Improving Student Activities and Learning Outcomes through the Problem-Based Learning Model in Chemistry Learning

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Keywords	Abstract
Problem-Based Learning, Learning Activities, Learning Outcomes	The research aimed to describe the increasing students' activities and students' learning outcomes on the mole concept material by applying a problem-based learning model. The subjects were students of class X-E at SMA Negeri 1 Rengel. This research used classroom action research. The research instruments were observation sheets of student activities and test sheets of learning outcomes. The learning tools of the study were teaching modules with Student Worksheets on the mole concept material. The data collection methods were observation and testing. The study concluded that, first, in each cycle, the activities of relevant students had a more significant percentage than the irrelevant students. The score was 88.89% in Cycle I and 94.59% in Cycle II. Second, students' learning outcomes have reached a classical completeness of 86.84% in Cycle II, and the average N-gain score is 0.63 in Cycle I and 0.89 in Cycle II. The percentage of students who obtained N-gain on high and medium criteria in Cycle II increased from Cycle I by 84.21% and 15.79%. In short, learning using a problem-based model can improve student activities and learning outcomes.

INTRODUCTION

Education is a process to help students develop themselves to face all changes and problems with an open attitude and creative approaches without losing their identity (Herlina, 2020). The learning process must be interactive, fun, and motivating students (Syahraini et al., 2022). Today, education demands knowledge and technology to develop students who will become human resources in the future (Indarta et al., 2022). Therefore, education needs to be developed by teaching science on a technological basis to realize the development of human resources for the better as an embodiment of quality education.

Indonesia has shown its efforts to improve the quality of education aspect. It is shown by the "Freedom to Learn" curriculum initiated by the Minister of Education, Culture, Research and Technology of the Republic of Indonesia (Kemendikbud Ristek RI), Nadiem Makarim, where the central concept of "Freedom to Learn" is freedom of thought (Indarta et al., 2022). Student character building is the main point of the learning process in the "Freedom to Learn" Curriculum

(Wannesia et al., 2022). Good discussions, teaching, and learning activities between teachers and students are expected to develop students' psychology (Wannesia et al., 2022).

The learning process is an educative interaction between teachers and students in a learning environment to achieve specific goals (Suswati, 2021). Interaction or reciprocal relationship between teachers and students is the primary condition for the learning process (Suswati, 2021). Students must interact more actively with teachers or between students (Syahraini et al., 2022). The interaction aims to make messages from the teacher well received by students, and teachers can receive student aspirations (Maulana et al., 2021). Teachers are the most dominant factor in determining the quality of learning learning (Wulandari & Surjono, 2013). Quality learning will also produce good learning outcomes (Wulandari & Surjono, 2013). Therefore, educators are expected to participate in improving the quality of educational aspects, one of which is through quality

learning activities with the idea of a Merdeka Curriculum.

Merdeka Curriculum is the current curriculum implemented in education in Indonesia. The new curriculum has benefits for renewal, development, and improvement of the previously used curriculum. So, it may be stated that the current curriculum is an improvement from the previous curricula. With an updated curriculum, it can be used to update, develop, and improve the current curriculum (Melani & Gani, 2023).

One of the basic materials of chemistry is the concept of moles which include relative atomic mass, relative molecular mass, and Avogadro's constant (Wahongan & Lumingkewas, 2022). The concept of moles is an essential material of chemistry that is abstract, and students must master many concepts, laws, and formulas to support the understanding of other concepts in chemistry (Sunaringtyas et al., 2015). Difficulty understanding the concept of moles can hinder students' understanding of other concepts (Sunaringtyas et al., 2015).

The research is also based on observations made by teachers in learning at SMA Negeri 1 Rengel. The observations indicate that learning in chemistry is still passive and teacher-centered. The observation shows that the learning activities carried out in class X-E chemistry are only about lecturing, taking notes, and memorizing. As a result, the concepts or formulas might not be mastered without knowing their origin and meaning. The difficulty of solving these various questions shows that students' understanding of concepts still needs to be improved so that student scores do not reach the Minimum Completeness Criteria (KKM) of 75%.

