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THE STUDENTS′ PROBLEM-SOLVING SKILLS IMPROVEMENT BY USING INTEGRATION OF MEANS-ENDS ANALYSIS ON PROBLEM-BASED LEARNING MODEL

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Abstract

This research aims to describe the problem-solving skills of students after learning with problem-based learning (PBL) model integrated by a means-ends analysis (MEA) strategy on global warming material content. This type of research is quantitative descriptive, which categorized into the true-experimental design, with a non-equivalent control group design. The subjects in the investigations are students of class XI MNS in the even semester of the 2019/2020 school year of State Senior High School 2 Sidoarjo which includes two experimental classes (XI MNS 1 and XI MNS 2) and one control class (XI MNS 7), whereas the learning model used is PBL model with MEA strategy applied to the "experimental classes" and the learning that commonly involves in school used for the control class. Data collection methods used are test methods and process assessment methods. The results of the pre-test and post-test analyzed by normality test, homogeneity test, paired t-test, One-Way ANOVA, and N-gain analysis. Based on data analysis, the results show that n-gain was in the high category and the improvement in students' problem-solving skills in the experimental class is higher than the control class. It implied that the integration of PBL and MEA could implement to another physics material to improve the students' problem-solving skills.

Keywords: Problem Based Learning (PBL), Means-Ends Analysis (MEA), problem-solving skills

Abstrak

Penelitian ini bertujuan untuk mendeskripsikan keterampilan pemecahan masalah peserta didik setelah diterapkan pembelajaran dengan model *problem-based learning* (PBL) yang diintegrasikan dengan strategi *means-ends analysis* (MEA) pada materi pemanasan global. Jenis penelitian ini adalah deskriptif kuantitatif yang dikategorikan kedalam *true-experimental design*, dengan *non-equivalent control group design*. Subjek penelitian adalah peserta didik kelas XI MNS pada semester genap tahun ajaran 2019/2020 State Senior High School 2 Sidoarjo yang mencakup dua kelas eksperimen (XI MNS 1 dan XI MNS 2) dan satu kelas kontrol (XI MNS 7), sedangkan model pembelajaran yang digunakan adalah model PBL dengan strategi MEA diterapkan pada kelas eksperimen dan pembelajaran yang biasanya dilakukan di sekolah digunakan untuk kelas kontrol. Metode pengumpulan data yang digunakan adalah metode tes dan metode penilaian proses. Hasil *pre-test* dan *post-test* dianalisis dengan uji normalitas, uji homogenitas, *paired t-test*, *One-Way* ANOVA, dan analisis *N-gain*. Berdasarkan hasil analisis data diperoleh bahwa *N-gain* berada pada kategori tinggi dan peningkatan keterampilan *problem solving* peserta didik pada kelas eksperimen lebih besar daripada kelas kontrol. Dapat diimplikasikan bahwa integrasi PBL dan MEA dapat diimplementasikan dalam pembelajaran Fisika dengan materi lainnya untuk meningkatkan keterampilan pemecahan masalah peserta didik.

Kata Kunci: *Problem Based Learning* (PBL), *Means-Ends Analysis* (MEA), *problem-solving*

INTRODUCTION

A problem exists when a problem solver has a goal but does not know how to accomplish it. (Mayer, 2012). In learning physics, there are further many problems faced by students (Duncker, 1945). In physics learning, the problem that often occurs is too much memorized of questions,

although it is that true that equations play a central role in physics both in terms of how to give examples of "concepts" that used as problem-solving. According to physicists, equality is not recognized as something that must memorize but can understand the principles or thoughts and the context in which they need to apply (Simons, 2014). In physics learning, the students' problem-solving skills are still low, especially in solving physics problems. Students sometimes do it mathematically without using analysis first, containing formulas, and questions that will come out, students have difficulty in solving complex problems (Azizah, 2015). Based on the results of the pre-research in December 2019 at State Senior High School 2 Sidoarjo by distributing questionnaires to 32 students in class XI MNS 2 (MNS, re: Mathematics and Natural Science), the results obtained were some of the competencies of students' problem-solving skills were still in the low category. The percentage of indicators of problem-solving skills identify by 43.75%, set up by 25%, execute by 28%, evaluation by 34%. The results of the pre-research show that the students' problem-solving skills are low because in physics, learning the only learn formulas, problem-solving not linked to phenomena in daily life..

