KnE Social Sciences
ICITEP
International Conference on Innovation and Teacher Professionalism
Volume 2023

Knowledge E
enriching | engaging | empowering

Research Article

The Ability of Problem-based Learning (PBL) to Improve Problem-solving Skills on Heat Topic Among High School Students

Aprilita Ekasari[1]*, Markus Diantoro[2], Parno[2]

[1]Departement of Physics, Universitas Musamus, Indonesia
[2]Departement of Physics, Universitas Negeri Malang, Indonesia

Abstract.
Problem-solving should be improved to support students' competence in solving physics problems as well as problems that occur in daily life. The initial research showed that high school students in Tulungagung have low level of problem-solving skills at 41.2% and 39.4%, respectively. Therefore, this study aims to determine the improvement of the problem-solving skills among high school students at PGRI Kalangbret who had been taught problem-based learning on the topic of heat. This study used research design of mixed methods embedded experimental model. The subjects consisted of 30 students at class X MIPA. This research used quantitative analysis to analyze the effect size test, N-gain test, paired t-test, and qualitative with the help of coding and data reduction, from pretest, pottest, observation, and field notes. Based on the results, it was found that students' problem-solving skill were improved after being taught with problem-based learning (PBL) on heat topic with an average N-gain score of 0.41; and effect size 1.66.

Keywords: problem-based learning, problem-solving skills, high school

Corresponding Author: Aprilita Ekasari; email: aprilita@unmus.ac.id

Published 5 June 2023

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICITEP Conference Committee.

1. INTRODUCTION

The main topic in physics subject that discuss in high school is Heat, besides motion, optics, electricity and magnetism. Heat is an abstract topic that cause students having difficulties to learn it [1] [2] [3]. Overcoming this challenge, it is needed to improve problem solving skills. Someone who has good problem solving skills will be able to determine what the real problem is [4] and be able to solve various physics problems. It is expected that students are able to solve physics problems and become competent problem solvers is the main goal in learning physics [5] [6]. Research on problem-solving skills with various learning strategies in the physics education has been widely carried out. Problem-based learning can improve students' problem-solving skills.

An initial study of problem solving skills and metacognition skills related to heat material had been carried out at SMA PGRI Kalangbret. This study showed that, the students'

problem solving skills was 28.7%. This study focused on improving the problem-solving ability of SMA PGRI Kalangbret on heat material with problem-based learning. Problem-based learning was expected to be able to provide students with more understanding of heat material, so as to improve problem solving skills and students' metacognitive abilities.

2. METHOD

The approach and type of this study was adapted from Creswell & Clark by using a mixed methods embedded experimental research model. The objective of this study was to evaluate the development of problem-solving skills towards the concept of heat. This study was conducted at SMA PGRI Kalangbret, in class X MIPA with a total of 30 students. This study was carried out through the following stages: the pretest was carried out before the first meeting to determine the initial problem-solving skills of students, by providing questions about problem solving skills in the form of 15 Essay Questions. The pretest results were analyzed quantitatively and qualitatively. The pretest scores showed the information about students' problem-solving skills. Learning the heat material with the PBL method was carried out for 4 meetings.

3. RESULTS AND DISCUSSION

3.1. Quantitative Analysis

The descriptive statistical analysis results towards the problem-solving pretest and posttest scores among students of SMA PGRI Kalangbret are presented in Table 1.

TABLE 1: Descriptive Statistics of Problem Solving Skills of PGRI Kalangbret High School Students

	N	Min	Max	Mean	Med	Std.Dev	Var	Skewnesss		Description
								Statistic	Std.Error	
Pretest	30	7	78	43.5	47.5	1.91	364	-.573	.427	**Normal**
Posttest	30	33	90	59.3	58	1.57	246	.156	.427	**Normal**

Note: Score range 0-100

The skweness value of the pretest and posttest scores of SMA PGRI Kalangbret based on Table 1 shows the data are normally distributed by the results greater than -1 and less than 1 so it can be concluded that. The mean and median values shown that the pretest and posttest data are normally distributed in Table 1 are almost similar, so it can be concluded that. After found out that the data were normally distributed, a paired

sample t-test was performed on SPSS 1.60 for Windows to determine the significance enhancement in problem solving skills of PGRI Kalangbret High School students as shown in Table 2.

Table 2: Paired Samples T-test on Problem Solving Skills of High School Students PGRI Kalangbret.

