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Problem-solving learning influence on physics learning outcomes based on logical thinking ability

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Abstract: Problem solving learning is designed to develop students' ability in solving scientific problem. The purpose of this study is to test the effectiveness of problem solving model on students' learning outcomes and logical thinking ability. It employed a quasi-experiment with a 2x2 factorial design. The subject was Tenth graders of SMKN 6 Malang. Randomly, it determined two classes of control class and two classes of experimental class. The instrument of this research was logical thiniing test instrument and Physics learning outcome instrument. In addition, it used lesson plan on static fluid as an instrument. Normality and homogenity testing were employed before testing the formulated hypothesis. It employed Liliefors for normality testing and Bartlett for homogenity testing. To test the hypothesis, this research employed Two-ways of ANAVA and Scheffe testing. The results show that (1) Physics learning outcomes of students who learnt by means of problem-solving learning strategy is higher than students who learnt by means of conventional one. (2) It affirms the interaction between problem-solving learning strategy and logical thinking ability of students on Physics learning outcomes. (3) Physics learning outcomes of students who learnt by means of problem-solving learning strategy with high logical thinking ability is higher than students who learnt by means of conventional one. (4) Physics learning outcomes of students who learnt by means of problem-solving learning strategy with low logical thinking ability is higher than students who learnt by means of conventional one.

Key Words: learning achievement; logical thinking; problem solving

1. Introduction

Learning process which is took place in classroom setting demonstrates interaction between teacher and students as well as among students in the classroom. After acquiring learning process in the classroom, students are demanded to be able to correlate learning material obtained with the real-life context which then would be able to apply the knowledge into the real-life setting. When students are successful in achieving such extent, it means they acquiring a meaningful learning process. In regard with observation conducted by the researcher during the learning process, predominantly students learn by memorizing formula of certain topic. Students have no idea upon how do the formula come. While working a problem in which the formula is obvious, students found no difficulty in obtaining a proper solution or answer. In contrast, if the items are converted to a different form, most students offer incorrect answer to problem. Such phenomena indicates a limited logical thinking ability possessed by students. Thinking logically plays a role as a basis to acquire higher order thinking abilitys.

In comprehending abstract concept within science learning and in achieving better learning ourcomes, logical thinking ability undoubtedly plays an important element (Fah, 2009). To identify further

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student's logical thinking ability in this research, it employed Group Assessment of Logical Thinking (GALT) instrument (Roadrangka, 1983). The scope within the logical thinking ability instrument above consists of six stages of reasoning as follows: : conservational reasoning, proportional reasoning, controlling variable, probabilistic reasoning, correlational reasoning, combinatorial reasoning. Previous research presented the relationship between the ability to think logically and the learning outcomes of students in Biology, Physics, and Chemistry (Roadrangka, 1983).

To stimulate and promote logical thinking ability and conceptual understanding on student, problem-solving learning is believed as one available learning approach to be appplied. Problem-solving learning strategy deals with a process focusing on encountering answer to a certain problem by means of finding or discovering combination of studied concepts. Previous research confirm the importance of problem-solving learning techniques to improve individual's ability to make decisions logically (Sumardyono; 2007)(Santyasa; 2007) (Hafizah, Misbah, & Annur, 2018) (Januarifin, Parno, & Hidayat, 2018). This research aims at implementing problem-solving learning technique which modified problem-solving learning which consists of five stages as follows: (1) problem orientation and hypothesis formulation, (2) organizing student, (3) data collection and hypothesis testing, (4) group work presentation, (5) analyzing and evaluating problem-solving learning process (Arends, 2008).

This research was conducted on Public Vocational High School 6 Malang. It took the entire Tenth Graders as research population. Whereas, four schools were taken as research sample. Then, of four classes taken, two classes served as experimental class and two classes served as control class which were determined randomly. Experimental classes received problem-solving learning strategy and control class received conventional learning strategy.

2. Methods

To discover the effect of problem-solving strategy in learning, this research employed quasy experimental research design (Cohen, Manion & Morrison, 2007) since experimental group in this research has been determined initially. Before receiving learning treatment, the entire subjects in the sample classes were taken a logical thinking ability test to determine cluster of logical thinking ability classification. It distinguished between high logical thinker and low logical thinker. The quasy experimental research scheme is presented in the following Table 1.

