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The Impact of Problem Based Learning Model Base on Practicum Activities on The Critical Thinking Ability of High School Student on Respiration System Material

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Abstract

Observations carried out at Senior High School of SMA Ar Rahman found that students' critical thinking abilities were still low, especially in the respiratory system material. The aim of this research is to determine the effect of the problem based learning model on students' critical thinking abilities through practicum on respiratory system material. The samples used were second grade class (XI-MIPA 1) as the experimental-class and XI-MIPA 2 as the control-class. The quasi-experimental research uses a posttest only control design. The variable measured is students' critical thinking abilities obtained from the pretest-posttest scores tested by the t-test. Student practicum activities, student responses, and teacher responses were analyzed using percentage qualitative descriptive analysis. The results showed the average critical thinking ability score for the experimental class was 76.93 while the control was 65.67. The results of the t-test show that there is a significant influence between biology learning using the Problem Based Learning model on students' critical thinking abilities at SMA Ar Rahman High School. The implication is that implementing the PBL model in respiratory system material can serve as an effective pedagogical alternative for educators on SMA Ar Rahman high school to foster higher-order thinking skills in students, which are essential in addressing 21st-century learning challenges. This study provides empirical evidence for the development of a biology learning model based on Problem-Based Learning (PBL) integrated with practicum activities

Keywords: *Critical thinking; High School; Problem based learning; Respiratory system*

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INTRODUCTION

The 21st Century Education is education that is based on science and technology. Education in the 21st century faces various complex and dynamic challenges along with increasingly rapid technological developments and globalization (Sepriyanti et al., 2022). Digital transformation, advances in information technology, and global social and economic changes have changed the way of life and work, which in turn requires adjustments in the education system. The 21st century students are characterized by the fact that they are required to learn and innovate in skills, digital literacy, as well as life and career skills (Virmayanti et al., 2023). The 21st century skills, including critical thinking, collaboration, communication and creativity, are critical to preparing young people for a changing world. These skills include the ability to think creatively, think critically and solve problems, communicate and collaborate (Partono et al., 2021; Lumintang et al., 2023). Critical thinking skills must be continuously and deliberately trained so that they can develop in potential directions (Budiarti & Airlanda, 2019).

In line with this, efforts to improve the quality of education continue to be made through various innovative learning methods and approaches. Problems at micro level education include monotonous teaching methods and a lack of adequate facilities and infrastructure. In the 21st century, teachers need to implement various learning innovations to achieve educational goals (Elitasari, 2022). Traditional teacher-centred and memorization-based approaches are increasingly being abandoned, replaced by more interactive and participatory methods. Thus, the need for more effective and innovative learning approaches is becoming increasingly urgent to ensure that the education system is not only able to keep pace with changing times, but can also equip students with the skills necessary for success in the future. In this context, the Problem-Based Learning (PBL) approach has emerged as a method that is recognized as being able to increase student engagement and help them develop skills relevant to the 21st century. The PBL, with a learning approach that is student-centered and based on real problem solving, is considered capable of providing a more meaningful and contextual learning experience.

Problem-Based Learning (PBL) is a pedagogical approach that emphasizes the learning process through solving real problems that are relevant to the context of everyday life to initiate innovative learning and learning so that it can provide students with active learning (Fitri et al., 2022). In PBL, students are faced with complex problem situations that require knowledge and skills to solve. PBL is a learning model that focuses on problems so that critical thinking is needed in solving problems (Fajrilia et al., 2019). This method emphasizes student-centered learning, where students are responsible for their own learning process with support from a facilitator or teacher. Problem-based learning is an educational approach that makes problems the starting point of the learning process (Ardianti et al., 2021). PBL aims to develop critical thinking abilities, problem-solving skills, and the ability to work in teams, all of which are important components of 21st century skills.

