Improving Problem-Solving Skills in Colloid System Topic Using Problem-Based Learning Model

Latifah Hanum[1*], Ratu Fazlia Inda Rahmayani[1], Sri Winarni[1], Habibati[1], and Nazzatul Izzati[1]

[1] Department of Chemistry Education, Universitas Syiah Kuala, Banda Aceh, Indonesia
latifah_hanum@usk.ac.id

Abstract. Problem-solving skills in the chemistry learning process are one of the abilities that must be mastered by students. This research aims to analyze problem-solving skills, learning outcomes, describe student activities and student responses. This research is qualitative descriptive research. The subjects of the study were 24 students of grade XI IPA-1. Data collection was obtained from LKPD, observation of student activities, post-test and questionnaire of student responses. The results showed that the percentage of problem-solving skills obtained was 52.22 and 56.67 with the good category, 66.67 and 73.33 with the good category, respectively. The percentage of student activity observations obtained respectively was 65.34 and 74.59 with the fairly good category, 80.75 and 84.29 with the good category. The classical learning outcomes of students using the PBL learning model amounted to 79.17 with good categories. The percentage of student responses was obtained at 85.65 with a very good category. Based on the results of the study, students' problem-solving skills and activities using the PBL learning model have improved as evidenced by an increase in the percentage of score acquisition. Student learning outcomes are classically complete and students respond positively to the PBL learning model.

Keywords: Worksheet, Cooperative Learning, Student Activity.

1 Introduction

The learning process will not proceed well if the model used in the teaching and learning process does not consider student conditions. The application of a learning model fundamentally contributes to the effectiveness of the teaching and learning process. The success of classroom learning can be seen in the continuous development of learning. Learning proceeds effectively when the teacher guides the learning process, utilizes instructional materials, employs teaching methods, selects learning models, creates a conducive learning environment, and utilizes other learning resources that support the learning process.

Problem-based learning (PBL) is one of the learning models that can be applied in chemical education. The PBL learning model is designed to solve presented problems. PBL is an instructional model that stimulates critical thinking and encourages students to actively participate in their learning [1].

One of the high-level thinking skills needed is problem-solving. Problem-solving is one of the learning outcomes achieved by students, involving active searching for

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information and concepts related to a problem. This high-level thinking skill should be trained and offered to all students, especially when dealing with complex problems in chemistry education. This process is preceded by the ability to think critically and develop informed opinions that can be framed within reasonable theories [2].

Based on interview results with a chemistry teacher, it was found that the Problem-Based Learning (PBL) model has never been implemented at SMAN 1 Indrapuri, even though the characteristics of students tend to prefer assignments rather than just listening to explanations from the teacher. The PBL learning model can enhance students' problem-solving skills. Therefore, based on the aforementioned issue, the researcher conducted a study with the title "Improving Problem-Solving Skills in Colloid System Material Using Problem-Based Learning Model".

2 Method

This research was conducted in class XI IPA 1 at SMA Negeri 1 Indrapuri, located in a village of Lampanah Ranjo, Indrapuri District, Aceh Besar Regency, Aceh Province. The research time follows the teaching material schedule applicable at the school. The research times took place in the even semester of the 2022/2023 academic year from May until July.

2.1 Research Subject

The study subject was 24 students in the 11th-grade science class, consisting of 14 female and 10 male students.

2.2 Type of Research

The type of research is qualitative descriptive design. According to reference [3], qualitative descriptive research aims to describe and depict natural and man-made phenomena, with a particular focus on their characteristics, qualities, and interrelationships. This research was conducted over four sessions, with each session lasting for 2 hours of instruction (2 x 45 minutes each).

2.3 Research Instrument

The instruments used are test question sheets, observation sheets for student activities, observation sheets for student problem-solving skills, and questionnaires for student feedback while attending the lesson.

2.4 Data Collection Techniques

1. Data on Problem-Solving Skill Results
Problem-solving skills were assessed using Learning Modules (LKPD) as teaching materials, and students received grades based on their performance. Students worked on LKPD which focused on problem-solving skills in a group format. In the 11th-grade science class (XI IPA-1). The total number of students in the group was 24. The students were 6 study groups, with each group comprising 4 students.

