. When significant differences were identified, post hoc analysis was performed using Tukey's HSD[a] test to examine pairwise group comparisons. All statistical analyses were conducted using SPSS version 25 for Windows.

3. Result and Discussion

Result

An initial overview of the performance of each group in learning, descriptive statistical analysis of student learning results was carried out. The presentation of descriptive data is intended to identify general patterns before conducting inferential statistical tests. The following table shows a summary of the values obtained from each treatment group.

Table 1. Descriptive Statistics of Learning Outcomes

Class	N	Mean	Std. Deviation	Minimum	Maximum
Control	25	60.00	3.74	50.00	69.00
Experiment 1	25	84.76	3.49	79.00	90.00
Experiment 2	25	87.44	2.65	82.00	92.00

The implementation of instructional methods varied across the three student groups involved in this study. Two experimental groups were exposed to blended learning strategies, while the control group was taught using conventional lectures. Specifically, Experimental Class 1 utilised a combination of a digital glossary, online discussion forums, individual assignments, and in-class discussions. Experimental Class 2, in contrast, received an additional component lecturer led explanations alongside similar blended tools. Meanwhile, the control class followed a traditional, face to face lecture format. Following the completion of the

seventh learning session, a post-test was administered to all participants to measure learning outcomes.

A summary of the descriptive statistics reveals noteworthy distinctions among the three groups. As presented in Table 1 on page 5, Experimental Class 1 achieved the highest mean score, averaging 87.44, indicating superior academic performance. In contrast, the control class recorded the lowest average score at 60.00. The variability of scores, as measured by the standard deviation, was greatest in Experimental Class 1 (3.49), suggesting more diverse achievement levels among its students. Conversely, the smallest standard deviation was observed in Experimental Class 2 (2.65), reflecting more consistent performance within the group.

When examining the minimum and maximum scores, further patterns emerge. The highest minimum score was observed in Experimental Class 2, with a lower bound of 82.00, suggesting that all students in this group performed at a relatively high level. The control class again posted the lowest minimum value (50.00), reinforcing the gap in achievement. Regarding maximum values, Experimental Class 2 reached 92.00, which was the highest overall, while the control group's top score peaked at 69.00.

These findings illustrate the potential impact of blended learning approaches on students' academic performance. The combination of digital and face-to-face elements appears to offer greater opportunities for engagement, understanding, and retention of material. Notably, the more structured support through lecturer guidance in Experimental Class 2 may have contributed to both high scores and low variance, indicating effective scaffolding throughout the learning process

Table 2. Normality & Homogeneity Test

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	Df	Sig.
Learning Outcomes	Control	.133	25	.200*	.932	25	.099
	Experiment 1	.142	25	.200*	.959	25	.397
	Experiment 2	.131	25	.200*	.946	25	.203

Based on the results of the normality test, the highest value of the post-test using the Shapiro-Wilk test in experimental class 1 is 0.397. The lowest value in the control class is 0. 099. These results show that the alpha significance level is greater than 0.05. Therefore, all classes are normally distributed. Then, the data was processed using parametric test statistics. Then, the homogeneity test shows that the alpha significance level value of 0.224 is greater than 0.05. This means that all data contain variances that are classified as homogeneous. The data obtained can fulfil the prerequisite test of analysis. Furthermore, the data will be tested using the one-way Anova test.

Table 3. Anova Test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11443.280	2	5721.640	517.068	.000
Within Groups	796.720	72	11.066		

The one-way ANOVA test results revealed a statistically significant difference, as indicated by the alpha (α) level being below 0.05. In this case, the calculated Fcount>Ftable (517.068>2.73), which leads to the

rejection of the null hypothesis (H_0) and acceptance of the alternative hypothesis (H_1). This finding confirms the existence of significant variations in learning outcomes among the control group, experimental group 1, and experimental group 2. Thus, the instructional method had a measurable impact on student achievement at a significance threshold of 0.05

