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Relationship between Learning Habits and Biology Learning Outcomes among Senior High School Students

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ABSTRACT

Purpose of the study: This study aims to analyze the relationship and differences between study habits and Biology learning outcomes among high school students based on their academic ability levels.

Methodology: This study employed a quantitative correlational design. The sample consisted of 152 students selected through proportionate stratified random sampling. Data on learning habits were collected using a four-point Likert-scale questionnaire comprising 38 valid items, while Biology learning outcomes were obtained from students' academic records. Data were analyzed using descriptive statistics, Pearson Product Moment correlation, significance testing, and coefficient of determination analysis.

Main Findings: Most students had learning styles in the excellent category (97.37%), but the majority of Biology learning outcomes were in the low category (70.40%). The relationship between learning styles and Biology learning outcomes was not significant in the high academic ability group (r = 0.126), but was significant in the medium (r = 0.255) and low (r = 0.490) academic ability groups. The contribution of learning styles to learning outcomes increased from 1.59% in the high academic ability group to 24.01% in the low academic ability group.

Novelty/Originality of this study: This study contributes new insights by examining the relationship between learning habits and Biology learning outcomes across different academic ability levels. The findings reveal that the strength and significance of the relationship vary according to students' academic ability, providing a more specific understanding of the role of learning habits in supporting Biology learning achievement.

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1. INTRODUCTION

Education is a process aimed at developing students' potential through effective and meaningful learning activities. The success of the educational process is often measured by the learning outcomes students achieve after participating in learning activities [1], [2]. Learning outcomes reflect students' mastery of the competencies established in the curriculum [3], [4]. In the context of Biology learning, learning outcomes are an important indicator for assessing students' understanding of complex and interrelated life concepts [5], [6]. Therefore, various

factors influencing learning outcomes need to be studied in depth to improve the quality of Biology learning in schools.

Biology is a science subject that requires students not only to memorize concepts but also to understand the relationships between concepts, analyze natural phenomena, and apply knowledge in everyday life. The abstract, broad nature of Biology material, rich in scientific terminology, often presents challenges for students in the learning process. This situation leads to differences in learning outcomes among students, even when they receive the same material [7], [8]. Several studies have shown that success in Biology learning is influenced by both internal and external factors [9], [10]. The internal factor that has received the most attention is the learning methods or habits adopted by students in their academic activities [11], [12].

Learning methods are a series of activities students undertake to acquire, understand, process, and retain information during the learning process. Learning styles encompass time management, concentration, note-taking, reviewing lessons, utilizing learning resources, and strategies for learning evaluations. Students who maintain a consistent learning style tend to understand the material more easily and achieve better academic performance than those who study without a clear strategy. Conversely, ineffective learning styles can lead to poor conceptual understanding and suboptimal learning outcomes. Therefore, learning styles are a crucial factor to consider when improving students' Biology learning outcomes.

In addition to learning styles, biology learning outcomes are also influenced by various other factors, such as the school environment, classroom emotional climate, learning models, learning motivation, and students' initial abilities. Research by Nathania et al. [13] found a positive and significant relationship between school environmental factors and the biology learning outcomes of MTs students. Research by Fadilah and Zulfiani [14] also showed that the emotional climate of the classroom was positively related to the biology learning outcomes of high school students. Meanwhile, Kurnianti et al. [15] and Harahap et al. [16] reported that the implementation of innovative learning models significantly improved students' biology learning outcomes. These findings indicate that biology learning outcomes are influenced by various interacting factors in the learning process.

Although extensive research has been conducted on the factors influencing Biology learning outcomes, studies specifically linking learning styles to Biology learning outcomes based on students' academic ability levels are relatively limited. However, these two studies failed to consider differences in students' academic ability levels as a variable that could influence the strength of the relationship between learning styles and learning outcomes. In fact, students with high, medium, and low academic abilities likely have different learning style characteristics, resulting in different learning outcomes.