2. Observation of Student Activities
This observation sheet for student activities uses a scale of 1, 2, 3, and 4, and it is conducted by marking a check (√) in the provided columns. The observation involved three observers, including one chemistry education student from Faculty of Teacher Training and Education (FTTE) Universitas Syiah Kuala (USK) who observed two student study groups, and two chemistry teachers from SMAN 1 Indrapuri who observed four student study groups, with each group consisting of 4 students. This assessment is used to evaluate student activities throughout the entire learning process, from the beginning to the end.

3. Learning Outcomes
Student learning outcomes data were taken by administering valid test questions to the 11th-grade science class (XI IPA-1) students. The test questions were presented in the form of a post-test, which was conducted after the learning of the PBL teaching model for colloidal Topics. The post-test was administered once during the fourth meeting

4. Student Feedback Questionnaire
The student feedback questionnaire consists of 9 questions. This questionnaire is individually filled out by the students after completing the learning process using the PBL model for evaluating problem-solving skills in the colloidal system material. Students respond to the questions by placing a check mark (√) in the score column that they consider appropriate. The score column provides two response options, "yes" and "no."

2.5 **Data Analysis Techniques**

1. Analysis of Problem Solving Skills
The data obtained from the completion of the Learning Modules (LKPD) for problem-solving skills are analyzed using the following formula:

$$\text{Problem-Solving Skills} = \frac{TS}{SM} \text{ x } 100\% \quad (1)$$

Where:
TS = Total score
SM = Maximum Score

Based on reference [4], the criteria for interpreting the level of problem-solving skill according to Table 1.

Table 1. Interpretation of problem-solving skill levels.

Score	Interpretation
81 – 100	Very Good
61 – 80	Good
41 – 60	Neutral
21 – 40	Disagree
0 – 20	Strongly Disagree

2. Analysis of Student Activities

According to reference [5], the data obtained from the student observation sheets are analyzed using a calculation of student activity. The specific formula for this calculation is provided below:

$$P = \frac{R}{SM} \text{ x } 100 \quad (2)$$

Where :

P = the percentage that seeking

R = raw score obtained by the student

SM = Maximum score

According to reference [6], the criteria for assessing the percentage can be found in Table 2.

Table 2. Criteria for assessing student activity observation result.

Percentage (%)	Descriptions
86 – 100	Very Good
76 – 85	Good
60 – 75	Neutral
55 – 59	Disagree
≤ 54	Strongly Disagree

3. Analysis of Learning Outcomes

According to reference [7], the test results of students from the Post-test can be analyzed using the following formula:

$$\text{Score} = \frac{Total\ Correct\ Answers}{Total\ Bumber\ of\ Questions} \text{ x } 100\% \quad (3)$$

Based on reference [8], after learning using PBL teaching model, student learning outcomes can be analyzed using descriptive statistics with a percentage formula as follows:

$$P = \frac{f}{N} \text{ x } 100\% \quad (4)$$

Where:

P = Percentage of Mastery
f = Total Number of Students who have completed a learning task
N = Number of Objects Studied

According to reference [9], the classical achievement of student learning is calculated using the following formula:

$$P = \frac{\sum Students\ who\ have\ completed\ a\ learning\ task}{\sum Students} \quad (5)$$

According to reference [8], based on the learning outcomes achieved by each student, the assessment of student learning results is categorized using Table 3.

Table 3. The assessment of student learning outcome.

Percentage (%)	Descriptions
86 – 100	Very Good
76 – 85	Good
60 – 75	Neutral
55 – 59	Disagree
≤ 54	Strongly Disagree

4. Analysis of Student Feedback

Based on reference [10], data obtained from student feedback forms can be analyzed according to the following formula:

$$P = \frac{A}{B} \text{ x } 100\% \quad (6)$$

Where:
P = Percentage of Mastery
A = Number of Students who Agree
N = Number of Students (respondent)

According to reference [11], based on the feedback obtained from students, the assessment of student feedback results is categorized according to Table 4.

Table 4. Score assessment of student feedback questionnaire.

Percentage (%)	Descriptions
86 – 100	Very Good
76 – 85	Good
60 – 75	Neutral
55 – 59	Disagree
≤ 54	Strongly Disagree

3 Results and Discussion

3.1 Problem Solving Skills

It appears you've provided information about the learning process, including how students work on Learning Modules (LKPD), build their knowledge, gather relevant information, discuss it with group members, and then take responsibility for group discussions through presentations. The development of problem-solving skills in PBL learning is assessed based on five aspects in a rubric for evaluation. The information you provided indicates that the improvement in problem-solving skills within each group, including the stages of problem-solving skills, can be observed in Table 5

Table 5. Improvement in problem-solving skills at each stage of problem solving.

