

Increasing Problem Solving Competence through Problem-Based Learning Model and Scientific Approach

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ABSTRACT

The purpose of this research was to analyse the level of student learning activities and to increase their competence in mathematical problem solving through Problem Based Learning method and scientific approach. This research was designed based on a classroom action. The subjects were Grade 8 students of Muhammadiyah Junior High School in Batu Malang. The research was conducted in 2015. Data were collected by observing students' learning activity, while tests were conducted to measure the students' ability in mathematical problem solving. Descriptive analysis was conducted to analyse the student learning activities and the level of their mathematical problem-solving ability. The results of this study showed that the implementation of mathematical learning using Problem Based Learning method and scientific approach can enhance students' learning activities and mathematical problem-solving ability.

Keywords: Learning activities, Mathematics, Problem Based Learning, scientific approach

INTRODUCTION

In 2013, Indonesia introduced competency-based curriculum, so-called the 2013 curriculum, for its elementary and secondary schools. The curriculum was developed based

on the standard (standard-based education) and competency-based curriculum theory. The curriculum is characterised by a learning process that emphasises active involvement of students (student learning centre) and using a scientific approach.

Student-centre learning is important. It has been documented that students are less active in learning so that their learning outcomes (such as mathematics achievement, level of their activity) are below par. This has

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impacted on students' critical and creative thinking. Therefore, students are less skilful in solving mathematical problems. Traditional pedagogies, such as lecturing and demonstrating solutions to problems, very often result in students' capability of solving "textbook problems," but they are unable to apply the knowledge to solve real life problems (Brown, Collins, & Duguid, 1989; Mayer, 1996; Perkins & Salomon, 1989; as cited in Hung, 2009).

There are several underlying reasons for this. First, teaching has been lopsided whereby teachers have laid emphasis more on the delivery of content and routine matters which do not offer much challenge for students. Second, students lack courage and initiative and tend to be afraid of making mistakes. They are embarrassed to express their opinions even though they have the ability to express their views.

Scientific approach used in the 2013 curriculum was introduced to overcome the problems above. This approach strongly supports 'student centred learning' and downplays the dominant role of teachers in the classroom. Therefore, students can construct knowledge through a series of activities including observing, questioning, gathering information, associating and communicating or concluding (Kemdikbud, 2014). One method that can be used to support scientific approach is a problem-based learning (PBL) method.

The PBL is a student centred learning which emphasises on the process of learning whereby the students come up with a solution while the teacher acts as a

facilitator (Chakrabarty & Mohamed, 2013). The PBL presents a contextual problem that stimulates students to learn (Bilgin, Şenocak, & Sözbilir, 2009; Hung, 2009) where they work in teams to solve real-life problems (Chakrabarty & Mohamed, 2013; Uden, 2006). It is in effect of an instructional model that challenges students to "learn how to learn", and work in groups to find solutions for real crisis. The problems are given to encourage students' curiosity in learning and before they learn concepts (Kemdikbud, 2014). The use of PBL method allows students to actively discuss with members of the group to solve problems, and to think critically and creatively to achieve the specified learning objectives.

There are five phases in PBL: (1) student orientation at problems; (2) organising the students; (3) guiding the investigation of individuals and/or groups; (4) developing and presenting work; and (5) analysing and evaluating the problem-solving process (Kemdikbud, 2014).

Mathematic problem-solving ability is one of the competencies to be achieved by students which can be solved by routine and non-routine ways. Problems that can be solved in a routine way will not help students develop critical and creative thinking. Therefore, problems should be presented in such a way that it forces the students to resort to non-routine method of solution. Slavin (2006) states that students can use various strategies in problem solving.

This non-routine method uses Polya phases, namely: (1) understanding the

problem; (2) planning the problem solving; (3) implementing the plan for problem solving; and (4) checking back (Polya, 1973). In stage 1, students are required to understand the mathematical problems in two ways - finding things that are known and things that are asked. In stage 2, students can identify things that are necessary to solve the problems, whether in the form of data and how the data were obtained or create a mathematical model that will be used to solve the problems. In stage 3, the problems are solved using the plan devised in stage 2. Finally, students are required to check the results. Using the stages as per the Polya phase, students are able to think critically, logically, and creatively so that the math learning goals can be achieved.