Based on previous research, there are several research gaps that require attention. First, most recent research focuses more on the influence of the school environment on biology learning outcomes [13], the relationship between the emotional climate of the class and biology learning outcomes [14], effectiveness of learning models on biology learning outcomes [15], [16], and the use of learning media to improve Biology learning outcomes [2]. Second, research specifically examining the relationship between learning styles or study habits and Biology learning outcomes is still relatively scarce. Third, research integrating students' academic ability levels as the basis for analyzing the relationship between learning styles and Biology learning outcomes is scarce in the current literature. This situation indicates the need for more in-depth research on the relationship between learning styles and Biology learning outcomes in terms of students' academic ability levels.

The novelty of this research lies in the analysis of the relationship between learning styles and Biology learning outcomes based on students' academic ability levels, categorized into high, medium, and low academic ability groups. This approach allows for more detailed identification of the characteristics of the relationship between the two variables in each academic group. Theoretically, this research can enrich the study of internal factors influencing Biology learning outcomes. Practically, the research results can provide a basis for teachers in designing learning strategies and academic services that are more appropriate to the characteristics of students at various levels of academic ability. Based on this description, the main objective of this study is to determine whether there is a relationship between learning styles and Biology learning outcomes based on students' academic ability levels.

2. RESEARCH METHOD

2.1. Population and Sample

The study population was all eleventh-grade students of public high schools in Tampan District, Pekanbaru, consisting of State Senior High School 15 Pekanbaru and State Senior High School 12 Pekanbaru. The study population consisted of 245 students spread across several classes at both schools. The sample size was determined using the Isaac and Michael formula with a 5% margin of error [17], [18]. Based on the calculations, a sample size of 152 students was obtained. The sampling technique used was proportionate stratified random sampling, which randomly selects samples based on the proportions of each group within the population. This technique was chosen because the study population is heterogeneous and consists of students with varying levels of academic ability.

For analysis purposes, the study sample was grouped based on students' academic ability levels. The grouping was carried out into three categories: 25% of the high academic ability group, 50% of the medium academic ability group, and 25% of the low academic ability group in each class. This grouping aimed to obtain a more comprehensive picture of the relationship between learning styles and Biology learning outcomes at each academic ability level. Based on the results of proportional sampling, 36 students were selected in the high academic ability group, 80 students in the medium academic ability group, and 36 students in the low academic ability group. Thus, the total sample size used in this study was 152 students. The distribution of samples in each class was adjusted to the number of students in each population stratum.

2.2. Research Design

This study employed a quantitative method with a correlational design. A correlational design is used to identify and analyze the relationship between two variables without any treatment or manipulation of the variables being studied [19], [20]. In this study, the independent variable (X) is the students' learning styles, while the dependent variable (Y) is the students' Biology learning outcomes. Through this design, the researcher sought to determine whether there is a relationship between learning styles and Biology learning outcomes in students with different levels of academic ability. The research design can be seen in Figure 1 below:

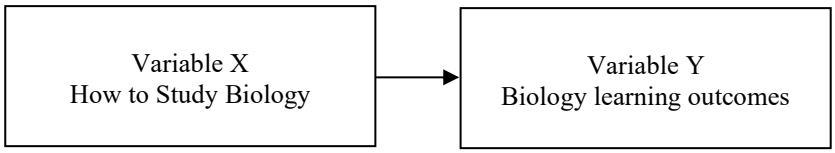

Figure 1. Research Design

2.3. Research Procedures

This research was conducted through several systematic stages to obtain data aligned with the research objectives. The initial stage involved determining the population and sample, followed by determining the research variables and indicators used as the basis for developing the instrument. The variables studied consisted of learning styles as the independent variable and Biology learning outcomes as the dependent variable. Next, the researchers developed a research instrument in the form of a learning style questionnaire based on the established indicators [21], [22]. The instrument was then tested for validity and reliability with respondents who shared similar characteristics to the research sample but were not included in the sample.

