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A Comparative Analysis of Biology Learning Outcomes of Grade 10 Students Using Independent Questions

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ABSTRACT

This study aims to compare the biology learning outcomes of students in classes X E4 and X E5 at SMA Veteran 1 Sukoharjo. Sukoharjo (a senior high school). The study used a descriptive quantitative method with an instrument in the form of a multiple-choice biology test consisting of 10 questions. The research sample involved all students in classes X E4 and X E5 in the 2025/2026 academic year, with a total of 76 respondents. Descriptive statistical analysis was conducted to obtain an initial overview of the students' Biology test results, while the prerequisite analysis tests included normality and homogeneity of variance tests. The normality test results showed that the student learning outcome data in both classes were normally distributed, and the homogeneity test results showed that the data variance was homogeneous, thus fulfilling the requirements for an independent two-sample t-test. The t-test results showed a significance value of Sig. (2-tailed) of 0.530 (> 0.05), indicating that there was no significant difference between the biology learning outcomes of students in classes X E4 and X E5 at SMA Veteran 1 Sukoharjo.

KEYWORDS

Learning outcomes, Biology, t-test.

1. Introduction

Student learning outcomes are influenced by internal factors within the student and external factors in the learning process, not just individual cognitive abilities. Research shows that interactions between teachers and students and the learning environment have a significant influence on student learning achievement, because effective communication between teachers and students can increase student engagement and motivation to learn, thereby positively impacting their learning outcomes (Indah & Fadilah, 2024). In biology learning, learning outcomes are not only influenced by students' cognitive abilities, but also by the quality of the learning process, the learning environment, and equality of treatment between parallel classesi (Arisandy et al., 2018).

Parallel classes at the secondary education level are generally designed with relatively equivalent academic characteristics so that the learning process is fair and equitable (Arikunto, 2021). However, in practice, differences in learning outcomes between parallel classes are still often found, which can be caused by variations in learning strategies, teacher-student interactions, and internal student factors (Yunianto, 2010).

Comparative research in the field of education is needed to test whether there are significant differences in learning outcomes between learning groups, so that it can be used as a basis for evaluating the effectiveness of the learning methods applied (Putri et al., 2025). One of the statistical analysis techniques commonly used to compare the means of two independent groups is the t-test (independent samples t-test), provided that the data are normally distributed and have homogeneous variance (Ghozali, 2018).

The use of normality and homogeneity tests prior to the t-test is an important step in quantitative research, as it aims to ensure that the data meets the necessary statistical assumptions so that the analysis results can be interpreted validly and reliably (Field, 2024). Data analysis using statistical software such as IBM SPSS also increases the precision and accuracy of processing educational research data (Priyatno, 2017)

Based on this background, this study aims to compare the biology learning outcomes of students in classes X E4 and X E5 at SMA Veteran 1 Sukoharjo using a t-test. The results of this study are

expected to provide an objective picture of the equality of learning outcomes between parallel classes and serve as evaluation material for teachers and schools in improving the quality of biology learning (Uno & Lamatenggo, 2016).

Biology education in high school emphasizes understanding complex concepts such as ecosystems and physiology, where variations in learning outcomes between parallel classes often become a major issue due to differences in class dynamics. Comparative research using independent t-tests effectively identifies such equality, as found in a comparative study of learning outcomes in plant biology concepts between experimental classes (Musyaropah et al., 2023). Therefore, this statistical approach is an important tool for evaluating the effectiveness of learning at the secondary school level.

Before applying the independent two-sample t-test, prerequisite tests such as normality (Kolmogorov-Smirnov/Shapiro-Wilk) and homogeneity of variance (Levene's test) must be performed to ensure the validity of the results. Recent research confirms that fulfilling these assumptions is crucial for high school biology learning outcome data, enabling accurate inferences between groups (Martina & Ramdani, 2024). This step is the foundation for reliable comparative analysis, linking empirical findings to parallel class contexts such as XE4 and XE5.

Several studies have found significant differences in biology learning outcomes between classes using a t-test at $\alpha=0.05$, especially when teaching strategies vary. For example, a comparison of classes using a cooperative model showed a calculated t > table t, proving the effectiveness of the intervention (Amelia et al., 2022). These findings highlight how variations in methods can affect equity, which is relevant for testing homogeneity between classes at SMA Veteran 1 Sukoharjo.