Some studies have supported the above method, such as Ajai, Imoko and O'kwu (2013), who found that the student achievement in algebra using PBL was better than conventional method. Padmavathy and Mareesh (2013) confirmed this finding emphasising that PBL method is effective for learning mathematics.

The purpose of this study was to analyse the learning and mathematical problem-solving ability of students using a combination of PBL and scientific approach at Muhammadiyah Junior High School 8 Batu Malang.

METHODS

This research design used classroom action with two cycles. The subjects were grade

8 students of Muhammadiyah Junior High School 8 Batu Malang (in 2015).

The study employed observation and test methods to collect data. Mathematic problem-solving skills of the students were collected through an essay test. The students' activities were measured by five indicators, namely observing, questioning, experimenting, associating, and communicating and using a 4-point Likert scale (1 = almost never; 2 = sometimes; 3 = often; and 4 = almost always). The mathematical problem-solving skills of the students were based on test scores. Data related to student activities were analysed descriptively using SPSS by counting the frequencies and calculating the percentages of the responses of each item in the first and second cycle. The students' performances were analysed in SPSS by counting the scores' average and using its trend from the first to the second cycle.

RESULTS

PBL using a scientific approach was implemented among 8th grade students of Muhammadiyah Junior High School 8 Batu Malang. There were 23 students in that class consisting of 15 males and 8 females. The mathematical problems focused on algebraic operations. The implementation of learning mathematics by using the PBL and scientific approach was divided into five phases: (1) orientation of students to the problem; (2) organising; (3) leading the investigation of individuals and groups; (4) developing

and presenting work; and (5) analysing and evaluating the problem-solving process.

The Teacher’s Activities on the Implementation of PBL using Scientific Approach

The teacher’s activities during the learning process of mathematics by using PBL with a scientific approach were collected through

observation sheet using a 4-point Likert scale (1 = almost never; 2 = sometimes; 3 = often; and 4 = almost always). Two observers were assigned to do this and these observations showed the implementation of mathematics learning by using PBL method and a scientific approach. Table 1 shows the teacher’s activities on the implementation of PBL by using the scientific approach in the first and second cycles.

Table 1
Teacher’s activities on the implementation of PBL using a scientific approach

No.	Teacher Activity	Score Average	
		Cycle 1	Cycle 2
1.	Encouraging the active participatory of the students in learning through 5 stages (observing, questioning, experimenting, associating, and communicating)	3.5	3.5
2.	Conducting instructional activities based on PBL and scientific approach	3.5	3.5
3.	Guiding students to solve the problems using Polya phases	3.75	4
4.	Conducting students’ orientation activities to the problems (Phase 1 of PBL)	3	3.5
5.	Organising the students to study the relevant materials to the problems (Phase 2 of PBL)	3.5	3.75
6.	Guiding the students to solve the problems using individual and group investigation (Phase 3 of PBL)	3.5	3.75
7.	Guiding the students to develop the results of their observation and asking them to present their findings	3.5	3.75
8.	Facilitating the students to analyse and evaluate the problem-solving processes (Phase 5 of PBL)	3.5	3.75
Score Average		3.47	3.69
Percentage		86,72	92.19

In both cycles, the teacher implemented mathematics learning by using PBL and a scientific approach. The implementation was marked by the characteristics of the approach to scientific indicator 1 and 2 in which the teacher encouraged students’ activities in learning through five stages (such as

observing, questioning, experimenting, associating, and communicating) and implemented the scientific approach very well, where the score averaged above 3. In addition, the teacher carried out 5 phases on PBL method, which included orientation of students on the problem, organising them,

guiding investigations of individuals or groups, developing and presenting work, and analysing and evaluating the process of solving the problem very well. Likewise, the teacher has been guiding the students to solve mathematical problems using the stages outlined in Polya.