The next stage was data collection by distributing the questionnaire to the students in the research sample. Furthermore, Biology learning outcome data was obtained through documentation of student academic grades obtained from the school. The collected data were then checked for completeness, tabulated, and analyzed using statistical techniques appropriate to the research objectives [23], [24]. Data analysis was conducted descriptively to describe the characteristics of the research variables and inferentially through correlation tests to determine the relationship between learning styles and Biology learning outcomes. The results of the subsequent analysis were used as the basis for drawing research conclusions.

2.4. Research Instruments

The instrument used in this research was a questionnaire on how students learn. The questionnaire was chosen because it was able to reveal information about students' learning habits and activities systematically in accordance with the research objectives. The preparation of the questionnaire is based on indicators of learning methods which include managing study time, taking notes, reading activities, repeating lesson material, studying concentration and completing assignments [25], [26]. The instrument was prepared using a Likert scale which was modified into four alternative answers, namely Always, Often, Sometimes and Never. The use of four answer categories aims to reduce the tendency of respondents to choose the middle category so that the answers given more reflect actual conditions.

The learning questionnaire consists of 50 statement items which include positive and negative statements. Before being used in research, the instrument is first tested for validity and reliability to ensure the quality of the instrument in measuring the variables studied. Statements that meet the validity criteria are then used as research instruments. The indicators for learning methods used in this research are presented in Table 1, while alternative scores for respondents' answers are presented in Table 2.

Table 1. Learning Method Variable Indicators

No	Variables	Operational Definition	Indicator
1	How to Study (X)	Learning methods are patterns or methods used by students to obtain, understand, and master learning materials to achieve learning goals effectively.	1. Manage your study time 2. Take notes 3. Read the study material 4. Review the study material 5. Concentrate on studying 6. Do your homework

Table 2. Alternative Questionnaire Answer Scores

Answer Options	Positive Statement Score (+)	Negative Statement Score (-)
Always	4	1
Often	3	2
Sometimes	2	3
Never	1	4

2.5. Data Collection Techniques

Data collection in this study was conducted using a questionnaire technique. The questionnaire was used to obtain data on students' learning styles, which served as the independent variable in the study [27], [28]. This technique was chosen because it allowed researchers to obtain information directly from respondents regarding their learning habits and activities. Furthermore, the questionnaire was deemed effective for collecting data from a relatively large number of respondents in a timely manner.

The questionnaire was structured based on established learning style indicators and used a Likert scale with four response alternatives: Always, Often, Sometimes, and Never. The questionnaire was administered to all respondents in the study sample after the instrument was declared valid and reliable [29], [30]. The data obtained from the questionnaire were then processed and analyzed to determine the relationship between learning styles and students' Biology learning outcomes based on their academic ability level. In addition to the questionnaire data, Biology learning outcome data was obtained through student grade documentation, which served as the dependent variable in the study.

2.6. Data Analysis Techniques

Data analysis in this study was conducted descriptively and inferentially. Descriptive analysis was used to describe the characteristics of students' learning styles and Biology learning outcomes based on data obtained from questionnaires and grade documentation [31], [32]. Learning style data was analyzed by calculating the scores obtained by each respondent, then converting them into percentages using the formula:

$$P = \frac{f}{N} x100 \qquad ...(1)$$

Next, learning method scores are categorized based on the criteria presented in Table 3.

Table 3. Categories of Student Learning Methods

Percentage Score (%)	Category
75–100	Excellent
50–74	Good
25–49	Poor

To describe students' Biology learning outcomes, the scores obtained are grouped into categories as presented in Table 4.

