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THE ROLE OF PROBLEM-BASED LEARNING TO IMPROVE STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY AND SELF CONFIDENCE

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Abstract

This study is a pre test-post-test experimental control group design having a goal to analyze the role of problem-based learning on students' mathematical problem-solving ability (MPSA) and self-confidence (MSC). The study involves 66 tenth grade students, a mathematical problem-solving test, a mathematical self-confidence scale, and perception of problem-based learning (PBL) approach scale. The study found that on MPSA, its gain, and on MSC students getting treatment with PBL approach obtained better grade than that of students taught by conventional teaching. The other findings, there was the high association between MPSA and MSC, and student performed positive opinion toward PBL approach.

Keywords: mathematical problem solving, mathematical self confidence, problem-based learning approach, perception toward problem-based learning

Abstrak

Penelitian ini adalah suatu eksperimen dengan desain pre test-post test kelompok kontrol dan bertujuan menelaah peranan pembelajaran berbasis masalah (PBM) terhadap kemampuan pemecahan masalah matematik (KPMM) dan percaya diri (PD) siswa. Penelitian melibatkan 66 siswa kelas sepuluh, satu set tes PMM, satu set skala PD dan satu set skala persepsi terhadap PBM. Penelitian menemukan bahwa dalam KPMM, peningkatannya, dan dalam PD, siswa yang mendapat perlakuan PBM mencapai mutu yang lebih baik dari pada mutu yang dicapai siswa yang mendapat pembelajaran biasa. Temuan lainnya adalah terdapat asosiasi yang tinggi antara KPMM dan PD, dan siswa menunjukkan persepsi yang positif terhadap PBM.

Kata kunci: pemecahan masalah matematik, rasa percaya diri, pembelajaran berbasis masalah, persepsi terhadap pembelajaran berbasis masalah

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In fact, the problem-solving ability is an essential ability should be possessed by and improved on high school students. Some reasons which found in that statement among others are various. Mathematical problem-solving is attached to the goal of mathematics teaching, in which method, procedure, and strategy are the main processes in general goal of teaching mathematics, even it is the heart of mathematics (Pujiastuti, Kusumah, Sumarmo, & Afgani, 2014). Besides that, mathematical problem solving is a basic ability in teaching mathematics, thus it helps individuals to develop their analytic thinking, helps students to be critical and creative, and to improve other mathematics abilities (Hidayat & Sariningsih, 2018; Jones, Swan, & Pollitt, 2015; Novita & Putra, 2016). Learning MPS is learning to think, to reason, and to implement owned knowledge.

Polya (1985) proposes problem-solving is an effort to seek a way out from a case which not easy to solve. Other experts, Hmelo-Silver, Duncan, & Chinn (2007) state a problem is a task that there is no complete algorithm for obtaining a solution. Therefore, problem solving is a process which

an individual uses his or her owned knowledge, skill, and understanding for solving a problem in an unknown situation (Hendriana, Hidayat, & Ristiana, 2018; Hendriana, Rohaeti, & Hidayat, 2017; Hidayat & Sariningsih, 2018; Isnaeni & Maya, 2014).

In sense problem-solving as a process, Polya (1985) offers steps solving problem as follow: a) to understand the problem: to identify the known element, asked element, and to examine sufficiency element for solving the problem; b) to relate the known and unknown factor and formulate them into a mathematical model; c) to select solving strategy, to elaborate, and to execute enumeration or solving mathematical model; d) to interpret solution to the previous problem, and to examine the truth of solution.

To consider the process or activities of problem-solving, it implies that MPS is a difficult and complex mathematics task. This statement implies that for executing a MPS, a person should have a specific attitude or strong mathematical soft skill, having interest in mathematics and viewpoint that he can solve difficult mathematics problem well. One kind of that mathematical soft-skill among other is mathematical self-confidence (MSC). Casey, Nuttall, & Pezaris (2001), proposes that self-confidence is confident feeling on own ability such as: unworried and responsible in executing activities, carrying out freely what he liked, having warm and polite attitude in interacting with other people, having accepted and respect other people, motivating for having high performance, and realizing on own advantages and disadvantages. Hendriana, Slamet, & Sumarmo (2014) state that self-confidence was to believe in own ability in mobilizing motivation and needed resources and acting fit demanded task. Indicators of self-confidence as follow: 1) To be confident toward his ability; 2) To take action in taking a decision independently; 3) To be unafraid to confront challenges, and 4) To respect toward his effort.

Relating to teaching and learning process, Kloosterman (1988) state that self-confidence is comprehending the task well as well as accustomizing to solve the task, observing the way of working of a successful person, should be accustomized of having mathematical self-confidence attitudes, carrying out integrated and continuous mathematics teaching process, stop pretending, thinking positively, and avoid to having negative thinking. Besides that, Kurikulum 2013 recommends that mathematical hard-skill for instance MPSA and soft-skill such as MSC should be improved accordingly and proportionally. A kind of mathematics teaching-learning approach is problem-based learning (PBL).

