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Effect of Problem-Based Learning Model on Biology Learning Motivation and Conceptual Understanding

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Abstract: Education plays a crucial role in shaping high-quality human resources. However, observations at SMA Negeri 5 Mataram revealed that students are less motivated to participate in classroom learning. This is evident from students' lack of attention to the teacher's explanation and their difficulty in understanding the material. One of the main causes is the use of monotonous, teacher-centered learning methods. This condition calls for innovation in teaching, such as implementing the Problem-Based Learning (PBL) model, which is designed to improve students' motivation and conceptual understanding. This study aims to analyze the effect of the problem-based learning model on students' learning motivation and understanding of biological concepts among Grade X students at SMA Negeri 5 Mataram. The research employed a quantitative approach with a quasi-experimental design using a non-equivalent control group, involving an experimental group and a control group with both pretest and posttest. The sample was selected using purposive sampling, with class X6 as the control group and class X7 as the experimental group. The instruments used were a questionnaire to measure learning motivation and an essay test to assess conceptual understanding. The data were analyzed using the Mann-Whitney test, which showed a significant difference between the experimental and control groups, with a significance value of 0.000 < 0.05. These findings indicate that the problem-based learning model has a positive effect on improving both learning motivation and conceptual understanding. A good understanding of concepts can enhance students' confidence in learning, thereby increasing intrinsic motivation. With strong motivation and conceptual understanding, students tend to achieve better academic outcomes and are more prepared to continue learning and adapting to future challenges.

Keywords: Conceptual Understanding; Learning Motivation; Problem-Based Learning.

Introduction

Education plays a crucial role in developing high-quality human resources. One of the important subjects in education is biology. Biology is the science that studies life logically and scientifically, and this body of knowledge has evolved continuously over time. Biologists constantly expand their understanding, making biology increasingly comprehensive. Like other sciences, biology develops in response to human needs to understand various phenomena and solve problems. Just as information technology continues to advance, biology also evolves rapidly, and today we have gained much new knowledge in this field [1]. Biology is one of the oldest and most extensive branches of natural science, aiming to answer fundamental questions about life [2].

In secondary school biology learning, teachers often face challenges in motivating students to learn, which negatively affects students' understanding of the concepts being taught. Traditional teacher-centered methods that rely heavily on lectures and memorization tend to be less effective in engaging students or helping them understand biology in depth. As a result, many students find it difficult to connect the subject matter to real-life situations and are less able to apply their knowledge critically in various contexts. This is concerning, as high motivation and conceptual understanding are essential for navigating the complex challenges of the modern world. Without strong conceptual understanding, students may be unprepared to solve real-world problems that require analysis, evaluation, and creative solutions. In addition, a lack of motivation can reduce the quality of learning and negatively impact academic achievement [3].

Students with high learning motivation are more likely to achieve strong academic outcomes. The greater the motivation, the more intense their learning efforts. A solid understanding of concepts can boost motivation by giving students a sense of control and confidence in their learning. The combination of strong motivation and conceptual understanding creates long-term positive impacts on learning outcomes. Students who possess both are more likely to succeed, not only in formal education but also in lifelong learning. They develop the skills and attitudes necessary to continue learning and growing—qualities essential in an ever-changing world [4].

A lack of motivation to learn can be caused by various internal and external factors. Internal factors include physical and mental conditions, psychological health problems such as fatigue, stress, anxiety, or depression, all of which may lower students' motivation to learn. Lack of interest, particularly when a subject is perceived as boring or irrelevant, can cause students to lose enthusiasm. Low self-confidence and fear of failure can also prevent students from making greater efforts. The

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absence of clear goals may leave students without a strong reason to continue learning [5].

External factors include unengaging teaching methods and low family support. Students may lose interest when their home environment does not offer encouragement or appreciation. Academic stress, such as excessive assignments or difficult material, can overwhelm students and decrease motivation. Limited access to resources like books, the internet, or a proper study space can also hinder the learning process.

The lack of motivation and poor conceptual understanding can also stem from a lack of innovative teaching models and insufficient encouragement for students to actively participate in the learning process. The use of inappropriate instructional models can hinder students' critical thinking and scientific reasoning abilities [6]. When students are not given space to think critically and solve problems independently, it becomes difficult for them to develop a strong grasp of biology concepts. Low learning motivation also leads to disinterest and disengagement, especially if the teaching methods used are monotonous and dull [7]. Conventional, non-contextual teaching approaches make it difficult for students to relate the material to their everyday lives [8].

