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THE EFFECT OF THE PROBLEM BASED LEARNING MODEL BASED ON SUBAK LOCAL WISDOM ON ECOSYSTEM MATERIAL ON THE CRITICAL THINKING ABILITIES AND LEARNING OUTCOMES OF HIGH SCHOOL STUDENTS

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Abstract

This research is a quantitative research with a pretest-posttest nonequivalent control group design that aims to explain and describe: (1) the influence of the PBL model based on local wisdom of Subak on critical thinking skills and student learning outcomes simultaneously in Biology learning on the topic of ecosystems, (2) the influence of the PBL model based on local wisdom of Subak on critical thinking skills of students in Biology learning on the topic of ecosystems, (3) the influence of the PBL model based on local wisdom of Subak on student learning outcomes in Biology learning on the topic of ecosystems. The sampling technique used was cluster random sampling with a research population of 483 students and a sample of 160 students consisting of classes X1, X2, X3, and X4 at SMA Negeri 1 Tabanan. The research instruments were critical thinking skills tests and learning outcome tests. Data analysis used Multivariate Analysis of Covariance (MANCOVA). Hypothesis testing was carried out using a significance level of 5%, hypothesis testing was carried out after assumption testing. Based on the data analysis, the implementation of the Subak local wisdom-based PBL model significantly impacted students' critical thinking skills and learning outcomes in ecosystems. The application of the Subak local wisdom-based PBL model in biology learning is expected to improve students' critical thinking skills and learning outcomes, as well as preserve Subak local wisdom with the community.

Keywords: local wisdom of subak, *problem based learning,* critical thinking, learning outcomes.

INTRODUCTION

Education plays a crucial role in improving the quality of human resources. High-quality human resources are expected to be competitive in the era of the Industrial Revolution 4.0, which coexists with the use of digital technology and 21st-century learning skills. These 21st-century learning skills are often referred to as the 4Cs, encompassing creative thinking, critical thinking and problem-solving, communication,

and collaboration (Jannah & Atmojo, 2022). Students are required to possess higher-order thinking skills to develop human resources capable of facing the challenges of the times (Syahria et al., 2022). In preparing human resources to compete in the mastery and development of science and technology, Natural Sciences (IPA) learning plays a crucial role (Sari et al., 2022). The role of science learning for future life is highly strategic, particularly in preparing future students who are critical, creative, and competitive, capable of solving problems and making quick and accurate decisions, enabling them to survive productively amidst the rapid waves of competition in the global digital era, which is full of opportunities and challenges.

One of the skills that must be prepared to face the development of the times is Higher Order Thinking Skills (HOTS), which examines critical thinking, creative thinking, and problem-solving (Laily et al., 2015). Critical thinking is the ability to objectively analyze, interpret, conclude, explain, and evaluate data (Facione, 2013). Critical thinking needs to be mastered by students to be able to face various personal and social problems in their lives. Critical thinking is a person's cognitive ability to express something with full confidence because it is based on logical reasons and strong evidence (Meilana et al., 2020). Critical thinking is a thought process to apply concepts, analyze opinions, synthesize and evaluate information, and draw conclusions. Critical thinking skills are the heart of the future of all societies in the world and must be possessed by students to face the problems presented in learning (Kurniawan et al., 2021). With this critical thinking ability, students will become more active, creative and able to master theories, events, facts, and concepts related to subjects which will later make a positive contribution to student learning outcomes (Asafa et al., 2023; Raturoma et al., 2023).

Learning outcomes are the abilities students acquire after receiving learning experiences from teachers through specific assessments that describe the criteria achieved (Agusti et al., 2022). To achieve learning outcomes that align with learning objectives, teachers must be able to package learning according to student characteristics. Teachers must strive for effective learning for students to provide meaningful experiences (Rosita et al., 2023). Students' ability to master material can contribute to achieving their learning outcomes and can achieve maximum learning outcomes (Marudut et al., 2020).

The reality in the field shows that the critical thinking skills of students in Indonesia are still relatively low based on the results of research by Amalia et al., 2024 stated that in general students have not been able to develop the habit of thinking and reading to understand important and strategic information needed to solve problems so that this is also related to the low critical thinking skills of students. Students' critical thinking skills are relatively low seen from teacher-centered learning which makes students unable to master the material in more depth so that students' critical thinking skills have not developed well (Nurfadilah, 2020). Based on these data, the achievement of students' critical thinking skills is limited to the ability to recognize and identify a number of basic phenomena, but have not been able to analyze and communicate various scientific topics, let alone apply complex and abstract concepts in students' daily lives.

