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The Influence of Quiz-Based Problem-Based Learning (PBL-Q) on Biology Concept Mastery among Students with Different Academic Abilities

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Abstract: The purpose of this study was to determine the effect of Problem Based Learning based on Quiz (PBL-Q) on students' mastery of biology concepts in terms of academic ability. The number of research participants was 62 Biology Education students at Universitas Pendidikan Mandalika. The study was conducted in the odd semester of the 2023/2024 and 2024/2025 academic years. The research material was from the plant physiology course. The instrument used to assess concept mastery was an essay test on Plant Physiology consisting of 11 valid and reliable questions. Data were analyzed using the Ancova test with a significance level of 5%. The results of the study showed that: a) there were differences in students' mastery of biology concepts based on learning models, students who used the PBL-Q model had better mastery of biology concepts than students who used the PBL model; b) there were differences in students' mastery of biology concepts based on academic ability, students with high academic ability were better than students with low academic ability; c) there were differences in students' mastery of biology concepts based on the interaction between the learning model and students' academic ability. Based on LSD notation, students' mastery of biology concepts is ranked from highest to lowest: PBL-Q students with high academic ability, PBL-Q students with low academic ability, PBL students with high academic ability, and PBL students with low academic ability. The findings of this study indicate that the PBL-Q learning model can help students improve their mastery of biology concepts in terms of academic ability, especially in Plant Physiology material.

Keywords: Academic Ability; Mastery of Biology Concepts; PBL-Q.

Introduction

Problem Based Learning (PBL) is defined as a learning model that has the characteristics of problem solving or a learning model with a disciplined basis in providing problem solving challenges (Dring, 2019; Duch et al., 2008; Liu et al., 2019). The PBL model provides students with the opportunity to conduct research, combine theory and practice, apply knowledge and skills to achieve meaningful learning (Halimah et al., 2023; Nilyani et al., 2023; Saputri et al., 2023). The presentation of problems in learning aims to encourage students to empower thinking skills, solve problems, apply knowledge, and train students to collect information (Almulla, 2019; Monika et al., 2023; Wang et al., 2008).

The characteristics of PBL include: 1) student-centered learning; 2) conducted in small groups; 3) lecturers act as facilitators; 4) problems become a means to develop thinking skills; and 5) new information is obtained independently or in groups (Maknun et al., 2014; Moutinho et al., 2015). PBL has been proven to improve learning outcomes in the areas of knowledge, skills and attitudes (Darmawan, 2021). The PBL learning model has several advantages, including the following: 1) increasing students' memory and understanding of lecture materials; 2) increasing concentration on relevant knowledge by using real problems and new

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information; 3) encouraging students to think to draw conclusions through finding the basis for arguments; 4) building teamwork, leadership, and soft skills; 5) building lifelong learning skills by getting used to solving ill-structured problems; 6) increasing the motivation of students and lecturers to actively build cooperation (Arsih et al., 2021; Jamaluddin et al., 2023).

On the other hand, PBL also has disadvantages, namely: 1) learning objectives will be difficult to achieve for lazy students; 2) requires a lot of resources, especially time and costs; 3) not all learning materials can be taught with this model (Duch et al., 2008; Gorghiu et al., 2015). Another disadvantage is that the PBL learning model requires complex learning preparation in terms of equipment, problems presented, and concepts. In addition, the weakness of implementing the PBL model is the difficulty of finding problems that are relevant to the concept (Gorghiu et al., 2015; Jamaluddin et al., 2023; Safitri et al., 2023).

A quiz is a series of interesting questions designed to make the learning process more challenging and enjoyable for students (Aiman et al., 2024; Rahma & Suratno, 2024). Quizzes can be used in almost all lecture materials and can be combined in the learning process. Several previous studies have succeeded in improving student learning outcomes by using quizzes (Damayanti & Yohandri, 2022). In the material of Plant Physiology, it is also suitable to be learned using quizzes combined with certain learning models, one of which is PBL. So that the Quiz-based PBL model becomes PBL-Q.