In modern education, the goal of learning is not only to deliver content but also to foster learning motivation and deepen conceptual understanding. Therefore, an effective and innovative teaching model is needed, one that can achieve both goals. One such model is Problem-Based Learning (PBL), which is a student-centered instructional approach. Students are challenged to solve real-world problems related to the subject matter. This model encourages students to think critically, seek information, and apply their knowledge in relevant situations [9].

Problem-Based Learning has been implemented across various disciplines and has shown positive results, especially in improving student engagement and motivation. Well-designed instructional models applied by teachers can significantly influence students' learning motivation and conceptual understanding, particularly when using the PBL approach [10]. PBL is expected to enhance both learning motivation and conceptual understanding because it encourages students to focus on solving real problems and forming hypotheses, which helps integrate their knowledge and skills. It is an effective model because it allows students to work collaboratively and facilitates deeper understanding of concepts. In this way, their knowledge grows continuously and they become more capable of solving problems in daily life.

A similar study published in the journal "The Effectiveness of Problem-Based Learning in Increasing Students' Cognitive Outcomes and Learning Motivation" demonstrated that the PBL model is highly effective in improving both cognitive outcomes and learning motivation [11]. Another study published in "The Effect of the Problem-Based Learning Model on Students' Conceptual Understanding and Critical Thinking Skills Regarding Ecosystems and Environment in Grade X of SMA Negeri 1 Sigi" found that PBL had a significant positive impact on students' understanding of biological concepts [12]. This study differs by examining the effect of the PBL model on two variables simultaneously: learning motivation and conceptual understanding. High learning motivation tends to lead to better conceptual understanding, and conversely, good conceptual understanding can boost students' motivation. Additionally, this study was conducted in one senior high school in Mataram, where no prior research had examined the influence of PBL on both learning motivation and conceptual understanding.

Based on observations at SMA Negeri 5 Mataram, it was found that students tended to lack motivation during the learning process. This was evidenced by students' inattentiveness to the teacher's explanation. Students were unable to deeply understand the material because the instructional method used was still teacher-centered. In other words, the learning process—which should actively involve students—was dominated by one-way delivery from teacher to student. As a result, students tended to memorize information without truly understanding the concepts. Moreover, low learning motivation was a major factor contributing to students' poor understanding of biology content. Given the importance of learning motivation and conceptual understanding, this study aims to examine the effect of the Problem-Based Learning model on students' learning motivation and conceptual understanding in biology at SMA Negeri 5 Mataram.

Research Methods

This study is a quantitative study employing a quasi-experimental design. Quasi-experimental research, like experimental research, aims to examine causal relationships through the application of a treatment to the intervention group [13]. The research design used in this study is the non-equivalent control group design, which includes a pretest before the treatment and a posttest after the treatment for each group. The study was conducted at SMA Negeri 5 Mataram, which has a total of 439 tenth-grade students divided into 12 classes. The samples selected were class X6 as the control group and class X7 as the experimental group, using a purposive sampling technique.

The instruments used in this study consisted of two types: a learning motivation questionnaire and an essay test to assess conceptual understanding. The motivation questionnaire, consisting of 29 statements, was developed based on the learning motivation indicators proposed by Uno [14]. The questionnaire used a Likert scale with response options: Strongly Agree (SA), Agree (A), Fairly Agree (FA), Disagree (D), and Strongly Disagree (SD). Before the instruments were used, validity and reliability tests were conducted. The conceptual understanding instrument consisted of 11 essay questions developed based on the concept understanding indicators according to Suryani [15]. This instrument also underwent validity and reliability testing prior to its use. Based on the results of the validity test of the motivation questionnaire, 7 out of 36 statements were found to be invalid. The reliability test of the remaining 29 valid questionnaire items showed a Cronbach's alpha correlation coefficient of 0.917, while the reliability test of the 11 conceptual understanding questions resulted in a Cronbach's alpha value of 0.813. These values indicate that both the motivation questionnaire and the conceptual understanding test items had very high reliability. The pretest for both learning motivation and conceptual understanding was conducted before the treatment during the first meeting, while the posttest was administered after the treatment in the final meeting. Data analysis in this study was carried out using appropriate statistical tests.