		Paired Differences					T	Df	Sig. (2-tailed)	Description
		Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference					
					Lower	Upper				
Pair 1	PRETEST - POSTTEST	-1.57	6.55	1.19	-18.21	-13.32	-13.178	29	.000	**Different**

Data presented in table 2. describes a significant difference between the pretest and posttest results in problem solving skills of SMA PGRI Kalangbret students with df = 29 of -13,178 p = 0.00 (two tails). These results indicate that problem-based learning was able to improve the problem-solving skills of high school students at PGRI Kalangbret towards heat material.

The value of d-effect size and the average value of N-Gain also show an increase in the problem solving skills of students at SMA PGRI Kalangbret. The calculation results of d-effect size is d = 1.66 with very large effect criteria (Morgan et al, 2005). The N-gain value is obtained from the calculation of the average value of students at SMA PGRI Kalangbret (g) = 0.41 which is included in the medium category (Hake, 1998). The analysis results of each indicator of problem solving skills shows an increase in the problem solving skills of High School students at PGRI Kalangbret as shown in Table 3.

Table 3: Analysis of the problem-solving skills indicators of high school students at PGRI Kalangbret.

Indicator	**Percentage (%)**	
	Pretest	**Posttest**
Argument	55,1	66,1
Causal	31,7	48,8
Problem Scema	31,8	55,8
Analogy	50	60

Table 3. shows there is a progress in students' problem solving abilities per indicator. The highest increase in problem solving skills occurred in the problem schema indicator from 31.8% to 55.8%. The lowest problem solving ability occurs in the argumentation indicator from 55.1% to 66.1% and the analogy indicator from 50% to 60%.

Table 4 describes an analysis per subject of the problem solving skills of high school students PGRI Kalangbret. The highest increase in problem-solving skills is in the Azaz

Table 4: Analysis problem solving skills in each subject of high school students PGRI Kalangbret.

Indicator	Percentage (%)	
	Pre-test	Post-test
Temperature and Heat	41	59
The effect of heat on the states of matter	46	63
Azaz Black	27	75
Heat transfer	46	59

Black sub-subject from 27% to 75%. The lowest increase in problem solving ability occur is in the sub-subject of heat transfer from 46% to 59%.

3.2. Qualitative Analysis

Qualitative Analysis on Problem solving skills indicators: analogies

Table 5: Cross Tabulation Problem Solving Skills on Students' Pre-test and Post-test Answers in Analogy Indicators.

		Analogy Post-test						Total
		A	B	C	D	E	F	
Analogy Pretest	A	3	3	0	0	0	0	6
	B	4	5	2	0	0	0	11
	C	1	5	3	0	0	0	9
	D	0	4	0	0	0	0	4
	E	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0
Total		8	17	5	0	0	0	30

Note:

A = Presented 4 factors of similarities or 4 factors of difference

B = Presented 3 factors of similarities or 3 factors of difference

C = Presented 2 factors of similarities or 2 factors of difference

D = Presented 1 factor of similarities or 1 factor of difference

E = Presented 1 factor of similarities or 1 factor of difference, but incorrect

F = No answer

The pre-test results that shown in Table 5, describes that 6 students mentioned 4 factors, 11 students mentioned 3 factors, 9 students mentioned 2 factors and 4 students mentioned 1 factor.

After conducting the problem-solving skills related to heat material, it was found that there were changes in students' answers during the post-test. There were 8 students mentioned 4 factors in post test who came from: 3 students mentioned 4 factors in pre-test, 4 students mentioned 3 factors in pre-test, and 1 student mentioned 2 factors in pre-test. There were 17 students mentioned 3 factors in post-test, who came from 3 students mentioned 4 factors in pre-test, 5 students mentioned 3 factors in pre-test, 5 students mentioned 2 factors in pre-test in pre-test, and 4 students mentioned 1 factor. There were 5 students mentioned 2 factors in post-test , who came from 2 students mentioned 3 factors in pre-test, and 3 students who mention 2 factors in pre-test.

Table 5 shows different results from previous studies because it presents data in the form of a crosstabulation of students' pre-test and post-test answers. In overall, these results show that students had increased problem solving skills on analogy indicators. Based on data describes in Table 5, there is changes in students' port-test answers. Students who mentioned 4 factors at the pre-test, only mentioned 2-3 factors in post-test. Researchers asked several questions to students in order to confirm the changes answers.