Plant Physiology is a branch of biology that studies how plants do the things they need to do to sustain life (Hopkins & Hüner, 2008). Plant Physiology also explains the various physiological functions of plants in the plant life cycle (Taíz & Zeiger, 2010). Students need to master the basic concepts in plant physiology so that they can behave and act appropriately in caring for plants. In turn, they also have sufficient provisions to guide their students when they become teachers. The presentation of plant physiology topics in biology textbooks is rich with various representations, such as pictures, graphs, symbols, and verbal descriptions (Campbell & Reece, 2012). Therefore, to master the study material of plant physiology, students need to improve their ability to work with various representations. Based on this idea, through learning plant physiology, it is expected that students can improve their mastery of concepts.

Anderson & Krathwohl (2001) states that mastery of concepts in a field of science includes a combination of mastery of knowledge of the field of science being studied and the dimensions of cognitive processes, including factual, conceptual, and procedural knowledge. Based on this view, someone cannot be said to have mastered a concept if they are only able to memorize facts and concepts that have been studied (Abdullah & Shariff, 2008). A person is said to have mastered a concept if he is able to combine the knowledge he has learned in a high-level thinking process (Anderson & Krathwohl, 2001; Krathwohl, 2002; Abdurrahman *et al*., 2011).

One of the factors that determines the success of conceptual learning is the mastery of concepts by teachers and/or prospective teachers. Previous research revealed that there are still many problems related to the mastery of concepts by prospective Biology teachers in Indonesia (Amin *et al*., 2016; Aprilia, 2015; Wulandari *et al*., 2016). Related to the field of Plant Physiology, preliminary research also revealed the low mastery of concepts of prospective Biology teachers. Through a test given to 37 prospective teacher students who had taken the Plant Physiology course, the average data obtained for students' concept mastery was 31.35 (on a scale of 100).

The success of a learning innovation can depend on the students' initial academic abilities (Leasa & Corebima, 2016; Mahanal et al., 2019). Initial academic abilities are abilities that students already have which will be used as assets to gain broader and more complex knowledge (Semerci & Batdi, 2015). In general, academic abilities can be grouped into high abilities and low abilities (Arikunto, 2013). There is learning that is only suitable for one group of students based on their academic abilities, such as research conducted by Leasa and Corebima (2016) that the NHT (Numbered Heads Together) model in students with high academic abilities has a higher average value than students with low academic abilities. However, the researcher hopes that the learning innovations resulting from this dissertation will have an equally good impact on both groups of students.

Based on the previous description, it can be seen that studies on the mastery of biological concepts have been conducted extensively both theoretically and empirically, however, a review from an academic field has not been conducted much, therefore it is considered necessary to carry out research on the improvement of The Influence of Quiz-Based Problem-Based Learning (PBL-Q) on Biology Concept Mastery among Students with Different Academic Abilities.

Method

This type of research is a quasi-experimental study with a pretest-posttest only control group design, involving 2 classes, namely the control class and the experimental class. The respondents in this study were 62 students of the 3rd semester biology education study program from the Universitas Pendidikan Mandalika, West Nusa Tenggara, Indonesia. This study was conducted in the odd semester of the 2023/2024 and

2024/2025 academic years. 31 students in the control class and 31 students in the experimental class.

The research activity began by giving a pretest of Biology concept mastery and a test of students' academic abilities. The pretest was used to measure students' initial concept mastery, both in the experimental class and the control class. The academic ability test was used to group students according to their academic abilities. The next step was to provide treatment to all classes, the experimental class used the PBL-Q learning model, while the control class used the PBL learning model. Learning activities were carried out for 11 meetings. After all the materials were taught to the students, the next activity was to provide a posttest. The stages of learning activities according to the PBL-Q syntax that has been developed are presented in Table 1.

Table 1. Syntax of PBL Model Based on Quiz (PBL-Q)

Phase	Indicator	Lecturer Activities
1	Student orientation to problems	Review learning objectives, explain required materials, and motivate students to engage in problem-solving activities.
2	Organizing students to learn	Helping students define and organize learning tasks related to the problem.
3	Guiding individual and group investigations with Quizzes	Encourage students to collect appropriate information, conduct experiments to obtain explanations and problem solving by presenting them through prepared quizzes.
4	Developing and presenting work results	Assisting students in planning and preparing appropriate work such as reports, and helping them to share assignments with their friends.
5	Analyze and evaluate the problem solving process	Helping students to reflect or evaluate their investigations and the processes they use.