The steps in PBL namely: a) Orientate student with a contextual problem; b) Organize student for researching by help student to define and to organize learning tasks related to the problem; c) Direct student to solve the problem, by motivating student to find precise information, to carry out experiment, and to seek explanation and solution; d) Improve and present the result of solving problem; e) Analyze and evaluate the process and outcome of problem-solving. Thus, PBL is thought to be able to increase MPSA and MSC (Hmelo-Silver, 2004; Jonassen, 2011; Kirschner, Sweller, & Clark, 2006; Padmavathy, & Mareesh, 2013).

Some studies reported the superiority of PBL on improving student's MPSA (Fitriani, 2013; Hendriana, Slamet, & Sumarmo, 2014; Mudrikah, 2016; Sumarmo, Mulyani, & Hidayat, 2018). Therefore, the aforementioned arguments motivate the researcher to carry out a study for improving students' MPSA and MSC by using a PBL approach.

METHOD

This study is a pre test-post test experimental control group design which has a goal to analyze the role of problem-based learning on students' MPSA and MSC. The study involved 66 tenth grade students, an essay MPSA test, an MSC scale, and a perception on PBL scale. The MPSA test consisted of 5 items adopted from Hendriana & Sumarmo (2014) as a guide. The characteristics MPSA test as follow: reliability test was r = .884; item validity (t) were $.52 \leq t \leq .74$; discrimination power (DP) were $.29 \leq DP \leq .49$, and difficulty index (DI) were $.28 \leq DI \leq .58$.The MSC scale consisted of 35 items with its reliability self r = .89, item validity (IV), $2.12 \leq t_{cal} \leq 3.96$ ($t_{table} = 2.04$). In the following, we attached sample items of MPSA test and a sample of MSC scale.

Sample 1: item of mathematical problem-solving test on trigonometry

Suppose area of Δ ABC is $(3 + 2\sqrt{3})cm^2$, length of sides AB = $(6 + 4\sqrt{3})cm$ and BC = 7 cm. A student is going to calculate the value of sin (A+C).

a. Draw a skets of Δ ABC
b. Identify the sufficiency of those data for solving the problem. When it is not sufficient, complete it and then calculate sin (A+C)
c. Examine the truth of your answer.

Sample 2: item of a mathematical problem-solving test (in daily life problem)

A plot of a land has a shape of four sides which bordered by pillars A, B, C, and D, and has right angle on A and on C. Based on measuring it is obtained the distance from A to D is 20 m, and the size of $\angle ABD = 60^0$ and $\angle CBD = 45^0$.

a. Draw a skets of the land, and complete it with the known and unknown data.
b. The land will be sold at Rp. 500.000,00/m^2. Compile mathematical model for determining the price of the land, and then solve it.

Sample 3. Item of Self Confidence Scale

Note: SA: strongly agree DA: disagree QS: quiet seldom
A: agree on SDA : strongly disagree

No.	Statement	SA	A	DA	SDA
1.	I was able to solve a problematic trigonometry problem.				
2.	I am nervous when I should have to explain my trigonometry work in front of the class.				
3.	I wait for friend's help when I face a difficult and complicated trigonometry problem.				
4.	I was able to solve by my self any trigonometry problem.				
5.	I reject the different opinion of my friends when we				

No.	Statement	SA	A	DA	SDA
	discuss trigonometry problem.				
6.	I was unafraid to offer a different strategy to solve trigonometry problem in small group discussion.				
7.	I feel to be free to pose my opinion in small group trigonometry discussion.				
8.	I am confused to compile a mathematical model for solving trigonometry problem.				

RESULTS AND DISCUSSION

Description of MPSA, MSC, and perception toward PBL of students was attached to Table 1. Based on Table 1, in the pre-test, it found that there was no difference of MPSA of students in both teaching approaches, and the grades were at very low level. Nevertheless, after learning process, on MPSA and its gain (N<G>) and MSC, students getting treatment with PBL approach attained at reasonably good grades and the grades of students taught by conventional teaching was at medium grade level.

Table 1. Description of Mathematical Problem Solving Ability, Mathematical Self Confidence of Students in Both Teaching Approaches

Variables	Stat	Problem Based Learning (PBL)				Conventional Teaching (CT)			
		Pre-Test	Post-Test	N Gain	N	Pre-Test	Post-Test	N Gain	N
MPSA	$\overline{X}$	14.48	35.52	.59	33	14.21	31.03	.47	33
	%	28.97	71.03			28.42	62.05		
	SD	15	6,59	.15		4.48	4.95	.06	
MSC	$\overline{X}$	-	102.40	-	33	-	95.30	-	33
	%		76.42				71.12		
	SD		12.35				12.57		