The results of the PISA (Program for International Students Assessment) survey officially released by the OECD (Organization for Economic Cooperation and Development) explain the lack of ability of students in Indonesia to solve problems. It evidenced by data released in 2018, which shows Indonesia's position ranked 72 out of 77 countries. In this 21st century, education required to emphasize critical thinking and problem-solving, creativity and innovation, communication, collaboration, and global awareness (Maulidyana, 2018). Of the five aspects, problem-solving is one of the priority aspects of education. Problem-solving is an attempt to find a way out of difficulty to achieve the goals previously obtained under new conditions. It is said to have problem-solving skills if someone can identify, formulate, hypothesize problems, analyze data and find solutions to problems.

Indonesia's educational goals are actually under the priorities of 21st-century education (Citroresmoi, 2017). Problem-solving skills improvement, the efforts are made to improve the quality of learning by changing the learning method so that physics lessons are more incredible, making students motivated and students more active in education. The learning model that suits the problem-solving skills is a problem-based learning (PBL) model. PBL is a learning model that presents a variety of authentic and meaningful problem situations for students, which can serve as a stepping stone for investigation and inquiry (Arends, 2012).

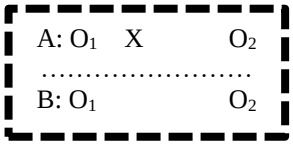
Learning by using the PBL model has the main characteristics that are preceded by a problem. Problems given are usually related to daily life and under the material to be taught. The existence of these problems can stimulate the interest of students and later will make students challenged to solve it. The more varied problems given make students more creative in finding solutions. The PBL learning model has several weaknesses, including the preparation of sophisticated learning tools, difficulty in finding relevant problems, frequent misconceptions, and requiring a long time. Minimize deficiencies, and a particular strategy is needed. One technique that can use is the Means-Ends Analysis (MEA) Strategy.

The strategy of MEA is a learning strategy of variations between problem-solving methods and syntax that presents the material on a heuristic-based problem-solving approach in the form of a series of questions that are a guide to help students in solving problems faced (Simon, 2014). MEA Strategy is a learning strategy that can involve all students actively participating in problem-solving learning activities. The learning strategy explains the problem-solving stage that will carry out during the learning.

One of the chosen physics material is Global Warming material. It is undeniable that lately, global warming often occurs, and the problem is a severe problem and the need for prevention efforts from all countries. By using global warming material, students expected to be able to develop actions to prevent global warming. Through the integration of MEA strategy on PBL model, students expected to be able to develop their thinking skills and understanding of global warming material. Based on the descriptions, the researcher intends to research to investigate the students' problem-solving skills improvement by using the integration of MEA on the PBL model.

METHOD

This study uses three classes consisting of one control class and two experimental classes, wherein the experimental classes of the students given the treatment of applying PBL model with the MEA strategy. Whereas, the control class was not treated in the form of a PBL model with the MEA strategy but instead used learning done at school. The research design used is a non-equivalent control group design with a quantitative descriptive research type which categorized into true-experimental research design. The research design represents as Figure 1.



(Sugiyono, 2010)

Figure 1. *Non-Equivalent Design*

Information:
O_1 = pre-test score (before treatment)
O_2 = post-test score (after treatment)
X = application PBL model with MEA strategy

The subjects of this study occurred students from State Senior High School 2 Sidoarjo, class XI MNS 2 and XI MNS 3 as an experimental class and XI MNS 7 as a control class with a total of 93 students. Data collection methods used consist of test methods (pre-test and post-test) and process assessment methods. This type of research includes quantitative descriptive research types that categorized into the pre-experimental design, the samples selected by purposive sampling.

Before conducting research, research instruments validated first. The items, after validation, were tested. The questions tested so that the available items used for pre-test and post-test questions that meet the criteria. The instrument used to collect data in this study consisted of a test sheet (pre-test and post-test), a process assessment sheet (student performance evaluation sheet during the worksheet filling process, poster making process, and poster presentation results. It's all obtained for further analysis in the form of increasing students' problem-solving skills towards learning. Researchers used two experimental classes and one control class. Research design shows in Table 1. Then categorize the n-gain values obtained by the criteria, as shown in Table 2.