Another cause of the low quality of students' thinking is science education that pays insufficient attention to the socio-cultural environment (Rosita et al., 2023). Currently, some educators are unable to connect scientific concepts to real life, and teaching does not emphasize the principle that science encompasses conceptual understanding and relates it to everyday life. However, local wisdom values in society can be utilized in learning, particularly in science learning in schools, thus making science learning more meaningful (Temuningsih et al., 2017).

Several innovations that have been implemented to improve learning outcomes and critical thinking skills include the implementation of innovative learning models (Nurhikmayati et al., 2020). One such innovative learning model is the Problem-Based Learning (PBL) model. PBL presents contextual problems to students, stimulating them to learn (Untari et al., 2022). This learning is designed based on realistic real-life problems, which can improve students' understanding of the material, problem-solving skills, and conceptual application skills, thus training them to think critically. Problem-based learning creates active learning conditions for students to solve problems through the stages of the scientific method (Saepuloh et al., 2021). In its application, PBL is not always effective. PBL also has weaknesses, including not all learning materials can be implemented PBL, teachers must remain active in presenting the material, and the high diversity of students in a class will make it difficult to assign tasks based on real-world problems (Shoimin, 2017). This is in line with research by Aryani (2018), which states that PBL is ineffective in terms of learning achievement and problem-solving skills because students still rely on textbooks to collect and solve the problems given. Another weakness of the PBL model is that it requires a significant amount of time and requires teachers who are able to effectively encourage student work in groups (Masrinah et al., 2019). These studies show inconsistent results regarding the impact of implementing problem-based learning models. Inconsistent findings from these studies on the same topic can create uncertainty in the decision-making process (Suyantiningsih et al., 2023).

This inconsistency relates to general obstacles encountered in implementing problem-based learning. Several factors hinder the implementation of problem-based learning, such as the learning environment and student characteristics, which can influence the effectiveness of the PBL model in practice, making it difficult for teachers to implement it in the classroom (Kusumawati et al., 2022). Therefore, the implementation of the PBL model needs to be linked to the students' environment. This aligns with contextual learning theory, which supports the importance of considering the interaction between individuals and their environment in the learning process. One way to do this is by linking learning to the culture or local wisdom within the community (Nisa, 2020).

Local wisdom is a set of knowledge possessed by a community to resolve problems or difficulties faced properly and correctly, in accordance with the values it supports. Local wisdom can be called the soul of local culture because it has been very well internalized and passed down from generation to generation (Eilana et al., 2022). Every part of the life of the local community will always be related to the environment. Local wisdom is the noble values that apply in the order of community life to, among other things, protect and manage the environment sustainably (Muliarsa et al., 2024).

Based on this understanding, local wisdom will always be connected to the lives of humans who live in a wise environment. Because the environment is a unified space with all objects within it, both living and inanimate (Komariah et al., 2018).

Bali, often known as the Island of the Gods, is renowned for its natural beauty. Beyond its stunning beauty, Bali is imbued with a rich array of local wisdom, ensuring its natural beauty remains sustainable. This local wisdom-based nature conservation has been passed down through generations as a timeless regional cultural heritage (Setyawati, 2023). Implementing local wisdom-based PBL learning will be highly beneficial because it can train students to explore, develop critical and analytical thinking, and collaborate to solve problems rooted in culture, local wisdom, and the interconnectedness of the environment and everyday life.

Based on the results of observations at SMA Negeri 1 Tabanan, in Biology learning, especially in class X, the PBL learning model has not been implemented and has not linked the learning material with the local wisdom values that exist in the environment around the students. In the learning process, teachers have not been optimal in developing students' critical thinking skills. Student activeness in learning is also still low based on several indicators including involvement in discussions, questioning skills, answering skills and courage to appear in front of the class. Data on learning outcomes of class X students at SMA Negeri 1 Tabanan, especially in Biology learning, is also low based on the criteria for achieving learning objectives in the sufficient category, namely in the range of 70 - 79. One effort to improve critical thinking skills and student learning outcomes is to link Biology learning materials with local wisdom of the Balinese people, one of which is the local wisdom of subak.