The main principles of Problem-Based Learning involve student-centered learning, the use of problems as learning stimuli, and collaborative learning. In PBL,

students learn to identify and formulate problems, search for relevant information, and apply the knowledge they gain to solve the problem. According to Ardianti et al., (2021) the main characteristics of PBL include: (1) a problem-based learning approach, in which problems serve as catalysts for learning; (2) collaborative learning, where students work in groups to achieve common goals; (3) integration of knowledge from various disciplines, allowing students to develop a holistic and in-depth understanding. Harapit (2018) inform that the characteristics of the PBL method include: (1) learning begins by providing problems that are relevant to real life; (2) the problem is selected according to the learning objectives; (3) students solve problems through authentic investigation; (4) in small groups, students work together to find solutions to given problems; (5) teachers act as tutors and facilitators; (6) students are responsible for obtaining knowledge and information from various sources; (7) students present the results of solving problems in the form of certain products.

Observations conducted at SMA Ar Rahman revealed that students' critical thinking skills remained relatively low, particularly in the topic of the respiratory system. This issue appears to stem from the limited implementation of practical activities by the teaching staff, especially biology teachers, who predominantly deliver lessons through theoretical instruction in the classroom. Moreover, during biology lessons, problem-based learning models have never been employed as part of the instructional approach. As a result, students tend to exhibit low engagement during the learning process, which contributes to the underdevelopment of their critical thinking skills. Consequently, this condition adversely affects their academic performance.

Based on the problems that have been found at Senior High School of SMA Ar Rahman, students' critical thinking skills are still low, it is necessary to look at the influence of practicum-based learning on students' critical thinking abilities on respiratory system material. According to Humaira et al., (2020) critical thinking is an activity in analyzing more specific ideas or notions, being able to distinguish them, determine, identify, examine and develop them in a more perfect direction. Kristiyono (2018); Santoso (2010) added Critical thinking skills are also important because students who are able to think critically about a problem will produce good output in their education. Ennis (2011) put forward 5 indicators needed for an effective critical thinking process, namely elementary clarification, basic support, inference, advance clarification, and strategy and tactics. In line to Ulviyani & Nisa (2022) that one instructional model that has the potential to enhance students' critical thinking skills is the problem-based learning (PBL) model. When integrated with practicum activities, PBL provides a framework in which real-world problems serve as the context for students to cultivate their problem-solving abilities. In this approach, Sanjaya (2011) students are guided to engage in authentic investigations, and through hands-on practicum experiences, they are able to conduct experiments grounded in theoretical knowledge, enabling them to derive practical and evidence-based solutions to the problems presented.

Several studies have been conducted using practicum-based PBL learning models. Zahra & Baa (2024) shows that applying PBL with practical methods can

improve students' critical thinking skills on the concept of reaction rate. Relevant results were also shown by Azizah & Purnomo (2020), that research results had an influence on student learning outcomes seen from student test results before and after implementing ecosystem material learning with the PBL model based on practicum activities. Apart from that, research by Wardana (2024) shows that learning using a practicum-based PBL model is able to improve student learning outcomes in waves and vibrations. This can be seen from the data on the increase in student learning outcomes, namely from cycle I 63.00 %, increasing in cycle 2 to 65.24 %. Based on previous research, there has been no research using respiratory system material. The human respiratory system material is abstract material and cannot be directly observed, so it requires several special techniques in the learning process. Therefore, it is necessary to have practicum-based learning on the human respiratory system material in order to create an interesting and enjoyable learning atmosphere for students. And there is still little research that measures students' critical thinking abilities, where practicum-based PBL will familiarize students with solving problems, thereby stimulating students' curiosity to try to study and solve problems through their critical thinking abilities.

In light of the background, observational findings, and prior research, there is a recognized need to implement biology instructional materials that incorporate meaningful, accessible, and engaging practical activities for students. Accordingly, this study aims to investigate the effect of practicum-based problem-based learning on the critical thinking abilities of high school students in relation to the respiratory system material.

METHOD

This research uses quantitative methods by applying an experimental approach. This approach makes it possible to test the influence of the independent variable on the dependent variable. The experimental method as explained by Sugiyono (2013) is a research approach that aims to evaluate the impact of a particular action on other variables under controlled conditions. Thus, it can be concluded that the experimental method involves manipulating research objects and establishing controls to assess causal relationships by giving special treatment to the experimental group and using the control group as a comparison.

This research uses Quasi Experimental as a research approach. Even though it includes a control group, this design cannot completely control external factors that might influence the experimental results refers to Sugiyono (2013). This research uses a one group preset-posttest design model.