The activities of the teacher in the implementation of PBL and scientific approach to mathematics learning were very good, and increased from cycle 1 to cycle 2 for each indicator. Data showed the increase of the teacher's activity score from 86.72% in cycle 1 to 92.19% in cycle 2. Based on the

data above, a combination of PBL method and a scientific approach to the study of mathematics had been well implemented in cycle 1 and 2.

Students' Activity on the Implementation of PBL and Scientific Approach

Student activities during the learning process of mathematics by using the Problem Based Learning and Scientific Approach were collected through observation sheets filled out by the two observers.

Table 2
Student activities on implementation of PBL using scientific approach

No.	Student Activity in Group	Score Average			
		Cycle 1	%	Cycle 2	%
1.	Group 1	3.18	79.5	3.41	85.25
2.	Group 2	2.86	71.5	3.23	80.75
3.	Group 3	3.23	80.75	3.14	78.5
4.	Group 4	3.14	78.5	3.50	87.5
5.	Group 5	3.23	80.75	3.45	86.25

Table 2 shows that the activities of students in groups on the implementation of PBL and scientific approach were good. The activity scores increased for students in all groups, except in the third group, whereby in cycle 1 it was 80.75, and decreased to 78.5 in cycle 2. It means that in the group discussion, the average activity of students in the first cycle increased in the second cycle, evidenced by group one, two, four, and five except for group three.

In group one and two, observing and reasoning had the highest scores while in the third and fourth group, the highest activity score was in observing and questioning. In group five, observing activity had the highest score. Overall, observing had the highest score.

Based on the data obtained, the students' activities in groups on the implementation of PBL and scientific approach to the study of mathematics have been able to be performed in the first and the second cycle.

Table 3
Student activities and implementation of PBL and scientific approach

Student activity	Observing		Questioning		Experimenting		Associating		Communicating	
	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
Very active	3	11	6	11	5	15	5	12	3	9
Active	16	8	13	10	14	5	14	8	16	11
Moderate	4	4	1	0	0	0	0	0	0	0
Less active	0	0	3	2	4	3	4	3	4	3

Table 3 shows the number of students who were very active increased from the first cycle to the second cycle. The increasing number of very active students was a result of decreasing number of the students who were active, moderate, and less active. This means implementation of mathematical learning by combining PBL and scientific method was able to enhance students' learning activities.

The scores were based on five activities: observing, questioning, experimenting, associating, and communicating to the individual student. The activities of the students increased from cycle 1 to cycle 2. The highest activity for each meeting was

very diverse. The activity of individual student who got the highest score was in observing and communicating. In the second to fifth meeting, observing, questioning, and associating increased.

The Mathematic Problem-Solving Ability Levels of the Students

Data related to problem-solving ability level of the students during the learning process of mathematics using PBL and scientific approach in 8th grade of Muhammadiyah Junior High School 8 Batu Malang were obtained using an essay test, both in the first cycle and the second cycle.

Table 4
Problem solving scores in PBL and scientific approach

Stage of Problem Solving	Description	Score Average	
		Cycle 1	Cycle 2
Understanding the problem	Understanding what is known and asked the questions provided	80.00	90.00
Planning problem solving	Linking the problem using the appropriate theorems or formulas in problem solving	77.50	82.50
Implementing plan for problem solving	Using formulas or theorems that have been planned to check the correctness of each step, and consistent in the use of the symbol	70.00	77.50
Checking back	Rechecking the accuracy of calculations and results	62.50	75.00
Average		72.50	81.25

Table 4 shows cycle 1 related to the level of problem solving ability of the students by implementing PBL and scientific approach, which were still below the minimum completeness, 72.5. Therefore, learning was continued to the second cycle, and which indicated problem solving ability of the students after the implementation of PBL and scientific approach exceeded the minimum completeness, equal to 81.25. An increase in the level of Polya problem-solving ability of the students from the first cycle to the second cycle was good for every stage of Polya and in overall terms. The mathematical problem-solving scores increased from 72.5 in the first cycle to 81.25 in the second cycle. Based on the data, it can be concluded that the implementation of PBL and scientific approach can improve mathematical problem-solving abilities of the learners.