The concept mastery instrument adopts the concept mastery test indicators from Anderson and Krathwohl., (2001) which includes three indicators of high-level thinking, namely analyzing, evaluating and creating. The instrument is in the form of an essay test totaling 11 from the material of Plant Physiology. The instrument used has met the valid criteria (average 0.613) with a high validity category and reliable with a value of 0.836 very reliable category. Furthermore, for the assessment rubric using a scale of 0-5. Furthermore, for data analysis using Ancova at a significance level of 5% with the help of SPSS 20.00.

Result and Discussion

Research Results

The following will explain the results of data analysis with ancova at a significance level of 5%. First, Table 2 will be presented regarding the results of the overall data analysis, then it will be detailed according to the stages of data analysis, starting from the influence of the PBL-Q model on concept mastery, the influence of academic ability on concept mastery and the influence of the interaction between the PBL-Q model and academic ability on concept mastery.

Table 2. Results of the Ancova test of data on students' mastery of biology concepts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9955.902[a]	4	2488.975	365.549	.000	.962
Intercept	491.042	1	491.042	72.118	.000	.559
Pre_CM	162.474	1	162.474	23.862	.000	.295
Model	166.631	1	166.631	24.473	.000	.300
Academic	360.539	1	360.539	52.951	.000	.482
Model* Academic	516.216	1	516.216	75.815	.000	.571
Error	388.105	57	6.809			
Total	319598.876	62				
Corrected Total	10344.007	61				

Based on Table 2, it shows that: a. mastery of biology concept in the PBL-Q model treatment, has a significance value of 0.000 (P-value <0.05) meaning "there is a difference in students' concept mastery in the application of several learning models; b. concept mastery in the academic ability treatment, has a significance value of 0.000 (P-value <0.05) meaning "there is a difference in students' concept mastery in different academic abilities; c. concept mastery in the interaction treatment between the PBL-Q model and academic abilities, has a significance value of 0.000 (P-value <0.05) "there is a difference in students' concept mastery in the application of several learning models and different academic abilities".

Differences in student concept mastery based on learning models.

Based on the LSD (Least Significant Difference) notation in Table 2, the corrected mean of concept

mastery in the PBL-Q learning model is significantly different from the PBL learning model. Students' concept mastery in the PBL-Q model class is better than in the PBL class.

Table 3. Results of the LSD test of students' mastery of biology concepts based on learning models.

Learning Model	Mean		Corrected Average	Improvement	LSD Notation
	Pretest	Posttest			
PBL-Q	41.232	81.282	76.120	97.13 %	a
PBL	27.878	60.635	65.474	117.50 %	b

Information:
PBL-Q: *Problem Based Learning-Quiz*
PBL : *Problem Based Learning*

The influence of academic ability on students' mastery of biology concepts.

Next, Table 4 shows the results of the LSD test of students' mastery of biology concepts based on academic ability. Based on Table 3, it shows that the corrected average LSD notation of the concept mastery of high academic students is significantly different from that of low academic students. Students with high academic ability have better concept mastery than students with low academic ability.

Table 4. Results of the LSD test of students' mastery of biology concepts based on academic ability.

Academic Ability	Mean		Corrected Average	Improvement	LSD Notation
	Pretest	Posttest			
High	37.487	77.390	75.096	106.44 %	a
Low	31.192	63.860	66.498	104.73 %	b

Student concept mastery is reviewed from the interaction of learning models with academic abilities.

Based on the LSD notation in Table 5, the corrected average of high academic students' concept mastery following the PBL-Q learning model differs significantly from all treatments. In order, students' concept mastery from highest to lowest is: PBL-Q model class with high academic ability, PBL-Q model class with low academic ability, PBL model class with high academic ability, and PBL model class with low academic ability.

Table 5. Results of the LSD test of students' mastery of biology concepts based on the interaction between learning models and academic ability levels.