No.	Stage of Problem Solving Skills	Percentage (%) of Meetings				Average
		P1	P2	P3	P4	
1.	Stage 1	66.67	72.22	83.33	83.33	76.39 (good)
2.	Stage 2	66.67	55.56	66.67	66.67	63.90 (good)
3.	Stage 3	50.00	66.67	77.78	77.78	68.06 (good)
4.	Stage 4	44.44	44.44	55.56	55.56	50.00 (neutral)
5.	Stage 5	44.44	44.44	50.00	61.11	50.00 (neutral)

Note :
Stage 1 = Problem identification
Stage 2 = Identification of problem solutions
Stage 3 = applying the problem-solving stages
Stage 4 = evaluating problem-solving solutions
Stage 5 = maintaining problem-solving solutions
P1 = 1st Meeting
P2 = 2nd Meeting
P3 = 3rd Meeting
P4 = 4th Meeting

Based on Table 5, a comparison of problem-solving skill outcomes at each stage in every meeting was obtained. Therefore, the graph of this data is as shown in Fig. 1.

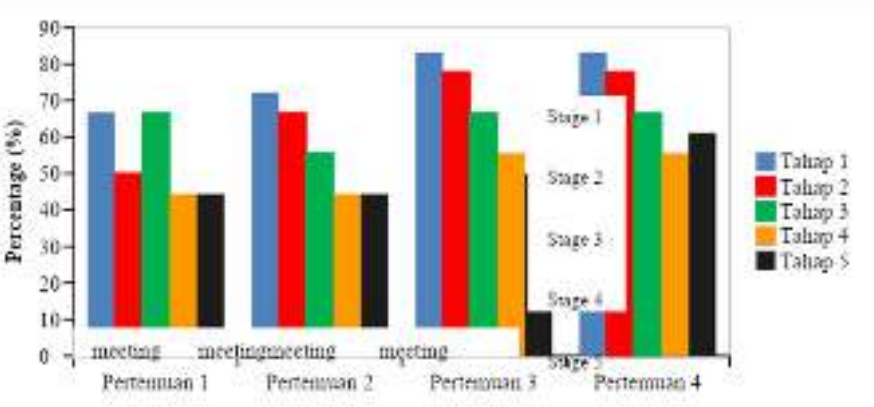

Fig. 1. Comparison of percentage results of problem-solving skills for each meeting.

According to Fig. 1, regarding the comparison of the percentage results of problem-solving skills at each stage in every meeting, differences are evident. From 1st meeting to the 4th meeting, there is an improvement, indicating that problem-solving skills at each stage in each meeting have changed for the better. This is demonstrated by the increasing trend in the problem-solving skills graph from Stage 1 to Stage 5.

Stage 1 is distinguished by blue-colored graphs, while stage 2 is marked with red. Moving on, stage 3 is indicated by green-colored graphs, and stage 4 is represented with an orange color. Finally, in stage 5, black-colored graphs are employed. In the first to fourth meetings, which had the highest percentage, participants primarily remained within stage 1. This is because, at stage 1, learners in each group could identify the issues in the learning materials (LKPD) due to the fact that in stage 1, participants solely utilize cognitive abilities such as recall (C1) and comprehension (C2). This aligns with reference [12], which asserts that understanding problems requires two fundamental cognitive abilities, namely, recall (C1) and comprehension (C2). During this step, learners are required to possess a strong memory and a comprehensive understanding to grasp the issues at hand.

During the implementation stage, as well as in the phases of identifying solutions, evaluating solutions, and maintaining problem-solving solutions, there was an increase in the percentage in each meeting. The increase in problem-solving skills at each meeting indicates that using the PBL model can enhance students' problem-solving skills. The elevating is consistent with reference [13], which asserts that the PBL learning model has been evident to accommodate the improvement of students' problem-solving skills.

3.2 Student Activities

In the learning process using the PBL model, there are 11 aspects assessed by observers during student observations. The enhancement in student activities in the stages of the PBL model can be known in Table 6.

Table 6. Enhancement of student activities in the PBL learning model.

