Problem-Based Learning Application to Measure Critical Thinking and Science Process Skills of Madrasah Aliyah Students in Yogyakarta

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Abstract. This study aims to compare critical thinking skills and science process skills of the grade X of Madrasah Aliyah students using a problem-based learning model and 5M, for electrolyte and non electrolyte solutions topics. The population in this study was students of grade X of Madrasah Aliyah Negeri in Yogyakarta and selected two classes as a sample. The sample was determined by purposive sampling technique. Data were obtained through a test using integrated-assessment instruments and their activities observations. The results showed that using the problem-based learning model has better quality compared to learning with 5M model, both for critical thinking skills and science process skills.

INTRODUCTION

Generally, the majority of senior high schools in Indonesia apply learning process by transferring knowledge without stimulating students to be active. Zejnilagic-Hajric., Sabeta, and Nuic [1] stated that commonly traditional learning system offers information content with a free-context problem. The main shortcoming of the traditional method is the lack of correlation between knowledge and real-world problem so that learning system orientates just learning outcomes not the learning process and potentially lacks active role of students during the process. This causes that their critical thinking such as problem identification, reconstructing idea, evaluating argument, problem-solving, as well as drawing conclusion, and their science process skills including observing, classifying, communicating, predicting, interfering, organizing data in table, identification variable, analyzing experimental data, as well as designing research do not develop maximally. Wulandari and Sunarya [2] argued that transferring Chemistry material to class demands students to not only remember the information. If this activity continues, the ability of students to think critically will be static or in other words, it is just a process transferring knowledge from teacher to students.

The situation demands the role of educators to demonstrate their creativity to design learning system in class. Designing the quality learning system will be arranged by the proper preparations of learning planning. Arif [3] outlined the preparations into three stages. First, it needs to identify the class' needs by observing the students' learning habits and their own potential. Second, it includes recognizing learners' competency by drafting indicators of material, determining method and media of learning, and arranging the assessment instructions. Third, it requires the drafting of the learning programs by compiling the supporting components to create the proper product of learning plans. The descriptions of the preparation of learning system show that an educator can creatively design the learning method to maximize the learning process in the class. By arranging the descriptions, the teacher can support the students to grow and develop their potential. The application of technical, tactics, methods, strategies, approaches and learning models can be one indicator of the creativity of a teacher. That step is one of the efforts of a teacher to create an active atmosphere among the learners so that learners can maximize their critical thinking and science process skills during the learning process. Further several researchers supposed that the problem-based learning method is a learning model supporting the active activity of students, such as group discussion which needs good interaction not only between teacher and students but also between the students and learning resources [4,5,6]. In addition other researchers noted that the problem-based learning method has a factual character of issue [7,8,9]. The system applying the model is formulated in the learning syntax. The syntax in the problem-based learning model covers (1) orientating the problem, (2) organizing learners, (3) investigating groups and individuals, (4) presenting as well as developing the work, and (5) analyzing and evaluating the process of problem-solving [10]. So it can be said that critical thinking is the ability of students to argue for the given problem and draw conclusions from the arguments between them, while the skills of the process of science are skills required by learners to gather knowledge related to the thinking processes absorbed by them in the learning process. Model syntax can facilitate the development of students' potential critical thinking and process science skills. The syntax of the model can facilitate the development of the potential of critical thinking and science process skills of students.

RESEARCH METHODS

The study was arranged in quasi-experimental research design using the post-test only non-equivalent control group design. The design is drawn in Table 1. The objects of this research were students of 1^{st} and 2^{nd} classes of X^{th} grade of natural science in MAN 1 Yogyakarta.

Table. 1. Research design of post-test only non-equivalent control group design

Group	Treatment	Post-test
E	X	O_1
K	-	O_2

Descriptions:

E : Experimental class

K : Control class

X : Learning system using problem-based learning model

O_1 : Score of post-test of experimental class

O_2 : Score of post-test of control class

The design shows that there were two classes in the study, the experimental class which has been given treatment of problem-based learning model and control class which was given 5-M model which is commonly applied in many schools. The objects of the research were determined as the experimental and control class by using purposive sampling. The Instruments of learning and collecting data used in this study included (1) the design of the implementation of the study, (2) student's worksheets (LKPD), (3) observation sheets of science process skills, and (4) integrated-assessment test (integrated test between critical thinking and science process skills).

Collecting data used observation sheet of science process skills filled out by the observer during the class and integrated-assessment test which was completed by the students after the problem-based learning model applied in the learning process. The analysis technique of data on the observation sheet used quantitative description, whereas the integrated-assessment test of students was tested by using ANOVA test operated in SPSS software 21.

RESULTS AND DISCUSSION

The results of the study focusing application of problem-based learning model for students in learning concept of nonelectrolyte and electrolyte solutions shown by student's critical thinking and science process skills were measured by many indicators, these were (1) identifying the problem, (2) reconstructing the argument, (3) evaluating arguments, and (4) determining solutions and drawing conclusions. Furthermore, science process skill aspects were observed by indicators of (1) observation, (2) classification, (3) communications, (4) prediction, (5) the inference, (6) organizing data in a table, (7) identifying variables, (8) analyzing the experimental data, and (9) planning the experiment.