Based on the background, a learning innovation is needed to increase student learning activities, so it is expected that increasing student learning activities in the classroom will impact learning outcomes. One of the efforts is to apply a problem-based learning model. A problem-based learning model is an approach to learning that helps students find problems from an actual event and collect information through self-determined strategies to make a problem-solving decision, which is then presented as a performance (Shofiyah & Wulandari, 2018).

The suggested learning model in the Merdeka curriculum is learner-oriented, one of which is a problem-based learning model (Liana, 2020). The model used Learning Cycle 5E, where the learning model consists of several phases. Then, it is organized to make students master the learning outcomes through their active role. The phases in 5E are engagement, exploration, explanation, elaboration, and evaluation (Rahmawati et al., 2021).

The problem-based learning model allows students to build their knowledge through problem-solving activities. This activity aligns with Piaget's constructivist and Bruner's theories, emphasizing student participation in discovering, processing information, and building knowledge (Tyas & Mundilarto, 2019). The problem-based learning model aims to optimize learning outcomes because it is student-centered, collaborative, contextual, integrated, and independent and can introduce more reflective learning activities (Hidayah et al., 2021). Learning independence and social skills can be formed when students collaborate to solve problems where they identify relevant information, strategies, and learning resources (Trianto, 2007).

The research results conducted by Wahongan & Lumingkewas (2022) show that student learning outcomes when using problem-based learning models are better than conventional learning models on mole concept material. The research aligns with research conducted by Maulana et al. (2021), where the model of Problem-based learning can improve student activity and learning outcomes.

Based on the background and the previous studies, the article conducted classroom action research. In applying the recommended problem-based learning model for the implementation of the independent curriculum, the researchers carried out classroom action research intending to describe the increased activity and student learning outcomes in the mole concept material by applying a problem-based learning model to class X-E students of SMA Negeri 1 Rengel.

RESEARCH METHOD

This research method section discussed the subject and location of research, research models, research procedures, and data analysis. Discussed in detail as follows:

Research Subject and Location

This research was conducted at SMA Negeri 1 Rengel from March to April 2023 with the study subjects, namely students of grades X-E for the 2022/2023 school year. This study used a type of classroom action research.

Research Model

Classroom Action Research aims to improve the quality of learning and focuses on learning activities in the classroom (Mulyatiningsih, 2019). The Classroom Action Research is collaborative or cooperative. Collaborative Classroom Action Research is a collaborative research model designed

and implemented by teachers, lecturers, and principals (Kustiani et al., 2017).

Research Procedure

This class action research procedure consists of two cycles with four stages passed, namely planning, implementing actions, observation, and reflection. Suppose the first cycle has yet to succeed in showing an increase in the activity and results of learning chemistry students. In that case, the treatment will be continued with the second cycle as an improvement until the goal is achieved. Before the stages in cycle I, initial reflection/observation activities are carried out, which aim to identify problems through observation of learning activities. The following is a model of the class action research cycle according to Arikunto (2017):
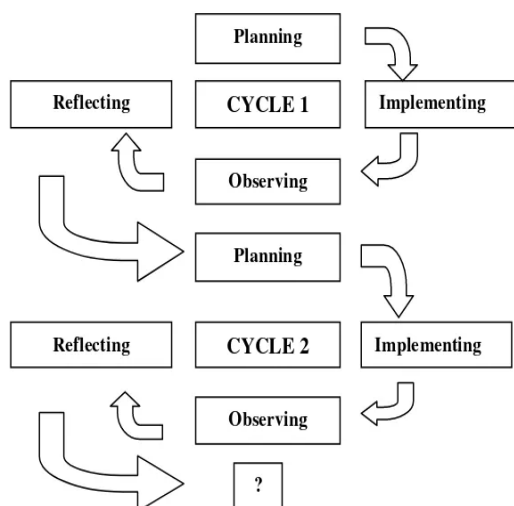

Figure 1. Classroom Action Research Cycle

The research instruments were observation sheets of student activities and test sheets of learning outcomes on mole concept material. The learning tools were teaching modules with Student Worksheets on the mole concept material. The data collection methods were observation and test methods.