The independent samples t-test is a commonly used inferential statistical technique for comparing learning outcomes between two independent groups, such as parallel classes in biology learning. This test is used to determine whether the difference in average learning outcomes is statistically significant or merely coincidental (Rizki et al., 2024). Therefore, the t-test is often used in educational research to objectively evaluate differences in learning outcomes between classes.

Several studies show that the independent t-test is widely used in biology learning studies, particularly to compare student learning outcomes after implementing a specific learning model. (Adrianti et al., 2022) reported that if the assumption of homogeneity is met ($p > 0.05$), the t-test can be used to assess differences in learning outcomes, and in certain contexts, it shows a significant improvement in the treatment group. These findings reinforce that learning factors play an important role in the variation of student learning outcomes.

However, in parallel classes that received relatively similar learning treatments, a number of national studies actually showed no statistically significant differences in learning outcomes (Sig. 2-tailed > 0.05). This indicates that equality in the learning process can produce relatively balanced learning outcomes between classes. Nevertheless.

Comparative analysis using independent t-tests, according to (Kusumasari & Saifuddin.,2020) in the Indonesian Journal of Biology Education, not only identifies differences in biology learning outcomes between parallel classes, but also evaluates the effectiveness of teaching strategies for the cognitive competency equality of high school students. The use of the t-test in classes X E4 and X E5 is relevant to verify the fairness of the learning process, as confirmed by (Martina & Ramdani, 2024) in the Journal of Classroom Action Research, which compared biology learning outcomes with a t-test (sig 0.016 < 0.05) between experimental groups. The theory of inquiry model effectiveness (Arisandy et al., 2018) states that a post-test t-test with t-count > t-table detects the superiority of homogeneous classes, similar to the superiority of X E5.

The implications of these findings are consistent with (Adrianti et al., 2022) in the Journal of Science Education, where an independent t-test on the learning outcomes of 10th grade Biology showed a significant difference (calculated t-value 3.917 > table t-value 2.003) due to variations in the TAI model, confirming the evaluation of academic equality in parallel classes. This reinforces that the learning processes in X E4 and X E5 can be compared inferentially for optimization. The independent sample t-test theory (Munandar, 2016) measures the difference in the mean of high school Biology learning outcomes before the mind map intervention, with the H0 criterion rejected if sig < 0.05. The gain score analysis theory (Nivensia Geby Maramis et al., 2025) in the Pentagon Journal uses a paired t-test to evaluate performance improvement, which is relevant for parallel classes with high variation such as this case.

2. Method

This study was conducted at SMA Veteran 1 Sukoharjo during the odd semester of the 2025/2026 academic year. The study used a descriptive quantitative method with the aim of comparing the learning outcomes of students in classes X E4 and X E5 based on the test data obtained. The research subjects were all students in classes X E4 and X E5 at SMA Veteran 1 Sukoharjo, each consisting of 38 students, so the sampling technique used was total sampling. In this study, no special treatment or experimental treatment was given to either class; all students followed the learning process as usual in accordance with the learning activities taking place at school.

The research instrument used was a biology learning outcome test consisting of 10 multiple-choice questions. The test was administered simultaneously to students in classes X E4 and X E5 to obtain data on their learning outcomes in Biology. The validity of the instrument was reviewed based on content validity, which was compiled in accordance with basic competencies, competency achievement indicators, and Biology material that had been taught, and had been reviewed by subject teachers. The instrument grid and sample questions are presented in the appendix..

Data analysis was performed using comparative analysis techniques with a t-test assisted by IBM SPSS software. Before the t-test was performed, the data was tested for prerequisites through normality and homogeneity tests. The t-test was used to determine whether or not there were differences in student learning outcomes between classes X E4 and X E5 at SMA Veteran 1 Sukoharjo.

3. Results and Discussion

3.1. Results

This study aims to compare the biology learning outcomes of students in classes X E4 and X E5 at Veteran 1 High School in Sukoharjo. The learning outcome data were analyzed to obtain an overview of the students' academic achievements in biology after participating in learning activities. The results of this analysis are expected to provide information for teachers and school officials regarding the equality of learning outcomes between parallel classes.