Table 1. Research Factorial Design

Logical Thinking Ability (B)	Learning Strategies (A)	
	Problem-solving (A_1)	Conventional (A_2)
High (B_1)	A_1 B_1	A_1 B_2
Low (B_2)	A_2 B_1	A_2 B_2

Remarks:

A_1 B_1 : Learning outcomes by means of problem-solving learning strategy on high logical thinking student
A_1 B_2 : Learning outcomes by means of problem-solving learning strategy on low logical thinking student
A_2 B_1 : Learning outcomes by means of conventional learning strategy on high logical thinking student
A_2 B_2 : Learning outcomes by means of conventional learning strategy on low logical thinking student

In this research, the instrument employed were syllabus and lesson plan . the syllabus of the learning was designed and arranged in accordance with standard of competence in applying basic concept of fluid, basic competence of laws related to static and dynamic fluid understanding. In which, this research was conducted during static fluid topic. The lesson plan was in accordance with the treatment given to the sample classes. In exerimental classes, the lesson plan was arranged based on problem-solving learning

strategy syntax. On the other hand, conventional learning used lesson plan which was based on conventional learning strategy syntax.

To obtain the data, this research employed measurement instrument in the form of logical thinking ability test items and Physics learning outcomes test items. It employed Group Assessment of Logical Thinking (GALT) (Roadrangka, 1983) as logical thinking ability test items which consists of six aspects of logical thinking ability: conservational reasoning, proportional reasoning, controlling variable, probabilistic reasoning, correlational reasoning, combinatorial reasoning. Furthermore, the researchers conducted content validation and empirical validation to the instrument of logical thinking ability. Instrument validation was performed by two validators who are lecturers focusing on Physics education and learning assessment and evaluation. First, we performed empirical validation of logical thinking ability items to two student of Vocational High School 6 Malang. Logical thinking ability items for students were used multiple choice items. Whereas, as for the learning outcomes, it measured the following aspects of cognitive: remembering, understanding, applying, and analyzing.The questions given were adjusted with the arranged indicators. the question items of learning outcomes on static fluid topic were arranged. We conducted content and empirical validation on learning outcomes instrument. Content validation was performed by two lecturers. Whereas, empirical validation of learning outcomes instrument test was performed by two students of Vocational High School 6 Malang who have obtained static fluid topic. Before applying the two insruments, the researcher measured its validity, reliability, item difficulty, and item discrimination.

After obtaining data, two ways of ANAVA was performed to analyze the data. It was performed to identify the difference of learning outcomes between students learning with problem-based learning strategy and students learning with conventional learning strategy. Futher, Scheffe testing was performed to examine the effectiveness of learning strategy. Previous to data analysis using two ways of ANAVA, pre-requisite analysis were performed such as normality testing and variant homogenity testing.

3. Results and Discussions

3.1. Student's Logical Thinking Ability

The student's logical thinking ability is divided into two classifications as follows: high logical thinking ability and low logical thinking ability. Table 2 below presents description of statistics regarding logical thinking ability between students learning with problem-solving strategy and students learning with conventional strategy.

Table 2. Score Description of High Logical Thinking Ability and Low Logical Thinking Ability

	N	Mean	Std. Deviation	Minimum	Maximum
High Logical Thinking Ability (Problem solving)	22	10,318	0,893	9,00	12,00
Low Logical Thinking Ability (Problem solving)	22	5,954	0,898	4,00	7,00
High Logical Thinking Ability (Conventional)	24	10,333	0,963	9,00	12,00
Low Logical Thinking Ability (Conventional)	24	5,875	1,034	4,00	7,00
Total	92	8,119	2,408	4.00	12.00

According to the data presentation in Table 2, in the experimental group which treating the students by means of problem-solving learning strategy, both average score between students with high logical thinking ability and students with low logical thinking ability are contrasting. Students with high logical thinking ability obtained 10.32 with the score range of 9.00-12.00. At the same time, students with low logical thinking ability obtained 5.95 with the score range of 4.00-7.00. The score of students learning with conventional strategy was also contrasting. Students with high logical thinking ability obtained 10.33 with the score range of 9.00-12.00. At the same time, students with low logical thinking ability obtained 5.87 with the score range of 4.00-7.00.

3.2. Physics Learning Outcomes of Students

Succeeding the treatment to both experimental classes and control classess, it obtained the score of Physics learning outcomes on students with high and low logical thinking ability who learn by means of conventional strategy and students with high and low logical thinking ability who learn by means of problem-solving learning strategy. In detailed, the score obtained of each classification of student (students learnt by conventional strategy and problem-solving model) is presented in the Table 3.