Table 4. Categories of Biology Learning Outcomes

Value Range	Category
> 83	High
75–83	Medium
< 75	Low

Inferential analysis was used to examine the relationship between learning styles and students' Biology learning outcomes. Prior to hypothesis testing, the data were first tested for normality and homogeneity to ensure the parametric analysis assumptions were met [33], [34]. The relationship between learning styles and Biology learning outcomes was analyzed using the Pearson Product Moment correlation test with a 5% significance level

($\alpha = 0.05$). The analysis was conducted on the entire sample and on each academic ability group: high, medium, and low ability. Interpretation of the strength of the relationship between variables refers to the obtained correlation coefficient. The criteria for interpreting the correlation coefficient are presented in Table 5.

Table 5. Interpretation of Correlation Coefficient

Correlation Coefficient (r)	Interpretation
0.80–1.00	Very strong
0.60–0.79	Strong
0.40–0.59	Currently
0.20–0.39	Low
0.00–0.19	Very Low

Significance testing is conducted by comparing the significance value (p-value) with a significance level of 0.05. If the significance value is less than 0.05 ($p < 0.05$), then there is a significant relationship between learning methods and students' Biology learning outcomes. Conversely, if the significance value is greater than 0.05 ($p > 0.05$), then there is no significant relationship between the two variables. To determine the magnitude of the contribution of learning methods to Biology learning outcomes, the coefficient of determination (R^2) is calculated. The coefficient of determination value shows the percentage contribution of the learning method variable in explaining variations in students' Biology learning outcomes.

3. RESULTS AND DISCUSSION

3.1. Description of Research Data

In this study, data on students' learning styles were obtained by distributing questionnaires to all respondents in the research sample. The questionnaire instrument used consisted of 38 statements arranged based on indicators of students' learning styles. Each statement was accompanied by four answer options: always, often, sometimes, and never. Scoring was done based on the type of statement, namely positive statements and negative statements. For positive statements, scores were given sequentially: four for the answer "always", three for the answer "often", two for the answer "sometimes", and one for the answer "never". Conversely, for negative statements, scores were given in reverse, namely one for the answer "always", two for the answer "often", three for the answer "sometimes", and four for the answer "never". Based on the number of statements used, the minimum score that respondents could obtain was 38, while the maximum score was 152. The details of the scores for each answer alternative are presented in Table 6.

Table 6. Summary of All Indicators of Students' Biology Learning Methods Based on High, Medium, and Low Academic Ability Levels

No.	Sub Indicators	Persentase (%)					
		High	Category	Medium	Category	Low	Category
1.	Managing study time	70.52%	Enough	73.33%	Enough	75.38%	Very Good
2.	Taking notes	67.12%	Enough	72.86%	Enough	68.28%	Enough
3.	Reading	68.31%	Enough	66.11%	Enough	78.07%	Enough
4.	Reviewing lesson material	72.04%	Enough	60.39%	Enough	73.95%	Enough
5.	Concentrating	63.30%	Enough	72.06%	Enough	73.74%	Enough
6.	Doing assignments	74.29%	Enough	73.34%	Enough	78.56%	Very Good
	Total	415.58		418.09		447.98	
	Average	982.10%					
	Category	Very Good					

Based on Table 6, in the group of students with high academic ability, the percentage of each learning method indicator was 70.52% for the study time management indicator, 67.12% for note-taking, 68.31% for reading activities, 72.04% for reviewing lesson material, 63.30% for study concentration, and 74.29% for doing assignments. These results indicate that the indicator of doing assignments had the highest value, while the indicator of study concentration obtained the lowest value in this group. In the group of students with moderate academic ability, the percentage of each indicator was 73.33%, 72.86%, 66.11%, 60.39%, 72.06%, and 73.34%. The indicator of doing assignments showed the highest percentage, while the indicator of repeating lesson material had the lowest percentage. Meanwhile, in the group of students with low academic ability, the percentages for each indicator, respectively, reached 75.38%, 68.28%, 78.07%, 73.95%, 73.74%, and 78.56%. In this group, the indicator for completing assignments achieved the highest percentage, while the indicator for taking notes showed the lowest percentage. In general, all learning method indicators in the three academic ability groups were in the good category, although there was variation in the percentages for each indicator.