Subak is a traditional organization in the field of water management at the agricultural level in indigenous communities in Bali that is socio-agrarian, religious, and economic in nature that has historically continued to grow and develop (Bali Provincial Regulation No. 9 of 2012). Subak also has noble values that are universal and highly relevant to the concept of sustainable development. Subak as an agricultural cultural heritage in Bali has values that are very appropriate in the context of education (Suryawan et al., 2023). Within it there are values of local wisdom such as the concept of Tri Hita Karana (THK) which is so global because it contains teachings to always maintain harmony. Utilizing the values of local wisdom that exist in Subak in education is very appropriate, because it will have a dual meaning both in conservation efforts and the achievement of more meaningful learning (Mantaka, et al., 2017). In problem-based learning integrated with local subak wisdom, students can explore agricultural ecosystems and their problems and relate them to the culture and traditions of environmental conservation within the subak to provide solutions to the problems they encounter. These learning activities also align with deep learning, providing meaningful and enjoyable understanding for students, which will impact their critical thinking skills and learning outcomes.

Based on this explanation, it is deemed necessary to conduct research on the influence of the Subak local wisdom-based PBL model on students' critical thinking skills and learning outcomes in biology. All of these ideas are outlined in a study entitled "The Influence of the Subak Local Wisdom-Based Problem-Based Learning Model on High School Students' Critical Thinking Skills and Learning Outcomes."

RESEARCH METHODS

The type of research used was a quasi-experiment. In this study, the researcher's rationale for using a quasi-experiment was the impossibility of randomly assigning each individual student to a new group (creating a new class), as the students had been divided into several fixed classes (groups) whose formation was without the researcher's intervention. The researcher assigned students to their respective classes, and the randomization process could only be carried out to select the experimental and control classes from several classes that had already been formed (Sugiono, 2015).

This study employed a pretest-posttest nonequivalent control group design. The choice of pretest-posttest nonequivalent control group design follows the type of research conducted, namely quasi-experimental research. Nonequivalent does not mean that this study is impossible to create an equivalent group condition, but refers to unequal randomization (Sugiyono, 2015). This design indicates that one group receives the experimental treatment and the other group serves as the control group. Both groups are given a pretest and posttest simultaneously. Pretest and posttest scores are compared to determine the effectiveness of the treatment applied to each class.

The population of this study was 483 students of class X of SMA Negeri 1 Tabanan in the even semester of the 2024/2025 academic year. The class X was distributed into twelve classes, namely: class X1, X2, X3, X4, X5, X6, X7, X8, X9, X10, X11 and X12. In this study, four classes were used as research samples, namely two classes as experimental classes and two classes as control classes. The four classes were selected using a random distribution technique or using a cluster random sampling technique. The sample selection in this study was carried out by drawing twelve classes as the research population. So all populations with different characteristics have an equal opportunity to be sampled. The sample selected based on the draw in this study was four classes, namely two experimental classes that will apply the local wisdom-based PBL model and two control classes that will apply the PBL model.

The research was conducted at SMA Negeri 1 Tabanan from January to June 2025. The independent variables in this study were the PBL model based on local wisdom of Subak and the PBL model. The dependent variables in this study were critical thinking skills and student learning outcomes. The covariate variable in this study was the initial abilities of students.

Data analysis conducted on critical thinking skills test scores includes assumption testing and hypothesis testing. The data analysis technique used is the Multivariate Analysis of Covariance (MANCOVA) test. Multivariate Analysis of Covariance (MANCOVA) is a statistical technique used to test the statistical significance of the influence of independent variables on dependent variables. In MANCOVA there are several explanatory variables that are quantitative and qualitative (nominal). MANCOVA also uses covariates, namely control variables that are not correlated with the

independent variable but are correlated with the dependent variable. MANCOVA is used to investigate the influence of independent variables on the dependent variable, as well as to ensure there is no interaction between the dependent and independent variables. MANCOVA is used when there are two or more dependent variables (Sugiyono, 2019), therefore in this study there are 2 dependent variables and uses 1 covariate variable, the MANCOVA statistical test is used.

RESULTS AND DISCUSSION

RESULTS

The critical thinking ability variable was measured using multiple-choice questions with critical thinking indicators for students in the experimental and control groups, including minimum, maximum, average, standard deviation, and variance. A statistical summary of the pretest-posttest data on students' critical thinking abilities is presented in Table 1 as follows.