Sample or Participant

The population in this study from students of SMA Ar Rahman High School for the 2024/2025 academic year. The sample selection was obtained using total sampling technique method. According to Sugiyono (2013) total sampling is all research objects that can be reached by researchers. So the research sample consisted of 72 students in second grade (XI-class) consisting of two classes, the experimental

class, the control class.

Instrument

The instrument in this research was a test in the form of essay questions given before and after the learning process. This research uses 10 questions in the form of essays to determine students' critical thinking abilities which are measured according to 5 indicators refers to Faradisa et al., (2022).

Data Analysis

Test Prerequisites

Normality Test

This test is intended to assess the extent to which the distribution pattern of the data collected is similar to the normal distribution. This is important to know whether the data represents a normally distributed population. The use of the Kolmogorov Smirnov normality test aims to reduce the risk of error and evaluate the suitability of the data distribution to the regression model.

Homogeneity Test

The homogeneity test is used to show differences in variations in two or more groups of sample data originating from the same population. This is used on post-test data from the experimental and control groups to evaluate whether the variation between populations is uniform, as explained by Sugiyono (2013).

Hypothesis Testing-Partial Test (T-Test)

Separate hypothesis testing is carried out to determine the effect of each independent variable on the dependent variable. This procedure involves the use of a t-test at a significance level of 95%, referring to the criteria established by Fitriyah (2024).

RESULT AND DISCUSSION

Institution Description

SMA Ar-Rahman Subdistrict, Medan Helvetia, Medan City, is a school located in one of the urban areas, precisely in the city of Medan Subdistrict, Medan Helvetia, which is a strategic place for students to reach. The majority of students and students are Muslim at Ar-Rahman Medan High School in Medan. Ar-Rahman Medan High School is a level of education that has achieved Accreditation A. Even though this educational institution is located in the city of Medan and has private status, it is no less competitive with other educational institutions with State Education Institutions located in the city of Medan.

Table 1. Characteristics of respondents by class

No	Class	Amount	Percentage (%)
1	XI MIPA [1]	36	50
2	XI MIPA [2]	36	50
	Amount	72	100

There are two classes of respondents who will be used in this research, namely class XI MIPA 1 and XI MIPA 2. The total number of these two classes is 72. Based on the table 1, it can be seen that both classes have the same number, namely class XI MIPA 1 with 36 students and class XI MIPA 2 with 36 students.

Students' Critical Thinking Ability

The results of research conducted at Ar rahman SMA included critical thinking skills from practical activities on respiratory system material, student and teacher responses to biology learning using the problem based learning (PBL) model. Data on students' critical thinking abilities obtained from the pretest-posttest scores for the experimental class and control class are presented in Table 2.

Table 2. Students' Critical Thinking Skills Obtained From The Pretest-Posttest Scores of The Experimental Class and Control Class.

Class	N	Critical thinking ability test			Average
		Ideal Value	Minimum Value	Maximum Value	
Experiment	36	100	60	93	76,93
Control	36	100	47	75	65,67

Based on the results of the pretest-posttest posttest score analysis, it can be seen that the average critical thinking ability score for the experimental class which used the PBL model of biology learning was higher than that of the control class students who used the lecture and discussion method. The pretest-posttest scores on students' critical thinking abilities were analyzed using the t test. The pretest-posttest scores on critical thinking skills for the experimental class and control class were tested for homogeneity and normality with the help of Microsoft Excel. The results of the homogeneity test of pretest-posttest scores show that both classes have the same or homogeneous variance. The results of the homogeneity test are presented in Table 3.

Table 3. Homogeneity Test Result of Pretest-Posttest Scores for Critical Thinking Abilities In The Experimental Class And Control Class.

Data	Varians(S2)		F_{count}	F_{table}
	Experimental class	Control class		
Pretest-Posttest Value	92,36	58,64	1,5750	2,1943

The homogeneity test is used to determine whether or not the posttest scores are uniform between the experimental class and the control class. Homogeneity test using Fisher's test. The results of the normality test of the pretest-posttest values show that the data comes from a normally distributed population. The homogeneity test results are presented in Table 4.