The research data was processed and analyzed using IBM SPSS software. The analysis stage began with descriptive statistics to describe the overall Biology test results of students in classes X E4 and X E5. Next, prerequisite tests were conducted, including normality and homogeneity of variance tests to ensure that the data met the statistical assumptions before proceeding to the comparison test.

Descriptive statistics of the biology test results between classes X E4 and X E5 show that both classes consist of 38 students. The average score for class X E4 was 85.33 (SD=14.34, SEM=3.46), while class X E5 had an average of 91.82 (SD=14.34, SEM=2.36). Both classes achieved high scores on a maximum scale of 100, with an average difference of 3.22 points. The level of data variation in both classes was high, especially in class X E4. The lower standard error of the mean in class X E5 indicates that the group's average estimate is more stable. This descriptive data shows that the academic performance of the two classes is relatively similar with different variations. With these data characteristics, further analysis can be carried out using parametric tests to compare the means of the two groups. The descriptive statistics of the biology exam results are presented in Table 1.

Table 1. Descriptive Statistics of Biology Exam Results

	Biology test score	
	Class X E4	***Class X E5***
N	38	38
Mean	88,68	91.32
Std. Deviation	21.330	14.384
Std. Error Mean	3.460	2.330

Based on Table 1, descriptive statistics of the Biology test results of students in classes X E4 and X E5 at SMA Veteran 1 Sukoharjo show that class X E4 consists of 38 students (N) with an average score of 88.68, a standard deviation of 21.330, and a standard error of the mean of 3.460. These values indicate that the Biology learning outcomes of class X E4 students are relatively high, although the distribution of scores is relatively varied.

Meanwhile, class X E5 also consists of 38 students, with an average Biology test score of 91.32, a standard deviation of 14.384, and a standard error of the mean of 2.330. This average score indicates

that the Biology learning outcomes of students in class X E5 are in the high category on a maximum scale of 100. The difference in average scores between class X E5 and class X E4 is 2.64 points, with the average score of class X E5 being higher than that of class X E4.

The larger standard deviation in class X E4 (21.330) compared to class X E5 (14.384) indicates that the variation or spread of students' biology learning outcomes in class X E4 is wider. This is reinforced by the larger standard error mean of class X E4 (3.460) compared to class X E5 (2.330), which shows a higher level of data diversity in class X E4. These descriptive statistical data form the basis for conducting inferential statistical analysis in the next stage, specifically through an independent two-sample t-test.

The average score above 88 in both classes indicates that students have achieved excellent cognitive competence in Biology, in accordance with the revised Bloom's taxonomy classification. Most students reached the levels of comprehension and application (C2–C3) with achievement percentages exceeding 80%, which are categorized as excellent. Although the mean difference between class X E4 and X E5 was relatively small (2.64 points) and was found to be statistically not significant based on the independent t-test results, this difference may still have practical significance in the context of learning. A small mean difference can occur when both groups have similarly high achievement levels and relatively homogeneous score distributions, which reduces statistical variability and limits the detection of significant differences. However, in educational practice, even slight differences in mean scores may reflect variations in learning consistency, classroom dynamics, or student engagement, which are important for instructional evaluation. These findings are consistent with previous research (Learning & Vs, 2025) published in the Journal of Biology Education, which reported comparable learning outcomes between experimental and control classes using cooperative learning strategies. Furthermore, the Revised Bloom's Taxonomy Theory (Ahadi & Zain, 2023)was applied to categorize the cognitive domain of biology learning outcomes, where achievement above 80% indicates an excellent level of understanding.

The high standard deviation (14.34–21.33) indicates that students in this group have varying levels of ability, with some students performing well and others performing less well, as found by (Jaharudin et al., 2020) in a study of the Biology learning cycle, where the initial SD of 19.26 decreased to 3.68 after the intervention. The higher standard deviation in X E4 may be due to differences in how students interact and learn, similar to what was found in a comparative study of Biology classes in high school. This descriptive analysis is important to perform before conducting a t-test to ensure that the assumption of normality is met, such as the Shapiro-Wilk test on the learning outcome data of the experimental and control classes. The Kolmogorov-Smirnov and Shapiro-Wilk normality test theories state that the data distribution is normal if sig >0.05, supporting the assumption of independent t-tests in parallel Biology classes.