Normality Test

The Shapiro-Wilk test was used to assess the normality of the data. This test is considered more accurate and appropriate for small to medium sample sizes. The decision rule for interpreting the Shapiro-Wilk test is as follows:
If p > 0.05, the data are normally distributed.
If p < 0.05, the data are not normally distributed [16].

Table 1 below presents the results of the normality test for students' learning motivation.

Class sample	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest_Learning Motivation_Experimental	0.946	37	0.071
Posttest_Learning Motivation_Experimental	0.963	37	0.254
Pretest_Learning Motivation_Control	0.930	37	0.022
Posttest_Learning Motovation_Control	0.974	37	0.542

Table 2. Results of Normality Test for Students' Conceptual Understanding

Class sample	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest_Conceptual Understanding_Experimental	0.882	37	0.001
Postest_Conceptual Understanding_Experimental	0.909	37	0.005
Pretest_Conceptual Understanding_Control	0.950	37	0.093
Posttest_Conceptual Understanding _Control	0.930	37	0.023

Homogeneity Test

In this study, the Levene's Test was used to assess the homogeneity of variance between the experimental and control groups. Levene's Test determines whether the variances of the two groups are equal, which is a prerequisite for certain parametric statistical tests.

If the significance value (p-value) < 0.05, it indicates that the test is significant, meaning the variances between the two groups are not equal.
If the p-value > 0.05, it means the test is not significant, and the variances between the groups are considered homogeneous (equal).

Table 3 shows the results of Levene's Test for students' learning motivation.

	Levene Statistic	df1	df2	Sig.
Pretest_Learning Motivation	0.283	1	72	0.597
Posttest_Learning Motivation	4.150	1	72	0.045

Table 4 shows the results of Levene's Test for students' conceptual understanding

	Levene Statistic	df1	df2	Sig.
Pretest_Coceptual Understanding	7.054	1	72	0.010
Posttest_Conceptual Understanding	2.516	1	72	0.117

Hypothesis Testing

The hypothesis testing in this study was conducted using the non-parametric statistical analysis, specifically the Mann-Whitney U Test. This test was chosen because the research data did not meet the assumptions of normality and homogeneity. The Mann-Whitney U Test is used to examine differences in the mean ranks of two independent samples when one or both samples are not normally distributed [17].

Results and Discussion

Learning Motivation

Descriptive statistical analysis was conducted to provide a general overview of students' learning motivation before and after the implementation of the learning model. The data analyzed includes the number of participants (N), minimum and maximum scores, mean, and standard deviation. This analysis provides initial information regarding changes in students' learning motivation after the treatment. The descriptive statistics of the pretest and posttest results of students' learning motivation are presented in Table 5.

Table 5. Pretest and Posttest Learning Motivation

Component	Control		Experimental	
	Pretest	Posttest	Pretest	Posttest
Number of students		37		37
Average score	72.6	80	71.5	85.5
Minimum score	50	71	60	69
Maximum score	85	89	85	98
Standard deviation	8.4	4.8	7.0	6.4

Table 5 shows a difference in scores between the pretest and posttest of students' learning motivation. The average pretest score of learning motivation in the experimental class was 71.5, while the average posttest score increased to 85.5, indicating an improvement of 14 points. In the control class, the average pretest score was

72.6, and the average posttest score was 80, showing an increase of 7.4 points. These data indicate an increase in learning motivation in both the experimental and control classes; however, the improvement in the experimental class was higher than in the control class.

The results of the Mann-Whitney hypothesis test on the pretest data of learning motivation showed a significance value of 0.303 > 0.05, indicating no significant difference between the experimental and control classes at the time of the pretest; thus, both classes had equivalent initial abilities. The results of the hypothesis test on the posttest data of students' learning motivation showed a significance value of 0.000 < 0.05, indicating a significant difference in learning motivation between the two classes (Table 6).