Table 4. Normality Test Results of Pretest-Posttest Critical Thinking Ability Scores For Experimental Class and Control Class

Data	Class	X^2_{table}	X^2_{count}
Pretest-Posttest Value	Eksperimen	2.69	7.81
	Kontrol	5.14	7.81

The T-test was carried out to determine whether there was an influence of PBL model biology learning on critical thinking skills through practicum activities. The t test results obtained t calculated 8.16* and t table 2.01. These data show that there is a significant influence between PBL model biology learning on students' critical thinking abilities on excretory system material at Ar-Rahman Medan High School, so it can be stated that PBL model learning has a positive effect on students' critical thinking abilities on respiratory system material.

This is in line with Hadi et al., (2010) which states that Problem-Based Learning (PBL) exerts a beneficial impact on the development of critical thinking skills as well as the comprehension of biological concepts. This is also in line with the Ayuningrum & Susilowati (2015) research which concluded that The implementation of the Problem-Based Learning (PBL) model demonstrated a positive impact on the critical thinking abilities of second-grade students. This is in line with Azizah & Purnomo (2020) statement which states that PBL learning can improve students' critical thinking abilities. Students' critical thinking abilities after learning in each aspect were analyzed in the experimental class and control class. The scores for each aspect of students' critical thinking abilities in the experimental class and control class are presented in Table 5.

Table. 5. Scores for Each Aspect of Critical Thinking Ability in the Experimental Class and Control Class

Aspect	Experimental class (%)	Criteria	Control class (%)	Criteria
Provide a simple explanation	67.46	Critical	58.93	Quite critical
Building skills Base	59.52	Quite critical	59.52	Quite critical
Conclude	96.43	Very critical	75.00	critical
Provide further explanation	73.21	Critical	63.84	critical
Set strategy and tactics	89.88	Very critical	81.55	Very critical
Provide alternatives solution to problem	83.67	Very critical	68.88	critical

Based on table 5, the descriptive percentage analysis showed that the critical thinking ability score for the experimental class is higher in the aspects of providing simple explanations, concluding, organizing strategies and tactics, and providing alternative problem solving. This can happen because students are trained to solve problems and present the results of their practical work in front of the class, students

are required to actively participate in asking and responding to questions so that students are able to develop their critical thinking skills, especially in the aspect of providing simple explanations. The aspect of delivering simple explanations encompasses activities such as formulating focused questions, evaluating arguments, and engaging in the process of posing and responding to inquiries (Ennis 2011). This is in line with Selirowangi et al., (2024); Santoso (2010) who state that Instructional approaches that require students to comprehend or formulate problems, define objectives and hypotheses, conduct observations or investigations, gather relevant data, and perform analytical reasoning to address the identified problems can significantly enhance their critical thinking skills.

The activity of reading problem texts in PBL model learning, through practicum activities, students are trained to develop the ability to consider whether learning sources are trustworthy or not. This ability is included in the aspect of building basic skills (Ennis, 2011). However, the score obtained by the experimental class was almost the same as the score obtained by the control class, which was quite critical. This is because thinking is an ability that must be trained and cannot be acquired instantly. This is in line with Redhana (2012) statement that critical thinking skills require continuous learning and practice. This view is reinforced by Zebua (2024), who asserted that critical thinking is not an innate ability that develops spontaneously, but rather a skill that must be systematically acquired and continuously practiced, both within formal educational settings and in daily life context.

Ways to get used to critical thinking according to Zebua (2024), namely: 1) taking action to collect evidence; 2) use the brain instead of feelings (think logically); 3) skepticism, namely a feeling of doubt due to the need for evidence, meaning not simply believing until finding strong evidence which is sometimes found by oneself. The aspect of critical thinking ability that has a higher percentage in the experimental class than the control class is the concluding aspect. This aspect has a high percentage because the PBL model trains students to draw conclusions from the text of the problems being discussed. Through concluding activities at the end of learning, students' critical thinking abilities in the concluding aspect can increase. This is in line with Paul & Elder (2006) that one of the characteristics of someone who has critical thinking skills is being able to draw good conclusions.