Table 1 Descriptive Statistics of Pretest-Posttest Results of Students' Critical Thinking Skills

Statistics	*Pretest*		*Posttest*	
	Control	Experiment	Control	Experiment
Amount	80	80	80	80
Minimum	35	45	55	75
Maximum	70	75	75	90
Average	54.25	55.87	65.37	85.19
Standard Deviation	6,147	7,053	18,635	4,317
Variance	37,781	49,747	51,756	18,635

Based on Table 1 above, we can see a comparison of students' critical thinking skills between the experimental group and the control group. The data illustrates that the results of the pretest of students' critical thinking skills did not have a significant difference in average scores between the control and experimental groups, which means that the initial abilities of students in both the control and experimental groups were not significantly different.

In the posttest results, critical thinking skills in the experimental and control groups increased, but a significant increase occurred in the experimental group. Based on the average value, the experimental group experienced an increase of 29.32 while in the control group it was 11.12. The increase in posttest results was caused by the treatment given, namely the PBL model based on local wisdom of Subak in the experimental class. This illustrates that critical thinking skills in the experimental class who learned with the PBL model based on local wisdom of Subak were better than the control group who learned with the PBL model.

The pretest and posttest data on critical thinking skills for each critical thinking skill indicator are presented in the form of a diagram in Figure 1.

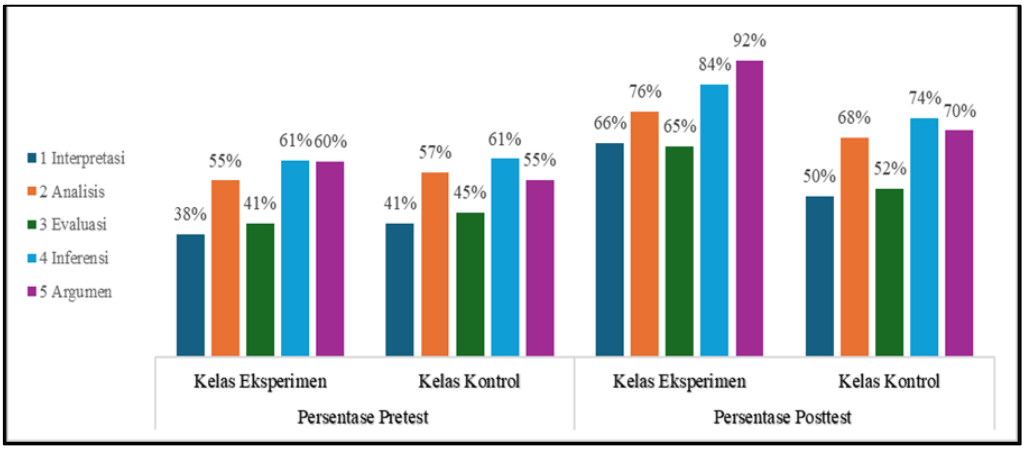

Figure 1. Results of measuring critical thinking ability indicators

Figure 1 shows that both groups experienced improvements in critical thinking skills indicators. Significant increases in scores for each indicator occurred in the experimental group, which was in the very high and high categories based on the benchmark assessment (PAP), compared to the control group, which was still in the high and medium categories. In the experimental group, the highest increase occurred in the argument indicator, with a score of 92% in the very high category. In the control group, the highest increase occurred in the inference indicator, with a score of 74% in the high category. This indicates that students who learned using the Subak local wisdom-based PBL model experienced a higher increase in critical thinking skills in each indicator compared to students who learned with the PBL model.

Learning outcome variables were measured using multiple-choice questions with cognitive learning outcome indicators for students in the experimental and control groups, including minimum, maximum, average, standard deviation, and variance. A statistical summary of the pretest-posttest data on student learning outcomes is presented in Table 2 as follows.

Table 2 Descriptive Statistics of Pretest-Posttest Results of Student Learning Outcomes

Statistics	*Pretest*		*Posttest*	
	Control	Experiment	Control	Experiment
Amount	80	80	80	80
Minimum	40	30	50	60
Maximum	70	70	75	95
Average	52.75	51.88	63.63	75.88
Standard Deviation	9,032	9,756	7,377	6,645
Variance	81,582	95,174	54,415	47,306

Based on Table 2 above, we can see a comparison of student learning outcomes between the experimental and control groups. The data shows that the pretest scores for student learning outcomes in the experimental and control groups did not differ significantly, indicating that the students' initial abilities were not significantly different.