Data Analysis Method

During the learning process, activities carried out by students are observed every 4 minutes for 80 minutes. Activity observation data from 2 observers were then analyzed by calculating the percentage of student activity during the learning process using a problem-based learning model using the following formula:

$$\% \text{ Activity} = \frac{\sum \text{Frequency of activity that appears}}{\sum \text{Frequency of overall activity}} \text{ x } 100\%$$

(Arifin, 2011)

Student activities support the effectiveness of learning using a problem-based learning model if the percentage of relevant activities is higher than the percentage of irrelevant activities.

Learning outcomes are analyzed from score data (pretest-posttest) to determine cognitive learning outcomes. The score data obtained by each student is then analyzed to determine the value using the following equation:

$$\text{Scores} = \frac{\text{Score Obtained}}{\text{Maximum Score}} \text{ x } 100$$

Learning outcomes can be assessed using discrete assessments on a scale of 0-100. Students are said to be complete if they have reached the KKM (Minimum Completeness Criteria) score set by the school, which is ≥80. The classical completion percentage is calculated using the following equation:

$$\% \text{ Classical completeness} = \frac{\text{Completed students}}{\text{Total Students}} \text{ x } 100\%$$

Classical completeness of learning outcomes is achieved if ≥85% of students obtain scores above the standard of KKM, which is ≥80.

The improvement of learning outcomes after the application of learning using the problem-based learning model is analyzed by the N-gain test through the following equation:

$$\text{N} - \text{Gain score} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

Then, the results are converted into the criteria in Table 1.

Table 1. N-gain Criteria

N-gain	Criteria
g ≥ 0,7	High
0,3 ≤ g < 0,7	Medium
g < 0,3	Low

(Riduwan, 2015)

Improving learning outcomes is said to be successful if the percentage of students in high and medium criteria is ≥85%.

RESULT AND DISCUSSION

Problem-based learning is a student-centered learning model. This learning model utilizes problems as the first step in gathering and integrating new knowledge (Indarta et al., 2022).

According to Tyas & Mundilarto (2019), activities in the problem-based learning model begin with the first syntax, namely student orientation to problems. The teacher provides perception by remembering the material that has been learned and motivates students by presenting problems with pictures.

The second syntax is to organize students to learn. The teacher divides the students into groups. Then, the teacher distributes the Student Worksheets. At the beginning of the student worksheet, students are given phenomena containing problems that will be identified and formulated.

The third syntax is to guide individual and group investigations. In this syntax, the activities carried out by the teacher are directing students to find solutions to problems that arise using previous knowledge and information. In the syntax of developing and presenting works, each group presents the results of discussions about solutions to problems that arise.

The last syntax is to analyze and evaluate the problem-solving process. The teacher responds to presentations, discussions, and the suitability of the discussion results with the studied material and evaluates each group.

In achieving the results of applying the problem-based learning model optimally and successfully, it must have well-planned stages starting when preparing problems adjusted to the curriculum, raising problems in students, supporting equipment, and assessment (Maulana et al., 2021). The analyzed data are student activities during the learning process and learning outcome data on mole concept material.

Student Activities

Student activities are known through the activity observation sheet instrument, observed by two observers. Activities carried out by students are observed to determine the suitability of all student activities with learning activities using a problem-based learning model aiming may be used as a support for teaching activities in improving learning outcomes. The results of the percentage of observations of student activities during two learning cycles are presented in Figure 2.
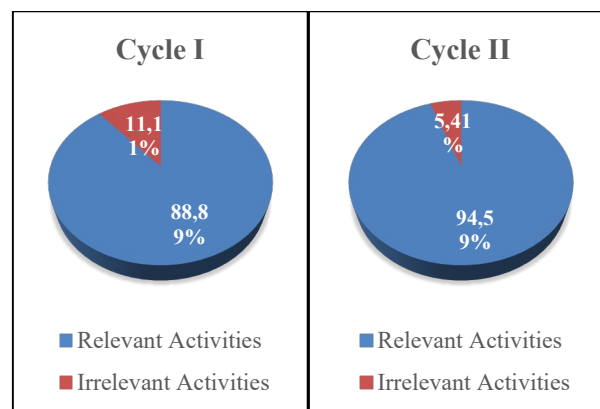