Table 7. Distribution of Student Learning Methods

Category	Interval	Frequency	Percentage (%)
High	91% - 100%	148	97.37
Medium	75% - 90%	4	2.63
Low	50% - 74%	0	0
Total		152	100

Based on Table 7, the majority of students' learning styles fall into the excellent category, representing 101 students, or 97.37% of the total respondents. Meanwhile, 4 students, or 2.63%, categorized their learning styles as good. No students were found to fall into the poor category. These findings indicate that, in general, students' learning styles fall into the excellent category, indicating that most students have adopted study habits that support optimal learning outcomes.

Table 8. Student Learning Outcomes

Category	Interval	Frequency	Percentage (%)
High	>83	13	8.55
Medium	74 – 82	32	21.05
Low	< 75	107	70.40
Total		152	100

Based on Table 8, 13 students, or 8.55% of the total respondents, fall into the high category. Furthermore, 32 students, or 21.05%, fall into the medium category, while the majority of students, 107 students, or 70.40%, fall into the low category. These results indicate that the majority of respondents have Biology learning outcomes in the low category, while only a small proportion of students reach the high category. This finding indicates that students' Biology learning outcomes still need attention and improvement.

3.2. Hypothesis Testing

Table 9. Correlation Test Results for the High Academic Ability Group

How to Study (X)	Learning Outcomes (Y)	t_{count}	t_{table}
$r_{xy} = 0.139$		0.74	1.701
		Conclusion: H_0 is rejected, H_a is accepted	

Based on the analysis results presented in Table 9, the calculated t-value was 0.74, while the table t-value was 1.701. Because the calculated t-value was smaller than the table t-value, the null hypothesis was accepted and the alternative hypothesis was rejected. These results indicate that there is no significant relationship between learning styles and Biology learning outcomes in the group of students with high academic ability. Therefore, the variation in learning styles among students in the high academic ability group did not show a significant relationship with differences in Biology learning outcomes.

Hypothesis testing for the group of students with moderate academic ability was conducted by formulating the following hypotheses: the alternative hypothesis states that there is a significant relationship between learning styles and Biology learning outcomes, while the null hypothesis states that there is no significant relationship between learning styles and Biology learning outcomes. Decision-making was carried out at a 5% significance level with n-2 degrees of freedom. The null hypothesis was rejected and the alternative hypothesis accepted if the calculated t-value was greater than or equal to the table t-value. Conversely, the null hypothesis was accepted and the alternative hypothesis rejected if the calculated t-value was less than the table t-value.

Table 10. Correlation Test Results for the Medium Academic Ability Group

How to Study (X)	Learning Outcomes (Y)	t_{count}	t_{table}
$r_{xy} = 0.255$		8.85	1.665
		Conclusion: H_0 is rejected, H_a is accepted	

Based on the analysis results presented in Table 37, the calculated t-value was 8.85, while the table t-value was 1.665. Because the calculated t-value was greater than the table t-value, the null hypothesis was rejected and the alternative hypothesis was accepted. These results indicate a significant relationship between learning styles and Biology learning outcomes in the group of students with moderate academic ability. Therefore, the better the learning styles employed by students in the moderate academic ability group, the higher the Biology learning outcomes they tended to achieve.

Next, hypothesis testing for the group of students with low academic ability was conducted by formulating two hypotheses. The alternative hypothesis stated that there was a significant relationship between learning styles

and Biology learning outcomes, while the null hypothesis stated that there was no significant relationship between learning styles and Biology learning outcomes. Decision-making was carried out at a 5% significance level with n-2 degrees of freedom. The null hypothesis was rejected and the alternative hypothesis accepted if the calculated t-value was greater than or equal to the table t-value. Conversely, the null hypothesis was accepted and the alternative hypothesis rejected if the calculated t-value was less than the table t-value.