Interaction	Mean		Corrected Average	Improvement	LSD Notation
	Pretest	Posttest			
PBL-Q HAA	45.718	85.574	77.054	87.17 %	a
PBL-Q LAA	36.747	76.99	75.187	109.51 %	b
PBL HAA	29.771	69.717	73.139	134.17 %	c
PBL LAA	25.985	51.552	57.810	98.39 %	d

Information:
PBL-Q HAA : *Problem Based Learning-Quiz* High Academic Ability
PBL-Q LAA : *Problem Based Learning-Quiz* Low Academic Ability
PBL HAA : *Problem Based Learning* High Academic Ability
PBL LAA : *Problem Based Learning* Low Academic Ability

Discussion

According to the data in Table 5, it can be seen that the LSD notation that has been found shows that the corrected average of the high academic students' mastery of biology concepts following the PBL-Q learning model is very significantly different from all treatments. In sequence, the results of statistical calculations show that the students' mastery of concepts from the highest to the lowest are: PBL-Q model class with high academic ability, PBL-Q model class with low academic ability, PBL model class with high academic ability, and PBL model class with low academic ability. Thus, students' mastery of biology concepts is much better after being taught using the Problem Based Learning learning model based on Quiz (PBL-Q).

Problem Based Learning based on Quiz (PBL-Q) is a learning process that can facilitate the development of students' thinking potential, especially high-level thinking (Gholami et al., 2016). PBL allows students to develop scientific attitudes through empowering thinking and Quiz accustoms students to think quickly

in solving problems. Real problems presented in learning whip up students' thinking power while being able to develop control of their cognitive processes (Gholami et al., 2016; Iftitah et al., 2023; Safitri et al., 2023). Students are trained to clearly and definitely understand the problems they face and then find out how much knowledge capital they already have to solve the problems they face. PBL-Q also directs how students monitor their cognitive processes to utilize the knowledge they already have so that self-evaluation occurs continuously. PBL empowers thinking skills starting from finding problems, finding solutions, implementing solutions, and evaluating solutions. PBL-Q also trains students to control their cognitive processes, starting from inventorying the knowledge capital they already have to evaluating the use of the knowledge they have.

The learning process carried out using PBL-Q is useful in developing metacognitive abilities and causing better retention of knowledge so that students have good mastery of concepts (Fatmawati, 2016). Problem solving in PBL-Q, students are designed to work collaboratively especially when working on quizzes that are done in groups. There is effective communication between group members in order to help each other and care for each other to solve problems. Students are accustomed to conveying their ideas verbally to other students and competing to complete the quiz in the fastest time. Likewise, at the same time they are also trained to respect the opinions and ways of thinking of other friends. Communication skills will develop during problem solving because the group mechanism works well. This means that students become more active (Aiman et al., 2024; Dunggio et al., 2024) and this condition has facilitated the development of communication skills.

Learning with quiz-based problem solving requires the habit of thinking analytically, evaluatively, and creatively (Dunggio et al., 2024). Problem solving starts from the ability to analyze facts and phenomena in the problem, this is the process of thinking analytically. The resulting solution plan has been thought out to be effective and efficient. Efforts to find answers or solutions effectively and efficiently are evaluative thinking skills (Yusuf, Y. Q., Natsir, Y., & Hanum, 2015). Meanwhile, the solutions offered are the fruit of the application of concepts in real and new situations. The relationship between students' prior knowledge and previous knowledge serves as a basis or foundation for thinking and strengthening mastery of concepts (Harto et al., 2019; Sari et al., 2024).

The students' answers have been able to provide the ability according to the indicator of concept mastery with the HOTS level, although it is not yet optimal. Therefore, it is necessary to provide treatment to improve concept mastery again, this has been suggested by previous researchers, namely the presentation of the initial introduction to learning has an effect and contributes to improving high-level thinking skills (Malik, 2015). Reviewing students' academic abilities is a process in which all knowledge and skills are measured so that they can explore their abilities in solving problems that arise, making decisions, analyzing all assumptions that arise and conducting investigations or research based on data and information that has been obtained so as to produce the desired information or conclusions (Fatmawati et al., 2022; Fatmawati & Husnul, 2021; Penelitian & Zubaidah, 2019). A person's mastery of concepts is influenced by their learning environment, one of which is the learning model they use (Fatmawati et al., 2019; Fatmawati & Husnul, 2021).