Table 3. Student's Learning Outcomes Score Description

	N	Mean	Std. Deviation	Minimum	Maximum
High Logical Thinking Ability (Problem solving)	22	20	0,975	18,00	22,00
Low Logical Thinking Ability (Problem solving)	22	17,045	2,214	13,00	21,00
High Logical Thinking Ability (Conventional)	24	18,291	1,488	15,00	21,00
Low Logical Thinking Ability (Conventional)	24	13,291	2,293	9,00	17,00
Total	92	17,097	3,077	9,00	22,00

According to the data presentation showed in Table 3 above, it indicates a contarsting results of Physics learning outcomes in the experimental classess learning by means of problem-solving model. Between students with high and low logical thinking ability, it obtained different score. Students with high logical thinking ability obtained an average score of 20.00 with the score range of 18.00-22.00. At the same time, students with low logical thinking ability obtained an average score of 17.04 with the score range of 13.00-21.00. Similarly, the average score Physics learning outcomes in the control classes learning by means of conventional model is contrasting. Students with high logical thinking ability obtained an average score of 18.29 with the score range of 15.00-21.00. Whereas, students with low logival thinking ability obtained an average score of 13.29 with the score range of 9.00-17.00.

3.3. Hypothesis Testing

Further, to examine the formulated hypothesis in this research, we performed two analysis approaches; Two-ways ANAVA and Scheffe Testing. Two-ways ANAVA aimed at identifying and obtaining a differences between two groups. Then, Scheffe testing aimed at identifying the effectiveness of problem-solving learning model. The results of Two-ways of ANAVA is presented in the Table 4.

Table 4. Two-ways of ANAVA Results

Variant	Db	JK	RK	F_{count}	F_{table} (α = 0,05)
Line (b)	1	171,226	171,226	51,100	3.98
Coloumn (k)	1	372,011	372,011	111,021	3.98
Interaction (bxk)	1	24,012	24,012	7,166	3.98
Error (within)	88	294,871	3,351		
Reducted total	91	1255.888			

Following, advanced testing to identify and observe the effectiveness of problem-solving model was performed. Table 5 presents a brief description of Scheffe testing.

Table 5. Scheffe Testing Results

Interaction	F_{count}	F_{table} (α = 0,05)
Problem-solving VS Conventional	49,725	2,71
High Logical Thinking Ability in Problem-solving Model VS High Logical Thinking Ability in Conventional Model	29,1	2,82
Low Logical Thinking Ability in Problem-solving Model VS Low Logical Thinking Ability in Conventional Model	19,315	2,82

3.3.1. The first formulated hypothesis is "Physics learning outcomes of students learning by means of problem-solving model is higher than students learning by means of conventional model"

To answer the first formulated hypothesis above, discrimination test by means of Two-ways of ANAVA was performed first and it is followed by Scheffe testing approach. A different score of Fcount and Ftable for each coloumn (k) in Table 4 serves as element to identify the difference. Two-ways of ANAVA indicates that Fcount is greater than Ftable (Fcount of 111.021 > Ftable of 3.98). the results affirm that Ha is accepted. It further means that Physics learning outcomes of students between classes taught by problem-solving model and classes taught conventional model are contrasting.

Scheffe testing presented in the Table 5 above indicates that Fcount score of problem-solving model versus conventional model is greater than Ftable obtained (Fcount pf 48.725 > Ftable of 2.71). The findings approve that Physics learning outcomes of students learning by means of problem-solving model is upper-hand than students learning by means of conventional model (Semedi, 2010) (Suryaman, 2010). Both studies approve the implementation of problem-solving model creates better outcomes than conventional classroom learning. Additionally, problem-solving model also promotes student's conceptual understanding on static fluid topic as well as its problem-solving when it compares with conventional learning (Prayogo, 2011).

3.3.2. The second hypothesis "there is interaction between problem-solving learning model and student's logical thinking ability on Physics learning outcomes"

To prove the second hypothesis above, the obtained Fcount and Ftable of interaction (bxk) in Table 4 was compared. The results of Two-ways of ANAVA indicates that Fcount is greater than Ftable (Fcount > Ftable; 7,166> 3,98), therefore Ho is rejected and Ha is accepted in this research. The findings further means that there is an interaction between problem-solving learning model and student's logical thinking ability on Physics learning outcomes.

Preference of cooperative learning model and strategy impact on student's logical thinking ability improvement (Saragih, 2011) (Aida, 2010). Problem-solving learning strategy offers an opportunity to students to develop and enhance their thinking ability as well as improving conceptual understanding on the important concepts in science (Darniwa, 2011) .