Table 11. Correlation Test Results for the Low Academic Ability Group

How to Study (X)	Learning Outcomes (Y)	t_{count}	t_{table}
$r_{xy} = 0.49$		5.83	1.691
		Conclusion: H_0 is rejected, H_a is accepted	

Based on the analysis results presented in the table, the calculated t value is 5.83, while the t table value is 1.691. Because the calculated t value is greater than the t table value, the null hypothesis is rejected and the alternative hypothesis is accepted. These results indicate that there is a significant relationship between learning styles and Biology learning outcomes in the group of students with low academic abilities. Thus, the learning styles applied by students play a role in achieving Biology learning outcomes in this group, where students who have better learning styles tend to achieve higher learning outcomes than students with less good learning styles.

3.3. Coefficient of Determination

The coefficient of determination was used to determine the contribution of learning styles to students' Biology learning outcomes in each academic ability group. The coefficient of determination is obtained by multiplying the square of the correlation coefficient by 100 percent. The greater the coefficient of determination, the greater the contribution of learning styles in explaining variation in students' Biology learning outcomes. In the group of students with high academic ability, the correlation coefficient was 0.126. The calculation results show a coefficient of determination of 1.59%. This finding indicates that learning styles contribute very little to Biology learning outcomes in the group of students with high academic ability, while 98.41% of the variation in learning outcomes is influenced by other factors not examined in this study.

In the group of students with moderate academic ability, the correlation coefficient value of 0.255 yields a coefficient of determination of 6.50%. These results indicate that learning styles contribute 6.50% to students' Biology learning outcomes, while the remaining 93.50% is influenced by factors outside the studied variables. Meanwhile, for the group of students with low academic ability, the correlation coefficient value of 0.490 yielded a coefficient of determination of 24.01%. This result indicates that learning styles contribute significantly more to Biology learning outcomes than those in the high or medium academic ability groups, accounting for 24.01%. Therefore, 75.99% of the variation in Biology learning outcomes in the low academic ability group is influenced by other factors not included in this study.

Overall, the results of the coefficient of determination analysis indicate that the contribution of learning styles to Biology learning outcomes tends to increase as students' academic ability levels decrease. This finding indicates that learning styles play a more important role in supporting learning outcomes for students with low academic ability than for students with high or medium academic ability.

The results of the study indicate that the relationship between learning styles and Biology learning outcomes varies across student academic ability levels. This finding indicates that the effectiveness of learning styles does not always have the same impact on all student groups. Theoretically, learning styles are an internal factor influencing learning success because they relate to how students manage their time, understand material, review lessons, and complete assignments. Good study habits enable students to gain a deeper understanding of the subject matter, thereby improving academic achievement [35], [36]. Therefore, the variation in the relationship found in this study indicates that the influence of learning styles is highly dependent on each student's individual academic characteristics.

The lack of a significant relationship among students with high academic ability suggests that learning outcomes in this group are likely influenced by factors other than learning styles. Students with high academic ability generally have strong prior knowledge, high intrinsic motivation, strong critical thinking skills, and more developed independent learning skills [37], [38]. These conditions enable them to achieve good learning outcomes despite variations in the learning styles they use. These findings align with the view that the academic achievement of high-ability students is more influenced by cognitive and metacognitive factors than general study habits.

Conversely, the significant relationship found in the groups of students with moderate and low academic ability indicates that learning styles remain a crucial factor in supporting Biology learning outcomes. In this group, the application of structured learning strategies, such as managing study time, reviewing lesson material, taking notes, and consistently completing assignments, can help students understand complex Biology concepts [39], [40]. These findings support the theory that learning success is determined not only by intellectual ability but also by the quality of the student's learning process. In other words, students who employ more effective learning styles tend to have a greater chance of achieving better learning outcomes.