No.	Assessment Aspects	Meeting Percentage (%)				Average
		P1	P2	P3	P4	
1.	Stage 1	71.00	79.25	83.25	87.50	80.25
2.	Stage 2	66.75	75.00	81.25	85.50	77.13
3.	Stage 3	64.00	72.25	80.50	80.50	74.31
4.	Stage 4	64.00	72.25	80.50	83.25	75.00
5.	Stage 5	66.75	75.00	83.25	83.25	77.06
Percentage (%)		66,50	74.75	81.75	84.00	76.75

Note:
1st Stage = Student problem orientation
2nd Stage = Organizing students for learning
3rd Stage = Guiding individual and group investigations
4th Stage = Developing and presenting the results of the work
5th Stage = Analyzing and evaluating the problem-solving process

Based on the data in Table 6, a comparison of student activity observation results for each meeting was obtained. Therefore, the graph of this data is depicted in Fig. 2.

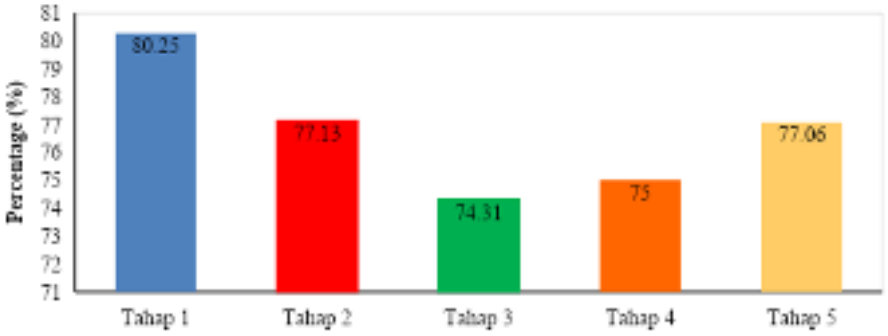

Fig. 2. Comparison of average percentage results of PBL learning model observation for each stage.

Based on Fig. 2, which illustrates the comparison of average percentage results of student activity observations for each meeting, differences in student engagement can be observed in each stage from the first meeting to the fourth meeting. In the graph, it is evident that the highest average percentage result of PBL learning model observation is in stage 1. Stage 1 is the phase where students are oriented toward the problem. This stage obtains the highest percentage because of the video presentations that students watch. Consequently, students find the learning process engaging as the teacher incorporates videos, making the learning experience less tedious.

The second-highest average percentage is in stage 2, which is the stage where students are organized for learning. In this stage, students are grouped and tasked with finding references for the given problem. With the group learning approach, students

feel motivated and engaged in the learning process, which contributes to their active participation. The third-highest average percentage is in stage 5, where students analyze the problem and decide the problem-solving phases. In this stage, students analyze colloid system materials together with their group members and the teacher, enhancing their understanding and analytical skills.

The fourth-highest average percentage is in stage 4, which is the stage of developing and expressing the work results. In this stage, students organize their ideas about the problem, and they subsequently present their findings in front of the class. The last highest average percentage is in stage 3, where students guide individual and group investigations. In this stage, students gather data from readings, which they will then analyze in alignment with the problem. This analysis helps in planning the problem-solving approach.

3.3 **Students Learning Outcomes**

The students' learning outcomes in this research were assessed by providing a multiple-choice test consisting of 10 items to 24 students in the XI IPA-1 class. The test was administered at the end of the learning process, after the students had learned problem-solving skills using the PBL (Problem-Based Learning) model. Based on the research results, the students' learning outcomes using the PBL learning model can be observed in Table 7.

Table 7. Student learning outcomes data.

No.	Student Initials	Score			Description
		Test (60%)	KPM (40%)	Final	
1	AZ	90	58.33	77.33	P
2	AR	90	53.34	75.34	P
3	DL	90	71.76	82.70	P
4	FK	50	58.33	53.33	F
5	FA	70	71.76	70.70	P
6	FB	60	58.33	59.33	F
7	HN	70	71.76	70.70	P
8	IF	90	53.34	75.34	P
9	IW	90	53.34	75.34	P
10	KG	80	53.34	69.34	F
11	KS	90	53.34	75.34	P
12	MY	90	71.76	82.70	P
13	MJ	80	71.76	76.70	P
14	MI	70	71.76	70.70	P
15	MS	80	58.33	71.33	P
16	NF	80	58.33	71.33	P
17	NS	80	65	74	P
18	NL	90	71.76	82.70	P
19	SN	80	65	74	P
20	SS	80	65	74	P
21	SU	90	53.34	75.34	P
22	TM	60	71.76	64.70	F