Table 6. Mann-Whitney Test Results for Learning Motivation

	Pretest	Posttest
Mann-Whitney U	589.500	330.000
Wilcoxon W	1292.500	1033.000
Z	-1.030	-3.844
Asymp. Sig. (2-tailed)	0.303	0.000

These findings strongly indicate that the implementation of the problem-based learning (PBL) model has a positive impact on increasing students' learning motivation. This improvement can be attributed to the main characteristics of the PBL model, which allow students to take an active role, think critically, and collaborate in solving real-world problems that are relevant to their everyday lives. Unlike lecture-based methods that tend to position students as passive recipients of information, PBL encourages deep mental and emotional engagement, ultimately creating a more enjoyable and intellectually stimulating learning environment.

Students' motivation to learn can be greatly affected by the teaching methods employed by educators [18]. Active, contextual, and participatory learning approaches foster a positive learning atmosphere and can enhance students' intrinsic drive to learn. The use of appropriate learning models and the creation of interactive classroom environments are essential factors in developing student motivation. When students are emotionally and cognitively engaged in the learning process, their eagerness to learn tends to grow [19].

Through its structured learning syntax—problem orientation, student organization, individual or group investigation, development and presentation of work, and analysis and evaluation of the process—the PBL model systematically meets those needs, thereby strengthening students' intrinsic motivation toward learning. Active learning, which focuses on student engagement in problem-solving activities, helps build self-confidence, promotes a sense of responsibility for their own learning, and strengthens social connections within learning groups — all of which play a role in boosting student motivation [20].

Problem-based learning positions students as the central agents in the learning process and emphasizes their active participation in solving contextual problems that reflect real-life experiences. Problem-solving activities, which demand critical thinking, teamwork, and personal responsibility in the learning process, directly contribute to an increase in learning motivation. Students view the learning experience as more demanding, relevant, and meaningful, which motivates them to participate more enthusiastically and engage actively in class [21].

Theoretically, this phenomenon can be explained by the Self-Determination Theory proposed by Deci and Ryan. The theory posits that intrinsic motivation will increase when three basic psychological needs are fulfilled: autonomy, competence, and relatedness. PBL provides space for students to feel control over their learning process (autonomy), experience success in task completion (competence), and work collaboratively with peers (relatedness). This is also consistent with Keller's ARCS motivational model (Attention, Relevance, Confidence, Satisfaction), in which PBL fulfills all four components through engaging and meaningful problem-solving activities.

However, it is essential to take into account the external validity of these results. The effectiveness of the PBL model in enhancing learning motivation could differ across various educational settings, particularly in schools with a more passive learning environment, limited teaching resources, or issues with classroom management. In institutions where educators lack experience with PBL, its implementation might lead to student misunderstanding and prove ineffective without adequate training and continuous professional development support.

Students' Conceptual Understanding of Biology

Descriptive analysis was conducted to examine changes in students' conceptual understanding before and after the implementation of problem-based learning in the experimental class and conventional learning in the control class. The results of the analysis are presented in Table 7.

Table 7. Pretest and Posttest Scores of Conceptual Understanding

Component	Control		Experimental	
	Pretest	Posttest	Pretest	Posttest
Number of students		37		37
Average score	64.6	74.3	59	84.5
Minimum score	41	48	9	59
Maximum score	79	90	78	95
Standart Deviation	10.1	9.8	17.4	7.6

Table 7 shows that the average pretest score in the experimental class was 59, while the average posttest score increased to 84.5, indicating a gain of 25.5 points. In the control class, the average pretest score was 64.6, and the posttest score was 74.3, with an increase of 9.7 points. These results indicate an improvement in conceptual understanding in both the experimental and control classes. However, the increase in the experimental class taught using the problem-based learning model was greater than that in the control class taught using the conventional learning model.

The results of the Mann-Whitney hypothesis test on the pretest data of conceptual understanding showed a significance value of 0.254 > 0.05, indicating that there was no significant difference between the experimental and control classes at the pretest stage, meaning both groups had equivalent prior knowledge. The hypothesis test result for the posttest data showed a significance value of 0.000 < 0.05, indicating a significant difference between the class taught using the problem-based learning model and the class taught using the conventional model (Table 8).