T : In question number 13, during the pre-test, you mentioned that the factors that affect heating are heat, mass, specific heat and temperature changes. However, in the post -test you answered that the factors affect mass are heating, specific heat, temperature changes, type of material. Does the type of material affect heating?

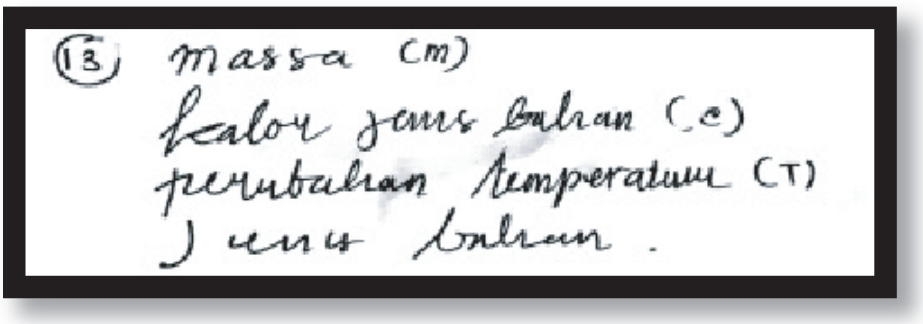

Figure 1: shows student answers related to analogy indicators in question number 13.

Figure 1. Students' answers in the analogy indicator of item number 13

S: In my opinion, the answer is Yes. Because different materials will require different amount of heat.

T: Is it really like that? Or is this type of material that have been represented by the specific heat of material?

S: I think so, ma'am.

T: Please explain the process!

S: Yes, ma'am. It affects the heating of heat, mass, specific heat of materials, and changes in temperature.

T: What about the type of material?

S: I am not sure. I'm afraid give incorrect answer.

When heating water, the energy was transferred which known as heat. The amount of heat (Q) is proportional to the mass of the object being heated (m), the specific heat of the object (c) and the temperature changes that occurs in the object (ΔT), so that it can be expressed as following formula :

$$Q = m\ c\ \Delta T$$

So that the amount of energy needed to heat the water depends on the heat Q), the mass of the heated water (m), the specific heat of water (c) and the change in temperature that occurs in the water (ΔT). Therefore, the amount of energy required to heat the water does not depend on the type of object.

Based on the the answers submitted by students, it was found that they still doubted about their answers which was an indication that students had difficulty understanding the heat material [3]. Students had not understood the concept of heat comprehensively, this is in accordance with the novice who recognizes the problem only on the surface features of the problem. Students' knowledge of heat material was still fragmentary [7].

All students shown a significant progress in problem solving skills on the Analogy indicator. This is shown in Table 6 of the post-test results, most of the students have been able to correctly mention the four factors of similarities or differences. From these results, it was found that students' problem-solving abilities on the analogy problem-solving ability indicators increased after learning with a problem-based learning model on the heat topic.

4. CONCLUSION

There was a progress in problem solving skills in High School students at PGRI Kalangbret after being taught with problem-based learning on the heat topic. The problem solving ability of students has an average N-gain score of 0.41; and effect size 1.66. The highest increase in problem-solving ability occurred in the Azaz Black sub-subject, while the lowest increase occurred in the temperature and heat sub-topics

References

[1] Ding L, Reay N, Leea A, Bao L. Exploring the role of conceptual scaffolding in solving synthesis problems. Physical Review Special Topics Physics Education Research. 2011. 10,020119

[2] Harrison A, Grayson D, Treagust D. Investigating a grade 11 student's evolving conceptions of heat and temperature. J Res Sci Teach. 1999;36(1):55-87.

[3] Hmelo-Silver CE. Problem-based learning: What and how student learn? Educ Psychol Rev. 2004;16.235-266.

[4] Kim E, Pak SJ. Students do not overcome conceptual difficulties after solving 1000 traditional problems. Am J Phys. 2002;70:7.

[5] Thomaz M, Malaquias I, Valente M, Antunes M. An attempt to overcome alternative conceptions related heat and temperature. Phys Educ. 1995;30:19-26.

[6] Yeo S, Zadnik M. Introductory thermal concept evaluation: Assessing student's understanding. Phys Teach. 2001;39:496-504.

[7] Docktor, Jennifer L, José PM, Brian HR. Impact of a short intervention on novices' categorization criteria. Phys Educ Res. 2012;8:020102. DOI:10.1103/PhysRevSTPER.8.020102