The level of problem solving ability of students after the implementation of PBL and scientific approach in 8th grade of Muhammadiyah Junior High School 8 Batu Malang was seen in 4 Polya stages, namely understanding the problem, planning the problem solving, implementing the plan for problem solving, and checking. An increase in the level of problem-solving ability of the students from the first cycle to the second cycle was good for every Polya stage and in overall terms. Mathematical problem-solving scores increased from 72.5 in the first cycle to 81.25 in the second cycle. The Polya stage that has been mastered well by the students was implementing while the

stages less controlled by the students were planning and verifying.

In the fourth stage of solving the problems, the level of abilities of the students increased from cycle 1 to cycle 2 and in overall terms. Stage 1 where the level of the students' skills in understanding the problems by writing what is known and asked through the questions provided had the highest score compared with the three other stages. In contrast, the level of students' abilities to recheck the accuracy of the calculations and results had the lowest score, 62.5 in first cycle and 75 in the second cycle.

The scores of Mathematic problem-solving ability of students from the highest to lowest were: understanding the problem (90), planning the problem solving (82.5), implementing the plan for problem solving (77.5), and checking back (75). The lowest score (checking back) indicated the students did not have the time to check the correctness of calculations and results in writing. The focus of their work was to solve all the given problems.

Therefore, it can be concluded that the implementation of PBL and scientific approach can improve the mathematical problem-solving abilities of learners.

DISCUSSION

The findings above showed a combination of PBL method and scientific approach can increase students' activities and mathematical problem-solving abilities.

The above approach is appropriate in mathematics learning, because it can encourage the students to be active in solving mathematical problems, ranging from observing, questioning, experimenting, associating, and communicating. The activities of the students in mathematic problem solving, both individually and collectively, increased from first cycle to second cycle using PBL and scientific approach. The current findings support Indonesian Government Regulation on curriculum for mathematics which emphasises on the active roles of students in learning math using scientific approach in learning.

Hence, a combination of scientific approach and PBL is best fit to enhance the active role and capabilities of students in solving problems in mathematics. These results are consistent with Fauziah, Abdullah and Hakim (2013) who found learning basic electronics using scientific approach and PBL among students can improve their activity and ability. Cie and Nie (2007) stated that the purposes of teaching problem solving in the classroom are to develop students' problem-solving skills, help them acquire ways of thinking, form habits of persistence, and build their confidence in dealing with unfamiliar situations.

The current findings were derived from the use of two cycles to examine the development of student's progress and activities in solving mathematics problems. The findings thus augment extant research that only uses PBL in single cycle to

investigate student's abilities in problem solving.

Findings further show that problem-solving activities in the classroom are an instructional approach that provides a context for students to learn and understand mathematics. In this way, problem solving is valued not only for the purpose of learning mathematics but also as a means to achieve learning goals. Hung (2009) reported that in PBL, the learners are presented with ill-structured authentic problems in which they are challenged to be active problem-solvers. This research thus supports the finding of Gunantara, Suarjana and Riastini (2014), and Ajai, Imoko, and O'kwu (2013) in which the implementation of Problem Based Learning can enhance students' problem-solving abilities. Students' mathematics learning activities were found to be good using a scientific approach (Fauziah, Abdullah, & Hakim, 2013; Rahayu, Syaifuddin, & Effendi, 2015).

The findings of this study have shown that the combination a Problem-based learning (PBL) and a scientific approach is perhaps the most innovative instructional method conceived and implemented in education. It aims to enhance students' application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills (Hung, 2009) and in enhancing their problem-solving skills as well.

Finally, findings of this study point to significant policy implications especially in curriculum implementation in Indonesia.

Such policies could mandate teachers to implement activity-based learning in combination with scientific approaches.

CONCLUSION

This research was conducted to describe and explain students' learning mathematics activities by combining Problem Based Learning and scientific approach. The aim is to analyse students' ability in solving mathematics. Findings of this study affirm that a combination of Problem Based Learning and scientific approach can enhance students' mathematical problem solving abilities.

The study also found a diversity of mathematical problem solving by students. Therefore, future study should examine the thinking processes of students in mathematic problem solving that are generated in cycle 1 and cycle 2.

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