Table 8. Mann-Whitney Hypothesis Test Results for Conceptual Understanding

	Pretest Conceptual Understanding	Posttest Conceptual Understanding
Mann-Whitney U	579.000	263.000
Wilcoxon W	1282.000	966.000
Z	-1.142	-4.565
Asymp. Sig. (2-tailed)	.254	.000

In addition to its impact on improving learning motivation, the implementation of the problem-based learning (PBL) model in this study also significantly contributed to the enhancement of conceptual understanding. This is evident from the comparison of pretest and posttest mean scores between the experimental and control classes, where students in the experimental class showed an increase from an average score of 59 to 84.5, while students in the control class only improved from 64.6 to 74.3. The result of the Mann–Whitney statistical test, which yielded a significance value of 0.000 < 0.05, further supports the claim that there is a statistically significant difference in biology conceptual understanding between the two groups after the treatment was given.

Problem-based learning is not limited to understanding the definition of a concept but also involves connecting it to real-life situations, applying it in new contexts, and explaining the scientific rationale behind a phenomenon—all of which are indicators of deep conceptual understanding. Previous studies have shown that implementing PBL in biotechnology education significantly improves conceptual understanding, as the method emphasizes not only theoretical knowledge but also practical application [22]. PBL encourages students to actively engage in the learning process, which allows for the development of stronger and more enduring cognitive structures, particularly because students are directly involved in constructing, connecting, and explaining concepts.

The success of improving conceptual understanding through PBL cannot be separated from the role of the model's syntax or phases. During the investigation stage, students do not merely receive information from the teacher, but are involved in activities such as data collection, analyzing information, and testing hypotheses they have developed. In the presentation and evaluation stages, students are trained to communicate their understanding, which strengthens concept elaboration both verbally and visually. These processes of presentation and reflection also help students identify thinking errors or misconceptions, ultimately leading to stronger conceptual understanding. The reflective components integrated into PBL play a key role in fostering critical thinking and metacognitive abilities, which in turn support the development of deeper conceptual understanding [23].

PBL provides space for students to construct knowledge through direct involvement in exploration, investigation, and reflection on the problems presented. When students encounter problematic situations, they are encouraged to construct essential biological concepts through discovery and discussion. This process allows students not only to understand definitions or formulas but also to connect concepts with real-world phenomena. This aligns with the principles of constructivist learning, which emphasize that knowledge is not passively received from the teacher but is actively built by students through their interactions with the learning environment [24].

The implementation of PBL in chemistry education has also been shown to significantly enhance students' conceptual understanding [25]. In the context of biology—which often includes abstract and complex concepts—the problem-based approach helps students develop mental models and strengthen concept retention through visualization and problem-solving. However, the effectiveness of PBL in enhancing conceptual understanding is highly dependent on the design of the tasks given, students' readiness, and the teacher's ability to facilitate discussions. If the problems provided are too difficult or irrelevant, students may experience confusion. Therefore, teachers need to provide appropriate scaffolding and carefully prepare materials to ensure learning objectives are effectively achieved.

While this study was carried out in a single school with students of varying backgrounds, many other studies have confirmed that PBL is broadly applicable and yields [26]. This indicates that the PBL model has strong external validity in improving conceptual understanding in general.

Conclusion

The study revealed that the Problem-Based Learning (PBL) model significantly enhances students' learning motivation and conceptual understanding in biology among Grade X students at SMA Negeri 5 Mataram. The experimental class using PBL showed greater improvement than the control class. Increased motivation was reflected in active participation and enthusiasm, while improved conceptual understanding was evident in students' ability to explain and apply biological concepts. PBL proved effective in fostering meaningful, collaborative, and critical thinking-based learning, aligning with constructivist theory and 21st-century learning principles. Future research is recommended to explore PBL's impact on other variables such as critical thinking, creativity, scientific literacy, or scientific attitudes across different education levels and school settings. It is also suggested to integrate PBL with other instructional models like STEM, flipped classroom, or blended learning. Additionally, qualitative and longitudinal studies are needed to gain deeper insights into the implementation process and the long-term effects of PBL on student learning outcomes.

Author Contributions
This article is the result of undergraduate thesis research conducted by a student. Haika Muliana played an active

role in designing the research, collecting and analyzing data, and preparing the initial draft of the manuscript. Professor Dr. Agus Ramdani, M.Sc., and Mrs. Dra. Kusmiyati, M.Si., as academic supervisors, provided conceptual direction, critical feedback, and systematic revisions to the content and structure of the manuscript. All three authors have approved the final version of this manuscript and take full responsibility.

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