Table 1. Research Design

Group	Class	*Pre-test*	Treatment	*Post-test*
Eksperimental 1	XI MNS 2	O_1	X	O_2
Eksperimental 2	XI MNS 3	O_1	X	O_2
Control	XI MNS 7	O_1	-	O_2

(Sugiyono, 2014)

$$(g) = \frac{\%\ G}{\%\ (G_{maks})} = \frac{\{\%(S_f) - \%(S_i)\}}{\{100\% - \%(S_i)\}}$$

(Anggawati, 2013)

Information:
(g) = Improvement of students' problem solving skills
% (Sf) = Average percentage of final test results (post-test)
% (Si) = Average percentage of initial test results (pre-test)

Table 2. Criteria for increasing Problem-Solving Skills using N-Gain

Score (g)	Category
< g > ≥ 0,7	High
0,7 ≥ < g > ≥ 0,7	Medium
<g> < 3	Low

(Sahyar, 2017)

Meanwhile, to find out whether or not there are differences in the results of the ranks of more than two groups, an ANOVA test is performed. ANOVA test is done by SPSS software if the data have a normal distribution and homogeneous.

RESULTS AND DISCUSSION

Students' problem-solving skills can determine from the pre-test and post-test scores, the problem-solving process skills in working on the worksheet, and the skills to make posters and presentations of posters. Before conducting research, the instruments are validated first, as for the instrument items, after being approved, the trial continued. The questions were tested on grade XII MNS 4 and XII MNS 6 and showed the most valid were six questions out of eight items that distributed according to indicators of problem-solving skills. The pre-test questions are given to 3 classes (2 class of experimental and 1 group of control) with the same problem to determine the students' initial abilities. After the pre-test completed, learning is done with a model of PBL with a MEA strategy for two experimental classes, then given a worksheet to be observed by students to develop problem-solving skills. The teacher gives assignments to make posters for the group and present them, and the results satisfy everyone, so students better understand ways to solve problems (Kwon & K.C, 2002). Sambada (2012) revealed that there is a positive effect between student creativity on the ability to solve physics problems. After the knowledge transfer process is complete, students gave a post-test to measure student problem-solving skills. The score of pre-test and post-test from the experimental class and control class can show in Table 3.

Table 3 shows the different values of the experimental class and control class. The results show that the value of

the experimental classes is higher than the control group (Almira, 2019). Its scores are higher because in the experimental classes given ways to answer to be more effortless and more detailed, namely means-ends analysis strategy. As we know from the method, we must test the normality and homogeneity of data distribution before doing statistical parametric analysis. The result of the normality test shown in Table 4. The result of the homogeneity test shown in Table 5.

Table 3. Analysis Descriptive Statistics of Eksperimental Class and Control Class

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Eksperimental 1	31	27	68	55.77	9.521
Post-Test Eksperimental 1	31	87	100	92.77	3.775
Pre-Test Eksperimental 2	31	25	69	54.35	10.750
Post-Test Eksperimental 2	31	86	100	95.35	3.508
Pre-Test Control	31	10	38	25.19	6.843
Post-Test Control	31	45	78	64.03	8.807
Valid N (listwise)	31				

Table 4. The Score of Pre-Test and Post-Test According to the Normality Test

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Score	Pre-Test Eksperimental 1	.126	31	.200*	.927	31	.036
	Post-Test Eksperimental 1	.130	31	.198	.931	31	.045
	Pre-Test Eksperimental 2	.119	31	.200*	.930	31	.044
	Post-Test Eksperimental 2	.102	31	.200*	.940	31	.085
	Pre-Test Control	.085	31	.200*	.983	31	.885
	Post-Test Control	.137	31	.146	.958	31	.261

Table 5. Homogeneity Test Result

		Levene Statistic	df1	df2	Sig.
PROBLEM SOLVING SKILL	Based on Mean	1.085	1	91	.300
	Based on Median	.973	1	91	.327
	Based on Median and with adjusted df	.973	1	90.404	.327
	Based on trimmed mean	.959	1	91	.330

Based on table 5, H_0 accepted if the sample distributed normally, that is if the significance value (sig) > 0.05 (Yamin & Kurniawan, 2014). Based on these data, it knows that the data for the pre-test and post-test of the experimental class and control class are distributed normally. Because the significance value for both tests is> 0.05, then H_0 is accepted. Then the homogeneity test can be shown in Table 5.