Descriptive statistical theory in the analysis of high school students' biology learning outcomes explains that a high standard deviation reflects a wide variation in student abilities, requiring learning interventions for homogenization. (Jaharudin et al., 2020) in an education journal found an initial standard deviation of 19.26 in the biology learning outcomes of grade X, which decreased to 3.68 after the problem-based model, indicating a reduction in score dispersion from low (30-70) to more evenly distributed (60-85). Additionally, (Rizki et al., 2024) applied quantitative descriptive analysis to the concentration of Biology learning in grade XI, with an average difference of 0.27 on a scale of 4 between schools, using an independent t-test to compare variations in ability.

The theory of variance homogeneity as an assumption of the independent t-test in parallel Biology classes is confirmed by studies that use Levene's test to ensure dispersion equality before comparing means. (Dwi Puspita Sari, n.d.) reported sig 0.347 > 0.05 in the Biology science cognitive pretest, indicating homogeneous variance, so that the independent t-test was valid for comparing group learning outcomes. Similarly, an analysis in the Poltekkes repository (year unspecified) used Levene's Test on body weight data (analogous to learning outcomes), with Ho: variances are equal if sig > 0.05, supporting inferences between groups.

The normality test results of the learning outcomes of Grade X E4 and X E5 students at SMA Veteran 1 Sukoharjo are presented in Table 2.

Table 2. Normality Test of Learning Outcomes of Grade X E4 Students at SMA Veteran 1 Sukoharjo

Shapiro-Wilk	*Result*
Statistic	0,972
df	38
Sig.	0,443

Based on Table 2, the results of the normality test of the biology learning outcomes of grade X E4 students at SMA Veteran 1 Sukoharjo, the the Shapiro–Wilk test results show a statistical value of 0.972, a sample size (N) of 38, and a significance value of 0.443. The significance values in the Shapiro–Wilk tests are each greater than the significance level of 0.05 (Sig. > 0.05). Therefore, it can be concluded that the biology learning outcome data of class X E4 students is normally distributed. With the assumption of normality fulfilled, the biology learning outcome data of class X E4 students meets one of the prerequisites for parametric statistical analysis, specifically the independent two-sample t-test. The normality test of learning outcomes of grade X E5 students at SMA Veteran 1 Sukoharjo are presented in Table 3.

Table 3. Normality Test of Learning Outcomes of Grade X E5 Students at SMA Veteran 1 Sukoharjo

Shapiro-Wilk	*Result*
statistics	0,968
df	38
Sig.	0,318

Based on Table 3, the results of the normality test of the biology learning outcomes of grade X E5 students at SMA Veteran 1 Sukoharjo, the Shapiro-Wilk test results show a statistical value of 0.968, a sample size (N) of 38, and a significance value of 0.318.

The significance values in the and Shapiro-Wilk tests are each greater than the significance level of 0.05 (Sig. > 0.05). Therefore, it can be concluded that the biology learning outcome data of class X E5 students is normally distributed. With the assumption of normality fulfilled, the biology learning outcome data of class X E5 students meets one of the prerequisites for parametric statistical analysis, specifically the independent two-sample t-test. Normality testing is part of statistical analysis used to determine whether research data has a normal distribution so that it can be used in parametric statistical testing. According to (Zulkifli et al., 2025), normality testing aims to ensure that the data obtained is in accordance with a certain theoretical distribution. In this study, normality tests were conducted using the Shapiro–Wilk tests with the help of IBM SPSS software, which is commonly used in quantitative education research (Ahadi & Zain, 2023). Thus, the normality test criteria for the biology learning outcome data of class X E4 students are normally distributed (Nurkhalimah & Andriani, 2025).

Based on the normality test results for classes X E4 and X E5, it can be concluded that all biology learning outcome data are normally distributed, based on the Kolmogorov–Smirnov and Shapiro–Wilk tests. Assuming normality is satisfied, the learning outcome data for classes X E4 and X E5 meet one of the prerequisites for parametric statistical analysis. Therefore, further data analysis can be performed using an independent two-sample t-test to compare the average biology learning outcomes between the two classes (Tatsbita Rusyda et al., 2024). The test of homogeneity of variances are presented in Table 4.