In the posttest results, learning outcomes in the experimental and control groups increased, but a significant increase occurred in the experimental group. Based on the average value, the experimental group experienced an increase of 24.00 while in the control group it was 10.88. The increase in posttest results was caused by the treatment given, namely the PBL model based on local wisdom of Subak in the experimental class. This illustrates that the learning outcomes in the experimental class who learned with the PBL model based on local wisdom of Subak were better than the control group who learned with the PBL model.

The pretest and posttest data on learning outcomes for each critical thinking ability indicator are presented in the form of a diagram in Figure 2.

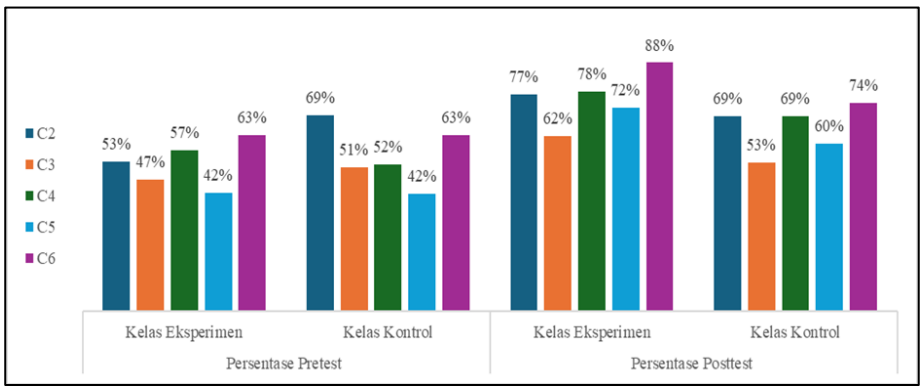

Figure 2. Results of measuring learning outcome indicators

Figure 2 shows that both groups experienced improvements in cognitive learning outcome indicators. Significant increases in scores for each indicator occurred in the experimental group, which was in the high category on average based on the benchmark assessment (PAP), compared to the control group, which was still in the moderate category. In the experimental group, the highest increase occurred in learning outcome indicator C6 (creating), with 88% in the very high category. In the control group, the highest increase occurred in indicator C6 (creating), with 74% in the high category. This indicates that students who learned using the PBL model based on local wisdom of Subak experienced higher learning outcomes in each indicator compared to students who learned with the PBL model.

After all prerequisite tests have been met, the research can proceed to the hypothesis testing stage. Hypothesis testing is conducted on all hypotheses proposed in this study. The null hypothesis (H0) is accepted if the significance value is above 0.05, and the alternative hypothesis (Ha) is accepted if the significance value is below 0.05.

Based on the results of the hypothesis testing on the three proposed hypotheses, among others, The first hypothesis proposed reads "The critical thinking skills and learning outcomes of students who learn with the PBL model based on local wisdom of Subak are not higher than those of students who learn with the PBL model" as H0, against the alternative hypothesis (Ha) which reads "the critical thinking skills and learning outcomes of students who learn with the PBL model based on local wisdom of Subak are higher than those of students who learn with the PBL model". The second hypothesis states that "the critical thinking ability of students who learn with the PBL model based on local wisdom of Subak is not higher than students who learn with the PBL model as H0, against the alternative hypothesis (Ha) which states "the critical thinking ability of students who learn with the PBL model based on local wisdom of Subak is higher than students who learn with the PBL model". The third hypothesis states that "the learning outcomes of students who learn with the PBL model based on Subak local wisdom are not higher than those of students who learn with the PBL model as H0, against the alternative hypothesis (Ha) which states "the learning outcomes of students who learn with the PBL model based on Subak local wisdom are higher than those of students who learn with the PBL model". Of the three hypotheses tested, the sig (p) value is 0.00 or >0.05 so that Ha is accepted and H0 is rejected.

DISCUSSION

Based on the results of data analysis, there is a positive influence or significant influence on the critical thinking skills and learning outcomes of students who learn using the PBL model based on local wisdom of Subak with students who learn using the PBL model in learning Biology on the topic of ecosystems.

Based on the results of statistical analysis of critical thinking skills and learning outcomes, a sig (p) value of 0.000 was obtained, less than 0.05. The significance in this case indicates that there is a difference in critical thinking skills and learning outcomes of students before and after being given treatment, namely the implementation of the PBL model based on Subak local wisdom. The results of the effect size test which shows how far the influence of the PBL model based on Subak local wisdom on critical thinking skills and learning outcomes simultaneously is at 2.48 with a very high effectiveness category. This shows that the PBL model based on Subak local wisdom is able to provide improvements in critical thinking skills and learning outcomes simultaneously. Learning that combines science and culture makes the learning feel very close to the daily lives of students, so that learning is student-centered.