Note: MPSA: Mathematical Problem Solving Ability, Ideal Score: 50
MSC: Mathematical Self Confidence Ideal Score: 134

Those findings were similar to results of some previous studies which giving treatment with PBL that students obtained MPSA at medium-fairly good level (Fitriani, 2013; Mudrikah, 2016). Similar finding on MSC, some studies that by using various innovative teaching approaches students performed fairly good MSC (Fitriani, 2013; Hendriana, et al., 2014; Karatas, & Baki, 2017; Montague, Krawec, Enders, & Dietz, 2014); Özsoy, & Ataman, 2017; Shahrill, Putri, Zulkardi, & Prahmana, 2018; Surya, & Putri, 2017; Solihah, Hendriana, & Maya, 2018). The testing hypothesis of those data was attached in Table 2.

Table 2. Testing Hypothesis of Mean Difference of Mathematical Problem Solving Ability, And Mathematical Self confidence on Both Teaching Approaches

Variables	Teaching Approach	$\bar{x}$	SD	n	Sig (2-tailed).	Sig (1-tailed).	Interpretation
MPSA	SA	27.68	6.50	28	.003	.001 < .05	$MPSA_{SA} > MPSA_{CT}$
	CT	23.00	4.06	28			
N-Gain MPSA	SA	0.54	0.16	28	.000	.000 < .05	N-Gain $MPSA_{SA}$ > N-Gain $MPSA_{CT}$
	CT	0.42	0.10	28			
MSC	SA	88.43	11.72	28	.026	.013 < .05	$MSC_{SA} > MSC_{CT}$
	CT	78.93	8.28	28			

Note: Mathematical Problem-solving Ability Ideal score: 50
Mathematical Self Confidence Ideal score MSC: 134

Further analysis, was about the association between MPSA and MSC. The association was analyzed by using contingency table such as in Table 3 and by using χ^2 testing. From Table 3, it was found value $\chi^2 = 27.500^a$ and sig.(2 tailed-.000 < .05). This meant that there was a high association (C = .674 or Q=.826) between MPSA and MSC. This finding that there was a medium-high association between hard mathematical skills and soft mathematical skills (Hendriana, et al.,2014; Purnami, Widodo, & Prahmana, 2018; Sumarmo, et al., 2018).

Table 3. Contingency Table of MPSA and MSC in PBL Approach Class

MPSA \ MSC	High	Medium	Low	Total
High	14	0	0	14
Medium	4	6	0	10
Low	0	6	3	9
Total	18	12	3	33

Besides, this study also found that students proposed positive opinion on PBL and they performed more active learning in all four phases of PBL than in conventional teaching such as in the following figures (Figure 1, Figure 2, Figure 3).

Figure 1. Students work in a small groupand teacher observes them in problem-based learning approach class

Figure 2 Students presented their group work in front of the class in problem-based learning approach class

Figure 3. Students asked and posed the response to the presenter from another group in problem-based learning approach class problem-based learning approach class

The students' positive opinion on PBL approach was similar to the finding of Surya & Syahputra (2017). The finding of student's difficulty in solving mathematical problem-solving tasks was attached in Table 4.

Table 4 Mean Score of Each Item of Mathematical Problem Solving Ability of Students in The Both Teaching Approach

Teaching approach	No	1	2	3	4	5
	Ideal score	14	10	10	8	8
PBL	$\bar{X}$	8,18	7,45	7,06	6,52	6,30
	% of ideal score	58,44	74,55	70,61	81,44	78,79
CT	$\bar{X}$	6,05	7,06	6,64	5,55	5,73
	% of an ideal score	43,29	70,61	66,36	69,32	71,59

Note: PBL: a scientific approach
CT: conventional teaching

In this study, students on both teaching approaches nearly did not realize difficulty on solving MPSA task; they attained almost good score on four items (more than 70 % out of ideal score), only on no one students realized a little bit difficulty. Seemingly, MPSA problems were not too difficult mathematical task for senior high school students. These findings that students were getting treatment with innovative teaching obtained at good grades on mathematical abilities (Hendriana, 2017; Hendriana, et al., 2017; Solihah, Hendriana, & Maya, 2018).

CONCLUSION

Problem-based learning approach took better role than conventional teaching on improving students' MPSA, its gain, and on students' MSC. Students are getting treatment with problem-based learning obtained at fairly good grades level on MPSA and MSC. Whereas, students taught by conventional teaching attained at medium grades level on both learning out comes. Besides that, students on both teaching approaches did not realize difficulties in solving MPSA tasks.

The other conclusion was that students performed more active learning in all four phases of problem-based learning, they were more creative, performed fairly good self-confidence, more able to communicate and work together in solving problems. Whereas students taught by conventional teaching tended fewer students active learning, and they waited for explanation from their teacher. Besides that, it was concluded that there was a high association between mathematical problem-solving ability and mathematical self-confidence, and students expressed positive opinion toward implementation of problem-based learning.

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