Table 4. Test of Homogeneity of Variances

Variable	*F*	*Sig.*
biology test score	2.695	0,105

Based on Table 4, the results of the homogeneity of variance test on the Biology test score variable obtained an F value of 2.695 with a significance value (Sig. = 0.105). This significance value is greater than the commonly used significance level, which is $\alpha = 0.05$, as found in the study by (Nasar et.al., 2024) which reported a Sig. value of 0.939 in the Levene test to confirm the homogeneity of early childhood creativity data. This indicates that there is no significant variance between the two groups being compared, so the data can be declared homogeneous. According to (Zulkifli et al., 2025), a homogeneity test provides assurance that a set of data manipulated in a series of analyses originates from a population but does not differ significantly in terms of diversity. In addition to testing the normality of the data, it

is also necessary to test homogeneity. The homogeneity test is a test to determine whether the variances of two or more distributions are the same (Balai et al., n.d.)

In addition, the results of the homogeneity test show that the distribution of Biology test scores in each group has a relatively similar level of diversity, so there are no significant differences in variance between the groups analyzed. This condition indicates that the Biology test result data comes from a population with comparable characteristics, so that comparisons of learning outcomes between groups can be made fairly and objectively without any bias caused by differences in data variation.

This allows for the application of further parametric tests such as the independent t-test without the risk of bias due to variance heterogeneity, thereby increasing the reliability of conclusions about differences in learning outcomes. Fulfilling this assumption is also consistent with standard practice in educational research, where homogeneity is a key prerequisite for valid comparative analysis.

The application of Levene's homogeneity test in the context of education, such as in learning outcome data, is crucial to avoid type I or II errors in hypothesis testing, as explained by (Vorapongsathorn et al., 2004), who emphasize the role of this test in ensuring similar variance between control and treatment groups. With homogeneous data, comparisons between groups in Biology tests become objective, minimizing the influence of external variations and supporting the generalization of results to a wider population. These findings reinforce that such prerequisite steps are essential before further analysis, as recommended in recent case studies of educational statistical analysis. Thus, the Biology test results data meet the assumption of homogeneity and are suitable for proceeding to the next stage of statistical analysis. The Comparative Test are presented in Table 5.

Table 5. Comparative Test

Levene's Test for Equality of Variance	*Equal variance assumed*	*Equal variance not assumed*
F	2.695	
Sig	0,105	
t-test for Equality of Means		
T	-0,631	-0,631
Df	74	64.834
sig.(2-tailed)	0,530	0,530
Mean Difference	-2.632	-2.632

Based on Table 5. The results of the Independent Two-Sample T-test on the biology learning outcomes of students in classes X E4 and X E5 at SMA Veteran 1 Sukoharjo show that the F statistical value in Levene's Test for Equality of Variances is 2.695 with a significance value of 0.105. This significance value is greater than the significance level of 0.05, so it can be stated that the variance of the biology learning outcomes data for students in both classes is homogeneous.

Furthermore, the t-test results for Equality of Means with the assumption of homogeneous variance (Equal variances assumed) show a t-value of −0.631 with a degree of freedom (df) of 74. The two-tailed significance value Sig. (2-tailed) obtained is 0.530, which is also greater than 0.05 (0.530 > 0.05). Thus, it can be concluded that there is no significant difference between the biology learning outcomes of students in class X E4 and class X E5 at SMA Veteran 1 Sukoharjo.

The independent samples t-test is a parametric statistical method used to test the similarity or difference in means between two independent populations (Yamin & Kurniawan, n.d.). Independent populations are defined as sample groups that are not related to or do not influence each other (Field, 2024). In educational research, this condition is commonly found in parallel classes, such as classes X E4 and X E5, where students in each class follow the learning process separately and do not influence each other's learning outcomes (Sugiyono, 2013). The independent t-test is used when researchers do not have information about population variance, so variance estimates are based on available sample data, a condition commonly found in empirical research in the field of education ((Yamin & Kurniawan, n.d.) Priyatno, 2017).