The aspect of providing further explanation in the experimental class and control class has the same critical thinking ability criteria, namely critical criteria. This aspect has critical criteria because students are required to read problem texts and discuss and find solutions to existing problems. Through these activities students can develop the ability to identify terms and definitions. The ability to identify terms and definitions is an indicator of the aspect of providing further explanation (Ennis, 2011). This can happen because each class carries out activities that can develop critical thinking skills. However, the experimental class carried out more activities that developed high level skills, while the control class carried out activities that developed low level skills.

According to Torff (2011) divides critical thinking skills into two parts, namely high-level critical thinking and low-level critical thinking. High-level critical

thinking activities include discussion, debate, problem solving, problem finding, giving opinions, making decisions, criticizing, analyzing, writing imagination, and classifying. Low-level critical thinking activities include taking notes, looking for words, filling in blank worksheets, watching videos, matching, memorizing, and summarizing. The aspects of managing strategy and tactics in the experimental class and control class have the same critical thinking ability criteria, namely very critical criteria. This can happen because each class carries out discussion activities which require the experimental class and control class to complete student discussion sheets through discussion activities. The aim of using discussion strategies is that students are encouraged to use their knowledge and experience to solve problems, without always relying on other people (Isjoni, 2007).

The aspect of critical thinking ability that has a higher percentage in the experimental class than in the control class is the aspect of providing alternative problem solving. This can happen because through PBL model learning students are trained to uncover problems, formulate solutions, determine actions, use arguments so that they can improve students' critical thinking skills. This is included in the sub-indicator aspect of managing strategy and tactics (Ennis, 2011). This is in accordance with the According to Miri et al., (2007) if educators/teacher intentionally and consistently cultivate students' higher-order thinking skills—such as through the use of real-world problems, facilitating classroom discussions, and guiding investigative activities—they can effectively enhance students' critical thinking capabilities.

Experimental class students have very critical thinking skills which are lower than the critical criteria after applying the PBL model and there are still students who get quite critical criteria. This is because thinking is an ability that must be trained and cannot be acquired instantly. This is in line with Redhana (2012) emphasized that the development of critical thinking skills necessitates ongoing learning and practice. This perspective aligns with Zebua (2024), who stated that critical thinking is not an inherent ability but rather a skill that must be intentionally taught and consistently cultivated through both formal education and daily experiences. The percentage of critical thinking ability criteria for experimental class and control class students is presented in Table 6.

Table. 6 Percentage Criteria for Students' Critical Thinking Abilities

Critical thinking ability criteria	Experimental class (%)	Control class (%)
Very critical	37	0
Critical	56	60
Quite critical	7	40

The implementation of the PBL model did not result in uniformly high levels of critical thinking skills among students in the experimental class. There found 7 % of students who meet the criteria that students are interested in PBL model biology learning, but judging from the activities of these students, they are less active in learning activities. Activities in the learning process are one indicator of students' desire to learn (Kurniahtunnisa, 2016). This is in accordance with the opinion of

Dalyono (2005) who states that learning is an active process so that if students are not involved in various learning activities as a student response to teacher stimulus, it is impossible for students to achieve good learning outcomes (in this case critical thinking skills). This is also supported by Mulyani (2013) who states that students' success or failure in taking lessons at school is influenced by basic abilities, talents, interests, motivation, attitudes and learning abilities.

Table 7 Recapitulation of results of student practicum activities

Activity	**Student activity (%)**			
	Experiment	**Criteria**	**Control**	**Criteria**
Fill in student worksheets/discussions	97	Very active	94	Very active
Pay attention to the teacher's explanation	96	Very active	96	Very active
Ask questions	34	Quite active	14	Not active
Listen to questions	94	Very active	93	Very active
Respond to friends' questions	37	Quite active	23	Not active
Read the problem text and mark it important part	73	Active	-	-
Reading literature to solve problems	90	Very active	85	Very active
Active in group discussions	85	Very active	82	Very active
Record the results of observations	91	Very active	86	Very active
Report the results of observations	89	Very active	89	Very active

The activities of the control class students were quite critical. After examining it, it turned out that students who had sufficient critical thinking skills were not present at the first meeting, although judging from the student response questionnaire, these students were interested in PBL model biology learning, but judging from the activities, these students were less active in learning activities. Activities in the learning process are one indicator of students' desire to learn (Maharani et al., 2024). This is in accordance with the opinion of Dalyono (2005) who states that learning is an active process so that if students are not involved in various learning activities as a student response to teacher stimulus, it is impossible for students to achieve good learning outcomes (in this case critical thinking skills). This is also supported by Mulyani (2013) who states that students' success or failure in taking lessons at school is influenced by basic abilities, talents, interests, motivation, attitudes and learning abilities.