Table 2 illustrates the result of the research due to the observation sheet of science process skills of students. The result of the observation of science process skills of students in both objects, experimental and control classes indicated that the first to seven indicators obtained showed the different percentage except indicator of observing. The experimental class showed the indicator of planning experiment at experimental class was higher than that in the control class. For point of observing, when students conducted an experiment about the identification of electric conductivity in some solutions, they felt enthusiastic so that it contributed maximum percentage for this indicator. For the indicator of classifying and organizing data in a table, the percentage of control class remained better than that of treated class due to the fact that the students in control class gave more caution when reading the instruction to fill the student worksheet then their counterpart did. For indicators of inference and communicating, experimental class stood at the higher point than the control group did because the member of experimental group answered completely the questions contained in students' worksheet. This is consistent with Rahayu's [11] study showing that the science process skill data for the communication indicator gets the value the highest among other science process skill indicators. This means that in the experimental class students are also able to draw conclusions and communicate, and this result is also in accordance with research of Feyzioglu [12].

Table 2. The Results of the Observation of Science Process Skills

No	Indicators of Science Process Skills	Science Process Skills (%)	
		Experimental Class	Control Class
1.	Identifying variable	89.66	90.63
2.	Planning experiment	100.00	87.50
3.	Observing	100.00	100.00
4.	Classifying	82.76	100.00
5.	Organizing data in table	82.76	100.00
6.	Inference	72.41	42.50
7.	Communicating	75.86	66.88

The data of frequency distribution of students of the experimental class in this study showed that combination of percentage for very high and high categories was about 90%, which can be classified as very good criteria. The data of the frequency distribution of students in both classes from the observation sheet are presented in Table 3.

Table 3. The Frequency Distribution of the Observations of Science Process Skills

No.	Score	Category	Experimental Class		Control Class	
			Total	%	Total	%
1.	X >15.20	Very high	15	51.72	11	34.37
2.	11. 40 ≤ 15.20	High	12	41.38	16	50.00
3.	7.59 ≤ 11.40	Medium	2	6.90	5	15.63
4.	3.79 ≤ 7.59	Low	0	0	0	0
5.	X ≤ 3.79	Very Low	0	0	0	0

The data illustrates that the experimental and control class had a fair frequency distribution of science process skills, however, the percentage of the composition of very high and high categories of the experimental class held higher score than that of control class, by about 93.10% and 84.37% respectively.

The analysis of data of integrated-assessment test showed taht the lowest and highest average score of the experimental class was better than that of the control class. The result of the integrated-assessment test is presented in Table 4.

Table 4. Score of Integrated-Assessment Test of Students

No.	Description	Experimental Class	Control Class
1.	Mean	62,75	57,87
2.	Lowest Score	48,00	36,00
3.	Highest Score	79,00	71,00

The data of integrated-assessment test was anaysed by ANOVA test processed by applying software of SPSS 21. The analysis was conducted to get information about the difference of average score of experimental and control class. Before ANOVA test was conducted for the integrated-assessment test, normality and homogeneity tests for the score of the test were done. The result of the normality and homogeneity test of the data is illustrated in Table 5.

Table 5. The Results of Normality and Homogeneity Test

Tests of Normality				
	Model	Shapiro-Wilk		
		Statistic	Df	Sig.
Integrated-Assessment test	PBL	0.938	29	0.087
	5M	0.962	32	0.309

Test of Homogeneity of Variances			
Integrated Assessment Test			
Levene Statistic	df1	df2	Sig.
1,711	1	59	0.368

The analysis showed that the value of significance was bigger than (α), 0.087 > 0.05, for experimental class and 0.309 > 0.05 for control class, which means that the data revealed statistically normal. - The analysis of data of integrated-assessment test of students showed that significance value was bigger than (α), 0.37 > 0.05, which means that the data revealed statistically homogeneous.

Anova test was used to deduce whether there was the difference average score of the integrated-assessment test of students of experimental class from that of the control class. The results of ANOVA test is shown in Table 6.

Table 6. The Results of ANOVA Test

ANOVA					
	Sum of Squares	*Df*	*Mean Square*	F	*Sig.*
Between Groups	362.829	1	362.829	4.366	0.041
Within Groups	4902.810	59	83.098		
Total	5265.639	60			

The experimental and control classes held the result of the average score of the integrated-assessment test by 62.75 and 57.87 respectively. The average showed the slight difference, but from ANOVA test shown in Table 6, it can be seen that significant value was found to be 0.041 which was smaller than 0.05 so there was the significant difference of average score between the two groups. From this analysis, it means that implementation of problem-based learning model had differences effect from 5M model in the learning process revealing critical thinking and science process skill. The result of this research, studying the impact of problem-based learning model on the development of critical thinking and science process skills of student, stood in the same place to those of Tarhan & Acar-Sesen [13], Istiana & Azizah [14], and Aidoo *et al* [9] stating that problem-based learning model could develop students' critical thinking. Susilo [15] gave addition that there was the gain of skill of students in some levels of intelligence from high to low. The results of this study also show that the problem-based learning model acquires students' science process skills, as found by Rahayu and Sudarmin [16] and Abanikannda [17].

CONCLUSION

The results showed that the problem-based learning model has better quality of learning compared to 5M model, both for critical thinking skills and science process skills. Using the problem-based learning model, the learning process was more effective, especially in inference and communication outcome.

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