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The effect of PjBL, PBL, and STEM learning methods on student learning outcomes on photosynthesis material

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ABSTRACT
Photosynthesis is a vital process in the biological world which is the basis for the survival of plants. It is important to ensure that the learning methods used are able to provide students with a deep understanding and encourage the development of critical and creative thinking skills in accordance with the demands of the independent curriculum. Several methods offer learning approaches that focus on applying theoretical concepts in practical contexts, such as PJBL, PBL, STEM and Conventional methods. It is hoped that this research can contribute to improving the quality of high school biology learning by providing insight into the effectiveness of different learning methods. The research method used is a Quasi Experimental method with a Posttest Only Design type. The research sample was four high school XII science classes using purposive sampling. The results of the hypothesis test show that the Sig. less than 0.05, so it rejects Ho and accepts H1, that there are differences in learning outcomes using PJBL, PBL, STEM and conventional methods. Based on the mean rank, it was found that the STEM method was better than the PJBL, PBL and conventional methods.

INTRODUCTION

Biology learning in Senior High School, especially grade 12 science major, has the aim of developing students' understanding of scientific concepts to hone science knowledge and skills in general, including photosynthesis (Samsudin & Hardini, 2019). Photosynthesis is a vital process in the world of biology that is the basis for plant survival (Dimec & Strgar, 2017). Meanwhile, the concept of photosynthesis is a difficult material because it is complex and has many abstract concepts and is limited in direct observation (Akhada & Yuliani, 2019). Therefore, it is important to ensure that the learning methods used are able to provide deep understanding to students and encourage the development of critical and creative thinking skills in accordance with the demands of the independent curriculum (Winarso & Haqq, 2020).

Currently, there are various learning methods that can be applied, one of which is the Project-Based Learning (PJBL) method (Simangunsong et al., 2022), Problem-Based Learning (PBL) (Isma et al., 2021; Rais & Suwanto, 2017), and Science, Technology, Engineering, and Mathematics (STEM) (Sumaya et al., 2021). These three methods offer learning approaches that focus on the application of theoretical concepts in a practical context, which can improve students' understanding and mastery of learning materials.

The application of the PJBL method is expected to motivate students to develop independent skills in exploring the concept of photosynthesis (Hutasuhut, 2010). In the PJBL method, students will be actively involved in projects or assignments that require them to seek information, think critically, and solve problems independently. The PBL method can also have a positive effect on student learning outcomes on photosynthesis material (Nurfiyanti et al., 2018; Husniati et al., 2016). By providing challenges or problems related to photosynthesis, students will be faced with real situations that encourage them to think critically, collaborate, and develop deeper understanding (Nurfiyanti et al., 2018). Meanwhile, the STEM approach integrates science, technology, engineering, and mathematics into learning (Sumaya et al., 2021). The application of the STEM method to photosynthesis material can help students understand the connection between these concepts and the real world, and stimulate students' interest in science and technology.

From the background of the problems that have been described, it is important to examine the effect of PJBL, PBL, and STEM methods on student learning outcomes on photosynthesis material in class 12 Science class Senior High School. This research is expected to contribute to improving the quality of biology learning at the high school level and provide further insight into the effectiveness of different learning methods

METHODS

In this study, a quasi-experimental method was used with the aim of observing the effect of learning methods on student learning achievement on photosynthesis material. The research was conducted in one of the public high schools in Bandung city with a population of all 12th grade science classes. The research sample was selected using purposive sampling technique by considering the class and initial ability of students. The ability of 12th grade science students must be the same, and have attended photosynthesis learning in class XII Science class. Four sample groups were obtained in the study, namely experimental group 1 using PJBL method, experimental group 2 using PBL method, experimental group 3 using STEM method and control group using lecture method. Each group consisted of 20 students, so the research sample was 80 people. The research design used is the Quasi Experimental Posttest Only Design, where the use of this design only gives posttests to experimental groups and control groups (Creswell & Guetterman, 2019). Posttest scores or student learning outcomes obtained then calculated the average (mean) and

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then tested using statistical tests, namely the Kruskall Wallis test (Hanief & Himawanto, 2017; Jamco & Balami, 2022).