Several theoretical foundations justify the Subak local wisdom-based PBL model for improved critical thinking skills and student learning outcomes. First, this influence is related to the characteristics of the PBL model, namely self-directed learning, where PBL encourages students to learn independently and seek information from various sources. Students develop skills in identifying learning needs, seeking relevant

information, and applying the acquired knowledge to solve problems (Suyanto, 2023). By integrating the Subak concept, which emphasizes the maintenance and preservation of the rice field environment, students are encouraged to learn about the components of rice fields that implement the Subak system and understand the interaction patterns of living things in the rice fields and the ecosystem problems that exist in the rice fields. Through the PBL model, students are directly involved in discussing, analyzing, and finding solutions to problems in the rice field ecosystem, such as pest infestations, disturbances to the water system, and land conversion that can disrupt the sustainability of the rice field ecosystem.

Second, related to the learning theory in the PBL model, which is in accordance with constructivism theory, namely that students discover and construct their own knowledge. This can be seen from how students analyze and solve problems in PBL, so that learning is not only about providing knowledge about Biology concepts but also making that knowledge meaningful through problem-solving activities based on local issues and linking it to local wisdom, which causes the concept to persist in students' minds and will later contribute to improving student learning outcomes. This is in line with Gusteti et al., 2022, who stated that PBL can help students think critically efficiently and become more insightful in solving problems both individually and in groups. Students can actively participate in the learning process and are directed to discuss material close to their daily lives. Learning that is close to students' lives can easily increase students' curiosity and make students actively seek solutions to these problems through creative ways (Rani & Mujianto, 2023).

Third, problem-based learning has syntax that encourages students to discuss and choose their own methods to solve problems presented by the teacher. This learning requires students to be active and collaborative in learning, thus developing independent problem-solving skills. The focus of this learning is on the chosen problem, so students not only learn concepts related to the problem but also scientific methods for solving it. Students must not only understand concepts relevant to the problem at hand but also gain learning experiences related to the skills of applying scientific methods to problem-solving and fostering critical thinking patterns. To create meaningful learning, problem-based learning can be integrated with local wisdom. Local wisdom is a highly effective tool for building connections between learning and students' daily lives. The integration of local wisdom values into science learning makes learning more meaningful (Adawiyah et al., 2022). Local wisdom is also considered an important aspect that must be integrated into the curriculum to develop an understanding and appreciation of local cultural values.

This is in line with previous research, which states that integrating Subak local wisdom into learning has various concepts that can be applied in learning, especially in biology. In practice, learning that integrates the Subak system can be carried out through various methods, such as field trips to Subak areas, research projects on ecosystems, and

discussions on the impact of climate change on traditional irrigation systems. With this approach, students not only learn theory but also gain direct experience that enriches their understanding of the interaction between humans and the environment (Trigunasih & Wiguna, 2022; Febriana et al., 2021). Subak is a traditional Balinese water management system based on local wisdom values such as mutual cooperation, harmony with nature, and spirituality. Subak is not only about irrigation, but also reflects the Tri Hita Karana philosophy of life, namely the harmonious relationship between humans and God, humans with humans, and humans with nature. Therefore, Subak has great potential to be integrated into problem-based learning to develop critical thinking skills, collaboration, and cultural and environmental awareness in students.

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the application of the Problem Based Learning model based on Subak local wisdom has a significant influence on improving students' critical thinking skills and learning outcomes in ecosystem material. This learning model not only focuses on understanding academic concepts, but also links the material to real-life contexts close to the students' environment, especially in the context of Balinese culture and agricultural systems. The PBL model based on Subak local wisdom can be used to improve critical thinking skills and learning outcomes in Biology learning, especially on the topic of Ecosystems.

Based on the findings in this study, the following conclusions can be drawn.

1. Simultaneously, there is an influence on critical thinking skills and learning outcomes between students who use the PBL model based on local wisdom of Subak and the PBL model.
2. There is a significant influence on critical thinking skills between students who use the PBL model based on local wisdom of Subak and the PBL model.
3. There is a significant influence on critical thinking skills between students who use the PBL model based on local wisdom of Subak and the PBL model.

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