Figure 2. Percentage of Relevant and Irrelevant Activities

Students carry out various activities during the learning. The activities are divided into two, namely relevant activities to learning and not relevant to learning. Relevant activities to learning are carried out following teacher instructions and the learning syntax. Relevant activities include activities refer to Table 2. However, students also do other things outside of teacher instructions and outside of syntax, or are called irrelevant activities. Irrelevant activities are done by students, such as chatting, joking, using cellphones, sleeping, daydreaming, and others.

Figure 2 shows that student activity during two learning cycles gets different percentages where the relevant student activity in the second cycle is more significant than the first. In each cycle, relevant student activities get a more significant percentage than irrelevant activities. And, this shows that the activities carried out by students follow the problem-based learning strategy. Details of student activities are found in Table 2.

Table 2. Percentage of Student Activity

No.	Student Activities	Cycle I	Cycle II
1.	Answer the teacher's questions when the teacher explains	8,33%	10,82%
2.	Ask the teacher questions	2,77%	5,41%
3.	Identify problems contained in the phenomenon	5,56%	5,41%
4.	Formulate problems with each group	5,56%	5,41%
5.	Seeking information from various relevant sources related to problems that arise	13,89%	13,45%
6.	Perform information processing to obtain troubleshooting	16,67%	16,22%
7.	Present the results of discussions with their respective groups about solutions to problems	11,11%	10,82%
8.	Respond to answers from other groups	5,56%	8,19%
9.	Reflect and evaluate the results of the presentation	11,11%	10,82%
10.	Formulate concepts and conclusions with teachers	8,33%	8,04%
11.	Irrelevant activities (such as making noise, playing mobile phones, sleeping, etc.)	11,11%	5,41%

The percentage of student activity in Table 2 shows an average percentage difference between student activity in the first and second cycles. The percentage of relevant activities in cycles I and II was 88.89% and 94.59%. In contrast, irrelevant activities get percentages in cycles 1 and 2 of 11.11% and 5.41%. An active and student-centered learning process can store knowledge in long-term memory (FSU, 2011). According to Jeyaraj (2019), students who are active in learning activities will support the effectiveness of the learning. So that student activities support the effectiveness of problem-based learning models.

Student Learning Outcomes

Learning outcomes are students' abilities after receiving learning experiences (Suswati, 2021). This study's improvement in learning outcomes was seen through learning outcomes tests using pretest-posttest question sheets containing ten multiple-choice questions on the mole concept material. This test consists of a pretest at the beginning of the meeting and a posttest at the end of the meeting in each cycle. The pretest and posttest scores are then analyzed to classify completeness. Students are declared complete if they have scored ≥80. The results of students' classical completeness are presented in Table 3.

Table 3. Classical Completeness Percentage

No.	Cycle	Completeness of Student Learning					
		Pre-Test			Post-Test		
		Completed	Not Completed	Completeness Percentage	Completed	Not Completed	Completeness Percentage
1.	Cycle I	0	38	0%	27	11	71,05%
2.	Cycle II	28	10	73,68%	33	5	86,84%

Based on Table 3, 38 students in the first cycle obtained pretest scores below KKM or incomplete. Here, the completeness of classical learning outcomes was 0%. In the post-test, 27 students obtained scores above KKM or complete. In comparison, 11 other students were considered incomplete because they received post-test scores below KKM. Then, the completeness of classical learning outcomes was 71.05%. The classical completeness of the first cycle still shows the unsuccess of this class action research. Therefore, cycle II evaluation and planning are carried out, such as increasing feedback to students so that they are more motivated in learning and providing more practice questions.