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Table 4. Test Tukey

	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Experiment 1	-2.680*	.941	.016	-4.93	-.43
	Experiment 2	24.760*	.941	.000	22.51	27.01
Experiment 1	Control	2.680*	.941	.016	.43	4.93
	Experiment 2	27.440*	.941	.000	25.19	29.69
Experiment 2	Control	-24.760*	.941	.000	-27.01	-22.51
	Experiment 1	-27.440*	.941	.000	-29.69	-25.19

Based on the data presented in Table 4, it is evident that the control group differs significantly from both experimental group 1 and experimental group 2, as indicated by p-values below 0.05. This statistical outcome confirms a meaningful distinction in learning performance between students taught through conventional methods and those engaged in blended learning environments. Moreover, when comparing experimental group 1 with experimental group 2, the difference also proves statistically significant ($p < 0.05$). These findings suggest that, although both experimental groups benefited from blended learning approaches, the degree of impact varied, implying differences in how the method was implemented or received by students in each group.

Table 5. Tukey HSD[a] Test

Class	N	Subset for alpha = 0.05		
		1	2	3
Control	25	60.00		
Experiment 2	25		84.76	
Experiment 1	25			87.44
Sig.		1.000	1.000	1.000

The data presented in Table 6, Subset 1, indicate that the mean score of learning outcomes in the control group differs noticeably from those in experimental groups 1 and 2. In Subset 2, the average score for experimental class 2 stands apart from the control and experimental class 1, confirming a statistically significant variation in learning performance.

The Tukey HSD[a] test results summarised in Table 5 reveal that disparities exist among the three class groups. These differences reflect the varying approaches employed in the learning design. In experimental class 1, blended learning was implemented through a combination of glossaries, online forums, assignments, and in-class discussions. Meanwhile, experimental class 2 adopted a slightly more enriched model, incorporating all the aforementioned components alongside direct lecturer-led explanations. The control group, by contrast, received instruction through conventional lecture-based delivery.

Although statistical analysis shows a significant difference in average scores between experimental classes 1 and 2, both strategies demonstrate comparable effectiveness in enhancing student learning outcomes. This suggests that, despite some variation in the delivery mechanism, blended learning in either form contributes positively to student achievement.

Discussion

Based on table 1, student learning outcomes in experimental class 2 are more optimal than in experimental class 1 and control. It proves that there are differences in student learning outcomes in experimental classes 1, 2 and control. This shows that the difference has a meaning, namely that in experimental class 2 students maximally achieve learning objectives compared to experimental class 1 and control. This is because in experimental class 2 learning activities include glossaries, discussion forums, assignments, class discussions. Experimental class 1 learning activities include glossary, discussion forum, class discussion assignment, lecturer explanation. This is what makes experimental class 2 have higher average learning outcomes, followed by experimental class 1 and control. The standard deviation value in experimental class 2 has the lowest value compared to other classes. This shows that the width of data variation in experimental class 2 is smaller than that of experimental class 1 and control. Therefore, it means that experimental class 2 has more even learning outcomes than other classes. In line with this, Nasution & Ratnawulan, (34) argue that a small standard deviation indicates that the class has evenly distributed variables.

Table 2 of the control class, experiment 1 and 2. There is a significant value of Shapiro-Wilk from the three classes greater than 0.05. This indicates that all classes are normally distributed. Based on this, data processing can be done through parametric statistical tests. Table 3 shows that all three classes have a homogeneity significance value greater than 0.05. Therefore, the three classes have fulfilled the prerequisite test for conducting one to way ANOVA analysis.

The data presented in Table 3 reinforces this interpretation, with a significance value of 0.00, clearly lower than the conventional threshold of 0.05. This outcome supports the conclusion that there are meaningful differences in student performance across the three groups. Hence, the application of blended learning demonstrably influences learning outcomes in a positive direction. This is in agreement with previous findings which suggest that blended learning contributes favourably to academic attainment (35,36).

Blended learning, which integrates face-to-face instruction with online educational components, offers a flexible and adaptive learning environment (9,37). It enables students and lecturers to engage both synchronously and asynchronously, using a variety of digital resources and interactive tools. According to Ghanem and Hamayil (38), this model creates an integrated space for academic interaction, where conventional in-person teaching is enhanced through technology-supported platforms.