The findings of this study also indicate that completing assignments is the most dominant aspect across all academic ability groups. This indicates that active student engagement in completing learning assignments is a crucial part of the Biology learning process. Completing assignments allows students to reinforce concepts, practice problem-solving, and apply the knowledge they have acquired during the learning process [41], [42]. In the context of Biology learning, which encompasses many scientific concepts, processes, and phenomena, the activity of completing assignments can help students develop a more meaningful understanding than simply memorizing the material.

The results of this study reinforce the findings of several previous studies that reported a positive relationship between study habits and student academic achievement [43]. However, this study provides a more specific perspective by showing that the strength of this relationship varies based on students' academic ability levels. These findings broaden understanding of the importance of considering students' academic characteristics when designing learning strategies and achievement improvement programs. Therefore, teachers' approaches should not be uniform but tailored to the needs and academic abilities of students [44], [45].

The findings of this study provide practical implications for Biology teachers and schools in designing more effective learning programs. Teachers need to pay greater attention to students with average and low academic abilities by fostering good study habits, such as learning time management, note-taking techniques, reading strategies, and regular review of material [46], [47]. Furthermore, schools can develop academic mentoring programs focused on improving students' study skills. These efforts are expected to help improve Biology learning outcomes while reducing the achievement gap between academic ability groups.

This study has several limitations that need to be considered when interpreting the results. First, the study only involved eleventh-grade students from two public high schools in one region, so generalizing the results to a wider population requires caution. Second, data on learning styles were obtained through a questionnaire, which still allows for subjective bias in respondents' responses. Third, the study only examined one internal factor, namely learning styles, while Biology learning outcomes can also be influenced by various other factors such as learning motivation, learning interest, family support, school environment, cognitive abilities, and learning quality, which were not analyzed in this study. Therefore, further research is recommended to involve a wider sample size and integrate various factors that could potentially influence learning outcomes to obtain a more comprehensive understanding of the determinants of students' Biology learning success.

4. CONCLUSION

This study concluded that the relationship between learning styles and Biology learning outcomes differed according to students' academic ability levels. The relationship was not significant in the high academic ability group, but was significant in the medium and low academic ability groups, with the strength of the relationship tending to increase in the low academic ability group. In the high academic ability group, the relationship between learning styles and Biology learning outcomes was in the very low category, with a correlation coefficient of 0.126, indicating no significant relationship. In the medium academic ability group, a correlation coefficient of 0.255 was obtained, indicating a significant relationship with a low correlation level. Meanwhile, in the low academic ability group, a correlation coefficient of 0.490 was obtained, indicating a significant relationship with a medium correlation level.

The results also showed that the indicator for completing assignments achieved the highest percentage across all three academic ability groups, while the indicator with the lowest percentage varied across groups. The average percentage of students' learning styles was in the good category, with the highest score found in the low academic ability group (74.66%), followed by the medium academic ability group (69.68%), and the high academic ability group (69.26%). These findings indicate that learning styles have a greater role in supporting the achievement of Biology learning outcomes in students with low academic abilities compared to students with high and medium academic abilities. Future research is recommended to involve a broader sample size from various schools and educational levels to ensure greater generalizability. Furthermore, further research could examine other factors potentially influencing biology learning outcomes, such as learning motivation, learning interest, self-regulated learning, parental support, and the learning environment, to gain a more comprehensive understanding of the factors that determine student learning success.

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AUTHOR CONTRIBUTIONS

Conceptualization, F.R. and M.Y.; Methodology, F.R.; Software, F.R.; Validation, F.R., M.Y., and M.; Formal Analysis, F.R.; Investigation, F.R.; Resources, M.Y. and M.; Data Curation, F.R.; Writing – Original Draft

Preparation, F.R.; Writing – Review & Editing, M.Y. and M.; Visualization, F.R.; Supervision, M.Y. and M.; Project Administration, F.R.; Funding Acquisition, M.Y.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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