In cycle II, students who completed the pretest rose to 28 students with a completion percentage of 73.68%. And during the posttest, it arises to 33 students with a percentage of 86.84%. Thus, learning using the problem-based learning model has a good effect on the knowledge of concepts/materials. In cycle II, the completeness of student learning outcomes increases and has achieved the success indicators set. Therefore, researchers decided to stop the study in this second cycle.

The percentage result of N-gain for each student varies. Improving learning outcomes is successful if the N-gain is in the high or medium criteria. The results of the percentage of N-gain of students in cycle I are presented in Figure 3. A total of 27 students obtained N-gain on the high criteria with a percentage of 71.05%. However, seven students obtained N-gain on the medium criteria with a percentage of 18.42%, and four students

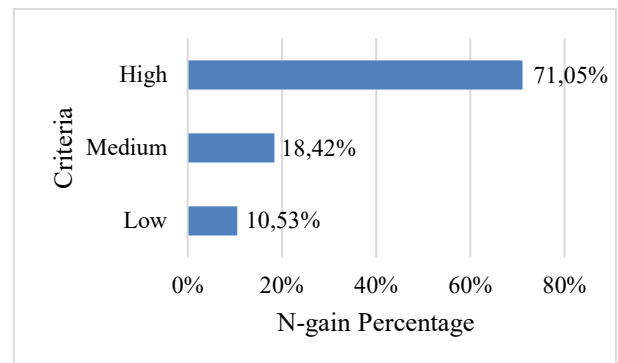obtained N-gain on the low criteria with a percentage of 10.53%.

Figure 3. Percentage of N-gain of students in Cycle I

The percentage of N-gain of students in cycle II is presented in Figure 4. 32 students obtained N-gain on the high criterion with a percentage of 84.21%. However, six students obtained N-gain on the medium criteria with a percentage of 15.79%.
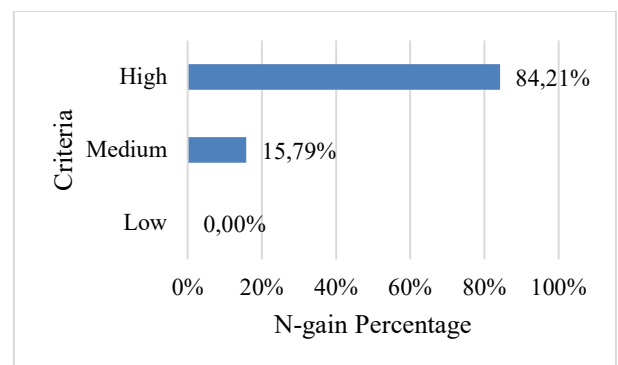
Figure 4. Percentage of N-gain of Students in Cycle II

The average N-gain obtained by students was 0.63 in cycle I and 0.89 in cycle II. Then, learning using the problem-based learning model can successfully improve student learning outcomes. This is supported by previous research that problem-based learning improves student learning outcomes (Abanikannda, 2016). The success of the problem-based learning model in improving learning outcomes of chemistry subjects on the mole concept occurs because of the influencing factors. These factors are intrinsic and extrinsic (Antara, 2022). Intrinsic factors include the student's willingness to succeed in learning, learning motivation, and the willingness to realize ideals (Antara, 2022). In contrast, extrinsic factors include rewards, conducive levels of learning activities, and exciting activities in the learning process (Utama & Kristin, 2020).

The successful implementation of this problem-based learning model is also supported by the results of the percentage of student activity that increases during cycle II. In line with research conducted by Siregar & Simatupang (2020), a positive and significant correlation exists between student learning activities and the learning outcomes of students taught with a problem-based learning model. According to Nowrouzian & Farewell (2013), learning using a problem-based learning model can improve communication, negotiation, collaboration, independence, confidence, decision-making, and group work skills.

CONCLUSION

Classroom action research has been carried out to describe the increase in activity and students' learning outcomes on the mole concept material by applying a problem-based learning model in class X-E of SMAN 1 Rengel. The results showed that the problem-based learning model can effectively improve student learning activities and outcomes. In each Cycle, the percentage of relevant student activities was higher than irrelevant activities. Then, the student's learning outcomes in Cycle II achieved classical mastery of 86.84%.

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