Table 1. Posttest control group research design

Group	T	Posttest
Experiment 1	X1	O1
Experiment 2	X2	O2
Experiment 3	X3	O3
Control	-	O4

Description:
X1 : Treatment with PJBL Learning Method
X2 : Treatment with PBL Learning Method
X3 : Treatment with STEM Learning Method
O : Posttest

This research instrument is designed to analyze the differences in student learning outcomes by using PJBL, PBL, STEM learning models. The research instrument used for data collection in this study was a cognitive test of multiple-choice questions. The data analysis technique used the One-Way Anova test. Previously, the prerequisite test was carried out first, namely the normality test and homogeneity test using SPSS version 26. Furthermore, the post hoc test was carried out to determine whether there were significant differences in student learning outcomes using the PJBL, PBL, and STEM methods.

RESULTS AND DISCUSSION

The implementation of the research in the experimental and control classes resulted in several findings, including student learning outcome scores, normality test, homogeneity test, and hypothesis test. The following are the details of the research results.

Table 2. Posttest cognitive learning outcomes of students

Calculations	Experiment		Control	
	PJBL	PBL	STEM	Conventional
Total score	1085	1115	1680	1645
Highest score	65	65	95	95
Lowest score	40	40	75	75
Average	54,25	82,25	55,75	84

From Table 2, it can be seen that the PBL learning method has a higher average score than the PJBL and STEM experimental classes, while the control class has an average of 84. Before carrying out hypothesis testing, the data will be tested for normality and homogeneity to assess whether the distribution of data is normal and homogeneous. The normality test results are listed in Table 3, while the homogeneity test results can be found in Table 4.

Table 3. Normality test of student posttest learning outcomes

Learning Methods	Kolmogorov-Smirnov[a]		
	Statistic	PBL	Statistic
PJBL	.189	PJBL	.189
PBL	.172	PBL	.172
STEM	.178	STEM	.178
Lecture/Conventional	.238	Lecture/Conventional	.238

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Table 3 shows the results of the Kolmogorov-Smirnov test on learning methods in the experimental class. If the Sig. > 0.05, it can be concluded that the data has a normal distribution (Widana & Muliani, 2020). The PJBL, PBL, and STEM methods show a Sig. value greater than 0.05, indicating that the data in the three methods are normally distributed. However, in the control class with the lecture method, the Sig. value was 0.04, which was less than 0.05, indicating that the data did not have a normal distribution.

Tabel 4. Student posttest homogeneity test results

		Levene Statistic	df1	df2	Sig.
Score_Biology	Based on Mean	.155	3	76	.926

Table 4 shows the results of the homogeneity test, namely the Levene Test. Based on the Levene Test, the Sig. value is greater than 0.05 so that the data is homogeneously distributed. In Table 3, it can be seen that the data of the lecture group is not normally distributed. Because the data obtained are not normal, an alternative ANOVA test will be carried out, namely the Kruskal Wallis Test. The Kruskall Wallis test can be used if the normality of the data is not met.

Hypothesis Test

To answer the formulation of the research hypothesis, whether there are differences in learning outcomes using different learning methods in class XII Science class on photosynthesis material. So, the hypothesis test was carried out using the Kruskal Wallis test by paying attention to the Asymp.Sig results.

Table 5. Results of Kruskal-Wallis Test

	Score Biology
Kruskal-Wallis H	60.384
Df	3
Asymp. Sig.	.000

Based on Table 5 shows the P Value indicated by the Asymp. Sig. In this case the P Value value is 0.000 which is less than the critical limit of 0.05 which means accepting H1 or there is a difference in learning outcomes using PJBL, PBL, and STEM learning methods.

Table 6. Mean ranks score biology

Learning Method	N	Mean Rank
PJBL	20	19.48
PBL	20	21.53
STEM	20	61.83
Conventional	20	59.18
Total	80	

Table 6 shows the results of Kruskall Wallis output with SPSS, where the Mean Rank value shows the average rank of each treatment. The results show that the mean rank of the STEM method is higher than the mean rank of the Lecture method (Conventional). The PJBL and PBL methods are not better than the Lecture method. The STEM method is a better method than the PJBL, PBL and Lecture methods

Kruskall Wallis Test

To see significant differences, further tests or post hoc Kruskall Wallis tests were carried out which are presented in Table 7 below.