No.	Student Initials	Score			Description
		Test (60%)	KPM (40%)	Final	
23	ZH	90	53.34	75.34	P
24	MF	60	65	65	F
Sum		1.840	1.449.11	1.776.3	
Average		76.67	60.38	74.01	
P					79.17
F					20.83

Based on Table 7 it can be stated that the learning achievement of students in the colloid system material in class XI IPA-1 at SMA Negeri 1 Indrapuri, using problem-solving skills with the PBL model, achieved a percentage of 74.01%. This percentage falls into the "good" category, in line with reference [8], which categorizes student achievement of 70 - 89% as "good." This indicates that learning with problem-solving skills using the PBL learning model can be used to train and enhance students' problem-solving abilities in the learning process.

The highest score taken by students on the post-test was 90, and the lowest score on the post-test was 50. The number of students in class XI IPA-1 who achieved classical passing in the colloid system material was 19 students, with a percentage of 79.17%. This "good" passing percentage is attributed to the student's ability to answer the post-test questions provided by the teacher based on the knowledge they acquired through the learning process using the PBL learning model. This indicates that problem-solving abilities using the PBL learning model can enhance students' learning outcomes. The success of learning with problem-solving skills using the PBL learning model is due to students' active involvement in the learning process and the stages of problem-solving skills that train students to gain a good understanding of the material they are studying. This aligns with reference [14], which asserts that the PBL model is a problem-based learning model aimed at elevating and enriching the active role of students during the learning process.

There are a total of 5 students out of 24 who did not pass, with a percentage of 20.83%. This is because their scores did not meet the minimum passing criteria (KKM). This situation can be attributed to a lack of preparation on the part of these students before taking the post-test. Therefore, it is essential to prepare adequately before facing the post-test so that students can calmly tackle the test, having already grasped the material that is being assessed. The percentages of passing and non-passing grades can be seen in Fig. 3.

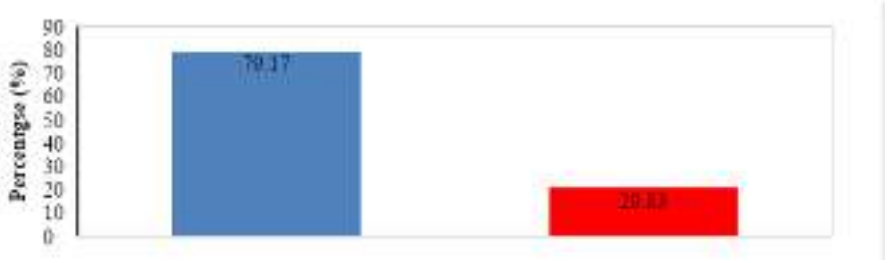

Fig. 3. Student learning outcomes in the PBL learning model.

3.4 Students Responses

In a classical sense, the positive response given by students to the PBL (Problem-Based Learning) model of learning is 85.65%. Meanwhile, the negative response given by students is 14.35%. When correlated with the criteria for assessing student response questionnaires, a response rate of 85.65% falls into the "excellent" category. In other words, the implementation of the PBL learning model to enhance problem-solving skills in colloid material has made students more interested in the learning process. This aligns with the reference [15], which suggests an increase in students' enthusiasm for thinking and problem-solving. They actively engage in discussions and problem-solving, making the classroom atmosphere enjoyable, and students become more motivated in learning using the PBL learning model.

Therefore, the PBL learning model can be a choice for teachers in their classroom instruction. The percentage of student responses to the PBL learning model can be seen in Fig. 4.

Fig. 4. Student responses to the PBL learning model

4 Conclusion

4.1 Conclusion

Based on the data analysis results presented, this research concludes that the use of the PBL (Problem-Based Learning) model for the colloid system topics can enhance problem-solving skills and student activity in class XI IPA-1 at SMA Negeri 1 Indrapuri, with both aspects falling into the "good" category. The learning outcomes achieved through using the PBL learning model, in a classical sense, also fall into the "good" category. The achievement indicates that implementation of the PBL learning model for the colloid system material can improve students' learning outcomes. Furthermore, student responses to the PBL learning model for the colloid system material fall into the "excellent" category. The achievement is evident from the positive response given by the students.

4.2 Recommendations

Teachers are encouraged to create a problem-oriented learning environment to promote greater student participation in expressing their ideas using their language; Students should further develop their problem-solving skills, as this competency is of paramount importance and should be cultivated in all students.

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