3.3.3. The third hypothesis is "Physics learning outcomes of students with high logical thinking ability is higher when learning with problem-based learning strategy than learning with conventional learning strategy"

To confirm the third hypothesis of this research, it was indicated by discrimination test on Physics learning outcomes of students who learnt with problem-solving learning strategy and students who learnt with conventional learning strategy. In detailed, the data is presented in Table 6.

Table 6. Discrimination Test Result between Students' Physics Learning Outcomes with Problem-solving and conventional learning on High Logical Thinking Ability

Variant	Db	JK	RK	F_{count}	F_{table} (0,05)
between A	1	33,498	33,498	20,772	4,11
Within	44	70,958	1,613		
Total	45	104,457			

The table shows that Fcount is greater than Ftable (Fcount > Ftable; 20.722>4.11). thus, it can be concluded that there is a difference in Physics learning outcomes between students who learnt problem-solving learning method and students who learnt conventional learning method with high logical thinking ability. To examine further the third hypothesis regarding the effectiveness of model, it compared the obtained score of Fcount and Ftable from Scheffe testing. Table 5 shows that Fcount of problem-solving model on high logical thinking ability students versus conventional model on high logical thinking ability students is higher than Ftable (Fcount of 29.1 > Ftable of 2.82). It further affirms that problem-solving learning method improves Physics learning outcomes of students with high logical thinking ability rather than by means of conventional learning strategy (Darniwa, 2011). Darniwa proves that logical thinking ability improvement is followed by student's conceptual understanding improvement. Learning strategy which offers and promotes students to solve certain problem and relate it with the basic concept they obtained. It further impacts on the enhancement of knowledge within student with higher scientific reasoning ability (Lawson, 1995).

3.3.4. The fourth hypothesis is "Physics learning outcomes of students with low logical thinking ability who learnt by means of problem-solving strategy is higher than students who learnt by means of conventional learning"

To confirm the third hypothesis of this research, it was indicated by discrimination test on Physics learning outcomes of students with low logical thinking ability who learnt with problem-solving learning strategy and students who learnt with conventional learning strategy. In detailed, the data is presented in Table 7.

Table 7. Discrimination Test Result between Students' Physics Learning Outcomes with Problem-solving and conventional learning on Low Logical Thinking Ability

Variant	Db	JK	RK	F_{count}	F_{table} (0,05)
between A	1	161,739	161,739	26,004	4,11
within	36	223,913	6,220		
Total	37	385,652			

The table shows that Fcount is greater than Ftable (Fcount > Ftable; 26.004 > 4.11). Thus, it can be concluded that there is a difference in Physics learning outcomes between students who learnt problem-solving learning method and students who learnt conventional learning method with low logical thinking ability. To examine further the fourth hypothesis regarding the effectiveness of model, it compared the obtained score of Fcount and Ftable from Scheffe testing. Table 5 shows that Fcount of problem-solving model on low logical thinking ability students versus conventional model on low logical thinking ability students is more significant than Ftable (Fcount of 29.1 > Ftable of 2.82). It further affirms that problem-solving learning method improves Physics learning outcomes of students with low logical thinking ability rather than by means of conventional learning strategy (Saragih, 2011). Saragih discovers the significant difference of ability improvment of students based on the learning strategies and the difference level of logical thinking ability.

Furthermore, the findings obtained during observation indicate that when students were grouped to perform problem-solving, it offers an easy apporach to solve the problem. The students were grouped based on a classification of logical thinking ability. It affirms that students with high logical thinking ability are relatively quick in solving the problem.

4. Conclusion

According to the findings and hypothesis analysis in this research, several points can be made to sum up as follows: (1) Physics learning outcomes of students who learnt by means of problem-solving learning strategy is higher than students who learnt by means of conventional one. (2) It affirms the interaction between problem-solving learning strategy and logical thinking ability of students on Physics learning outcomes. (3) Physics learning outcomes of students who learnt by means of problem-solving learning strategy with high logical thinking ability is higher than students who learnt by means of conventional one. (4) Physics learning outcomes of students who learnt by means of problem-solving learning strategy with low logical thinking ability is higher than students who learnt by means of conventional one.

Based on the research, several points can be made as suggestion. Problem-solving learning strategy serves as better learning strategy than conventional model. Therefore, it is important to consider problem-solving strategy as one of the alternative learning approaches to improve student's learning outcomes. This problem-solving method is applicable to varied topics in Physics learning, hence the learning will be more encouraging. Secondly, it is important to take into account student classification. Based on the observation, students with high logical thinking ability were having more enthusiasm in following the learning which offered them more challenge in solving problem. It proves that monotonous learning approach without encouragement of challenging approach discourages students to be actively involved in learning and hence the outcomes will be low.

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