Face-to-face elements of blended learning provide opportunities for direct communication and immediate feedback, while the online aspects offer flexibility in access, timing, and learning pace. This duality supports a more personalised learning experience and allows students to revisit materials independently. Overall, the findings of this study align with existing literature asserting the pedagogical value of blended learning in improving student engagement and academic outcomes.

Based on Table 4 blended learning does not produce a uniform effect but can vary in its effectiveness depending on design quality, learner engagement, or

contextual factors within the learning environment. This variation aligns with earlier studies which have asserted that well-executed blended learning enhances student achievement (39), (40). It also reinforces the broader perspective that incorporating blended strategies into education can elevate overall teaching quality (41), (42). Thus, the present findings contribute to the growing body of evidence supporting the implementation of blended learning models in higher education. Not only does such an approach offer pedagogical advantages, but it also appears to foster improved academic outcomes when thoughtfully designed and adapted to learner needs.

Based on Table 5 this finding affirms the potential of blended learning to foster a more engaged and effective educational experience. By integrating various interactive components, such as discussions and instructor input, students are provided with multiple pathways to internalise concepts. The outcomes support the argument made by Schaber et al. (43) and Bower et al. (44), who assert that blended learning transcends the mere transfer of content via digital platforms. Rather, it aims to cultivate a holistic learning environment that promotes deep understanding, student autonomy, and adaptive engagement.

In general, the results of ANOVA, Tukey, and Tukey HSDa tests show that the application of blended learning can significantly improve student learning outcomes compared to the lecture method. Both experimental classes also showed relatively the same level of effectiveness in improving student learning outcomes. In line with this statement, the findings of Puspitasari et al. (45) & Eryilmaz (46) described that the implementation of blended learning has an effective impact on learning outcomes. This shows that a learning approach that integrates online and offline learning can create a more flexible, interactive and student-centred learning experience.

This research shows that the implementation of blended learning in various forms of learning design, both with and without direct explanation from lecturers, is effective in significantly improving student learning outcomes compared to the lecture method. Although there were variations in the approach between experimental classes, both resulted in the effectiveness level but with a slight difference from the mean value. This shows that flexibility in blended learning design can still create a meaningful learning environment. The findings reinforce the view that blended learning is not only about technology integration, but also about designing collaborative, interactive and student-centred learning experiences. The impact of this research contributes to enriching pedagogical practices in higher education, as well as providing a basis for curriculum development that is adaptive and responsive to 21st century learning needs

4. Conclusion

Drawing upon the findings and discussions presented, it is evident that the application of blended learning significantly influences students' academic performance in both experimental groups. In the first experimental group, the blended learning strategy incorporated a combination of glossaries, discussion forums, assignments, and classroom-based discussions. Meanwhile, the second experimental group received additional support in the form of direct lecturer explanations, complementing the same blended elements.

In contrast, the control group received instruction exclusively through conventional classroom lectures, without any incorporation of blended learning methods. Of the three groups involved in the study, students in the second experimental group demonstrated the most significant improvement in their academic

performance, followed by those in the first experimental group. The control group achieved the lowest average scores overall.

Further statistical analysis, using both the Tukey and Tukey HSD[a] tests, revealed that there were significant differences in learning outcomes between the experimental groups and the control group. These results affirm the effectiveness of blended learning in enhancing students' academic attainment, particularly when the teaching approach is thoughtfully designed and effectively implemented.

This study contributes to the field of higher education, particularly in biology education, by providing empirical evidence that a well-designed blended learning approach can enhance student engagement and academic achievement. This study also emphasises the importance of integrating digital learning tools with direct instructional support to optimise learning outcomes. These findings have theoretical and practical implications for the development of more effective, interactive, and student-centred learning environments in higher education. Nevertheless, this study was conducted within a specific academic context and focused primarily on cognitive learning outcomes during the implementation period. Therefore, future research may further explore the application of blended learning across broader educational contexts, longer periods of implementation, and additional aspects of learning, such as motivation, engagement, and digital competencies, in order to obtain a more comprehensive understanding of its educational impact.

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