Mastery of concepts in Biology is the capital to trigger a fast, accurate, and assumption-free thinking process, this is related to the students' previous academic abilities. Mastery of Biology concepts should be developed early on through learning, especially science learning (Fatmawati, 2016; Sari et al., 2024), because it is useful for preparing students to become critical thinkers, able to solve problems, become independent thinkers, avoid indoctrination, fraud, brainwashing, and make decisions appropriately and responsibly. Mastery of Biology concepts, especially in Plant Physiology material should always be trained in learning so that it can demonstrate an understanding of complex biological relationships, so that students can connect complex phenomena from various levels of organization with the mastery of concepts they have (Fatmawati et al., 2023). The use of PBL-Q can guide students to learn science concepts, correct their incorrect or incomplete knowledge, learn concepts in depth, and adapt the learning obtained in school to their daily lives. In addition, the use of PBL-Q in science learning can complement learning content, increase students' attention to learning, ensure permanent learning, change students' prejudices against science and make learning more entertaining and useful.

Academic ability is the ability that students have in solving problems or tasks they face according to the knowledge they have (Amin et al., 2016). Academic abilities are divided into three groups, namely high, medium and low academic abilities (Noviyanti et al., 2019). A person with high academic ability has better behavior and study habits than someone with low academic ability (Chusni et al., 2022), This learning behavior and habits are also related to a student's ability to manage their study time. Academic ability can be obtained from a person's ability to solve questions after the learning process and is very useful for obtaining information on the progress that has been achieved including determining the next steps in the learning

process (Chusni et al., 2022; Fatmawati et al., 2022). Therefore Corebima in Iqbal et al., (2015) proposes that learning activities need to pay attention to differences in academic ability so that the gap between high and low-ability students can be reduced both in the process and learning outcomes. Such as the results of the study which found that the use of innovative models was able to reduce the gap in students' science process skills between groups of students with high academic ability and groups of students with low academic ability (Diella & Ardiansyah, 2019; Kesulitan et al., 2017).

The application of PBL-Q in learning by first identifying students' academic levels can encourage and improve better mastery of biological concepts, students' skills in collecting, storing and delivering information (Celik et al., 2011; Hong & Choi, 2015; Safitri et al., 2023; Suhirman et al., 2021), influences metacognition, critical thinking, and learning outcomes (Nurfathurrahmah, 2018; Zubaidah, 2016). The implementation of PBL-Q at a high academic level in higher education is highly recommended because it is expected to provide impacts such as 1) critical, analytical, and solution-oriented thinking from complex real problems, 2) finding, evaluating, and utilizing appropriate learning resources, 3) building cooperation in teams and small groups, 4) demonstrating oral and written communication skills flexibly and effectively, and 5) applying the knowledge and intellectual skills acquired at university to become sustainable learners (Duch et al., 2008). However, the application of the PBL-Q model can also provide a good impact for students with low levels.

Conclusion

The results of the study indicate that: a) there are differences in students' mastery of biology concepts based on learning models, students who use the PBL-Q model are better than students who use the PBL model; b) there are differences in students' mastery of biology concepts based on academic ability, students who have high academic ability are more critical than students with low academic ability; c) there are differences in students' mastery of biology concepts based on the interaction between the learning model and students' academic ability. Based on LSD notation, the sequence of students' mastery of biology concepts from highest to lowest is: PBL-Q model class with high academic ability, PBL-Q model class with low academic ability, PBL model class with high academic ability, and PBL model class with low academic ability. The limitation of this research is that the number of respondents used as research subjects is still small.

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Author Contributions

Preparation of proposals, plans for using costs, A. F., and S.M; Data collection and classroom teaching, S.M.; Data analysis, conceptual, preparation of research articles and reports, A. F.; correction of data results and financial reports, A. F., and S.M.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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