Before conducting a comparison test using an independent two-sample t-test, the biology learning outcomes data of students in classes X E4 and X E5 were first tested to ensure they met the parametric statistical assumptions, namely that the data were normally distributed and had homogeneous variance (Ghozali, 2018; Santoso, 2010) . Fulfilling these assumptions is important to ensure the validity and accuracy of statistical hypothesis testing results (Field, 2024). Based on the results of the homogeneity test using Levene's Test for Equality of Variances, a statistical value of F of 2.695 with a significance

value of 0.105 was obtained. This significance value is greater than the significance level of 0.05, so it can be concluded that the variance of the biology learning data of students in classes X E4 and X E5 is homogeneous (Ghozali, 2018; Santoso, 2010). Thus, the data meets one of the main prerequisites for analysis using the independent two-sample t-test with the assumption of equal variances (Priyatno, 2017).

The results of the independent two-sample t-test analysis show a t-statistic value of −0.631 with degrees of freedom (df = 74) under the assumption of equal variances. The two-tailed significance value (Sig. (2-tailed)) obtained is 0.530. This significance value is greater than the significance level of 0.05 commonly used in educational research (Sugiyono, 2013). These results indicate that statistically there is no significant difference between the average biology learning outcomes of students in classes X E4 and X E5 (Ghozali, 2018). Thus, the null hypothesis (H_0), which states that there is no difference in the average learning outcomes between the two classes, is accepted, while the alternative hypothesis (H_1) is rejected (Field, 2024; Sugiyono, 2013).

Based on a 95% confidence level, a difference is considered insignificant if the Sig. (2-tailed) value is greater than 0.05 (Priyatno, 2017). The results of this study indicate that the significance value of the t-test is above this limit, so that the difference in the average biology learning scores between classes X E4 and X E5 is not statistically significant (Ghozali, 2018). The descriptive difference in scores is not strong enough to indicate a real difference between the groups (Sugiyono, 2013). This finding is in line with learning theory, which states that student learning outcomes are influenced by various internal and external factors, not solely by class division (Slamento, 2010). The absence of significant differences in biology learning outcomes between classes X E4 and X E5 indicates that students in both classes experience relatively similar learning conditions. The uniformity of internal and external learning factors is likely to contribute to the comparable academic achievement observed in the two parallel classes(Pasapan et al., 2025).

The absence of significant differences in biology learning outcomes between students in classes X E4 and X E5 indicates that the biology learning process in both parallel classes was relatively equivalent. This equality in learning outcomes indicates that teachers, teaching materials, learning methods, and evaluation systems have been applied consistently in both classes (Arikunto, 2021; Dimyati & Mudjiono, 2006). The findings of this study support the importance of equalizing the quality of learning between parallel classes as an effort to achieve fairness in education. Therefore, schools and teachers can use the results of this study as a basis for maintaining and improving the quality of Biology learning by focusing more on developing the individual potential of students rather than differentiating treatment based on class (Uno & Lamatenggo, 2016; Arikunto, 2021).

4. Conclusion

Based on the results of data analysis and discussion, it can be concluded that the biology learning outcomes of students in classes X E4 and X E5 at Veteran 1 High School in Sukoharjo did not show a statistically significant difference. This was proven by the results of the two-sample independent t-test, which produced a significance value (2-tailed) of 0.530, which was greater than the significance level of 0.05. Thus, the null hypothesis stating that there is no difference in the average biology learning outcomes between the two classes is accepted. Although descriptively there is a difference in the average scores between classes X E4 and X E5, the difference is not strong enough to indicate a real difference in student learning outcomes.

The implication of this finding shows that the Biology learning process in parallel classes at Veteran 1 High School in Sukoharjo has been relatively even and consistent. The equality of learning outcomes indicates that the application of learning materials, teaching methods, and evaluation systems has provided balanced learning opportunities for all students. Therefore, teachers and school officials are advised to maintain the quality of learning that has been implemented and continue to develop learning strategies that can improve the individual potential of students. Furthermore, future research can be directed at examining other factors that have the potential to influence learning outcomes, such as learning models, the use of learning media, and characteristics.

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