Student Activities Control class student activities are the same as the activities observed in the control class except for the activity of reading the problem text and marking important parts. The activities of filling in student worksheets/discussions, paying attention to teacher explanations, listening to questions, reading literature to solve problems, being active in group discussions, recording observation results, and reporting observation results have the same very active criteria as experimental class students, while the activities of asking questions and responding to friends' questions from experimental class students show quite active criteria while control class

students show inactive criteria. Based on the results of this analysis, it shows that the activity of the experimental class is higher than that of the control class. This is supported by Ciardello (2003) who said that students will be more motivated and active if they are faced with problems and students are asked to find answers to questions accompanied by supporting evidence (found on Table 7).

Student Responses to the PBL Learning Model

Student responses to the PBL learning model on excretory system material were obtained through student response questionnaires. The results of the student response questionnaire to the PBL learning model for each aspect and indicator are presented in Table 8.

Table 8. Results of Student Responses to the PBL Learning Model

Aspect	Indicator	Response each indicator (%)	Criteria	Response of each aspect (%)	Criteria
Students' attitudes towards learning biology	1. Shows interest in biology subjects	85	Very good	88	Very good
	2. Shows the usefulness of biology subjects	93	Very good		
Students' attitudes towards the PBL Learning model	1. Shows interest in problem learning models based learning	70	Good	76	Good
	2. Make it easier for students to understand the material	78	Good		
	3.Motivating students in learning	79	Good		
	4. Encourage students to solve problems	68	Enough		
	5. Showing activeness in learning	71	Good		
	6. Demonstrates the usefulness of learning models problem based learning	84	Good		

Based on the results of the student response questionnaire, it can be seen that of the two aspects responded to by experimental class students, the students responded very well to aspects of students' attitudes towards biology subjects, while aspects of students' attitudes towards the PBL learning model responded well. Aspects of students' attitudes towards biology subjects are divided into two indicators, namely showing interest in biology subjects and showing the usefulness of biology subjects

which are responded very well. Aspects of students' attitudes towards PBL model learning are divided into six indicators.

Indicators show interest in the PBL learning model, indicators make it easier for students to understand the material, indicators motivate students in learning, indicators show activeness in learning, and indicators show the usefulness of the PBL learning model are responded to by students well, while indicators that encourage students to overcome problems are responded to by students quite well. This can happen because students are not used to solving problems through PBL model learning. This is in accordance with Chin & Chia (2005) who showed that some students initially experienced difficulties in identifying their own problems in PBL, but after discussions with family and friends, were able to overcome these initial obstacles and then formulated personally meaningful problems for investigation. Because they are not used to dealing with problems, students experience difficulties in overcoming these problems.

Teacher Responses to the PBL Learning Model

Teacher responses to the PBL learning model were obtained through interviews with biology subject teachers. The biology teachers in the experimental class and control class as a whole gave positive responses to the PBL model learning on the excretory system material. The teacher said that he had never applied the PBL model and more often used discussion and assignment methods. Teachers believe that the PBL model of learning makes students more enthusiastic in learning because students learn about various problems that occur in everyday life. Teachers feel interested in implementing the PBL model of learning because students can find out about the problems that exist around them. The criticism and suggestions given are limiting the problem texts used in learning because using the PBL model requires a lot of time.

CONCLUSION

Based on the results of the research and discussion, it was concluded that learning the Problem Based Learning (PBL) model through practicum activities on respiratory system material at Ar-Rahman Medan High School had an effect on improving students' critical thinking skills with a score of 56% in the experimental class and this shows that students already have critical thinking skills. This study provides empirical evidence for the development of a biology learning model based on Problem-Based Learning (PBL) integrated with practicum activities, and affirms that the integration of problem-solving approaches and laboratory practice can serve as an effective strategy for developing higher-order cognitive skills at the secondary education level

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