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Table 7. Pairwise comparison of learning methods

Learning Method	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.a
PJBL-PBL	-2.050	7.292	-.281	.779	1.000
PJBL-Conventional	-39.700	7.292	-5.444	.000	.000
PJBL-STEM	-42.350	7.292	-5.807	.000	.000
PBL-Conventional	-37.650	7.292	-5.163	.000	.000
PBL-STEM	-40.300	7.292	-5.526	.000	.000
Conventional-STEM	2.650	7.292	.363	.716	1.000

Table 7 shows that there is no significant difference in student learning outcomes between the PPA and PBL groups, and between the Lecture and STEM groups. However, there is a significant difference in student learning outcomes between the PJBL and Lecture method groups, between the PJBL and STEM methods, and between the PBL and STEM methods.

Comparison of PJBL and PBL methods can be seen in the Rank Mean, where the PBL method is better than the PBJL method. In accordance with Lestari & Juanda's (2019) research which compared PJBL and PBL methods and found that the PBL method was better than the PJBL method. This is because in the PBL method, students are more active and understand when given problems to solve with the group. Each group is required to work together to conclude the results of the discussion. Whereas in PJBL, students are not too focused on the material being taught and only a few people are active in working on the project that has been given. While working on the project takes quite a long time and is even continued at home.

Based on Table 6, it shows that the lecture method is better than the PJBL method and is significantly different. In line with the research of Novitasari & Suhartono (2021) who found that the PJBL and lecture learning models had a significant effect on student learning achievement. According to Elmasari (2016), the PBL method is more influential than the lecture method, but based on the results obtained, the lecture method is better than the PBL method, although there is an increase in learning outcomes before and after learning activities with conventional methods (lecture) (Elmasari, 2016).

Based on the research, it is found that the lecture method is better than the PJBL and PBL methods. This can be caused because conventional methods or lectures also have advantages. The advantages of the lecture method are that the teacher can explain the lesson well and more easily, the lecture method is easier to implement, and can be followed by a large number of students (Tasliya & Bardi, 2016).

Comparison of the STEM method with the Lecture method in Table 7, shows that the STEM method is better than the conventional method or lecture. This is supported by Tunggai's research (2023), which found that the STEM method can improve students' concept understanding more effectively than conventional methods because the STEM method involves students more actively in thinking and solving problems so that students' concept understanding is more improved than the lecture method. STEM learning makes students more capable of experiencing the problem-solving process because students are given the freedom to design. Students more easily remember and master technology (Kaniawati et al., 2015). If students are accustomed to integrating problems with STEM, it will help students' critical, logical, and systematic thinking processes (Kaniawati et al., 2015). Based on several research results, it shows that learning using STEM methods is an effective method and can increase student learning motivation, including science learning motivation (Burke et al., 2020; Farwati et al., 2021; Ilyas et al., 2022).

STEAM is a model designed according to student needs, integrating content from various sciences into the curriculum. STEAM provides interesting and fun teaching (Wu et al., 2022) and can be applied flexibly (Kant et al., 2017). In addition to fun learning, STEAM can also increase creativity. High creativity is characterized by flexible, fluent, detailed and original abilities in solving problems related to the environment (Habib, 2023).

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CONCLUSION

Based on the results of research and data analysis, it can be concluded that there are differences in student learning outcomes on photosynthesis material using PJBL, PBL, STEM and Lecture methods. Decision making based on the results of the Kruskall Wallis test with an Asymp. Sig value of 0.00 is less than 0.05 or the critical limit, thus rejecting Ho and accepting H1. The average ranking of learning methods shows that the best method is the STEM method compared to the PJBL, PBL and Lecture methods. There is a significant difference in student learning outcomes between the groups of PJBL method with Lecture, between PJBL method with STEM, and PBL method with STEM.

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