According to Yamin (2014), H_0 accepted if it has a homogeneous variance, that is if the significance value (sig) >0.05. Based on Table 6, it knows that the significance value (Sig) in the pre-test and post-test is >0.05 so that the pre-test and post-test are homogeneous. After the data is recognized to exist "normally" distributed and homogeneous, the information checked using paired t-test so that significant differences can be observed in students' problem-solving skills before and after learning with the criteria $t_{calc} > t_{table}$. The results of the paired t-test shown in Table 6.

Table 6. The result of Paired Sample Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-Test Eksperimental 1 - Post-Test Eksperimental 1	-37.000	7.607	1.366	-39.790	-34.210	-27.081	30	.000
Pair 2	Pre-Test Eksperimental 2 - Post-Test Eksperimental 2	-41.000	9.459	1.699	-44.469	-37.531	-24.134	30	.000
Pair 3	Pre-Test Control - Post-Test Control	-38.839	5.305	.953	-40.784	-36.893	-40.765	30	.000

Table 6 shows that the significance value (2-tailed) is 0,000 <0.05. H_0 is accepted if the significance value (*p*-value) <0.05, meaning that there is a significant difference between the pre-test and post-test values, as shown in Table 6 (Safitri & Achmadi, 2018). Then to measure the consistency or similarity of the average of the students' problem-solving skills improvement if the sample normally distributed and homogeneity, a One-way ANOVA test is performed, and the results shown in Table 7.

Table 7. One-Way ANOVA Result

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18743.247	2	9371.624	270.034	.000
Within Groups	3123.484	90	34.705		
Total	21866.731	92			

Based on Table 7, the result of One-way ANOVA is 0.00 or (sig) <0.05, that means H_0 rejected (Gravetter, 2007). It knows that there are significant differences in improving the problem-solving skills of students from all three classes. Then further tests or post hoc tests are required. The post hoc test can show in Table 8.

Table 8 describes the result of the post hoc test using the LSD technique. The option of the post hoc LSD test was due to the same figure of samples in each class (n= 31). The relation between the control class with the experimental class 2 and the control class with the experimental class 1 has a mean difference with a substantial quantity. It indicates a significant difference occurs between the control group with the experimental class 1. While the relation between experimental class 1 and experimental class 2 has a minor mean difference value so that it can indicate that there is no significant difference or the consistency of improvement occurred in the control class fair to not using the PBL model with the MEA strategy. Result of inconsistency, the relation between the control class with the experimental class 2 as well as between the control class and the experimental class 1 has a sign (*) which indicates a significant difference in the value of increase or inconsistency (Table 8). While the relation between the experimental class 1 and the experimental class 2 does not have significant or consistent improvement.

Table 8. The Results of Post Hoc Test

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Eksperimen 1	-31.323*	1.496	.000	-34.89	-27.76
	Eksperimen 2	-28.742*	1.496	.000	-32.31	-25.18
Eksperimen 1	Control	31.323*	1.496	.000	27.76	34.89
	Eksperimen 2	2.581	1.496	.202	-.99	6.15
Eksperimen 2	Control	28.742*	1.496	.000	25.18	32.31
	Eksperimen 1	-2.581	1.496	.202	-6.15	.99

An N-gain analysis used to calculate how far the increase if students problem-solving skills on global warming material. By using N-gain analysis, it can see how students' problem-solving skills included in the low, medium, or high category. The result of the n-gain investigation of the three classes shown in Table 9.

Table 9. N-Gain Result

Class	*N-gain <g>*	Category
Experimental 1	0.84	High
Experimental 2	0.89	High
Control	0.52	Medium

Based on Table 9, it can analyze that the n-gain value of the experimental class 1 is 0.84, the experimental class 2 is 0.89, and the control class is 0.52. The results of the experimental class 1 and experimental class 2 are not much different, but the experimental class is very different from the control class. According from Hake in Anggawati (2013) the value $< g > \geq 0.7$ included in high category, $0.7 \geq < g > \leq 0.3$ included in medium category, and $<g> < 0.3$ included in low category. From the result of Table 9, the experimental class 1 in the high category, the experimental class 2 in the high category, and the control class in the medium category. The students' problem-solving skills of experimental classes is higher than the control class, so it can conclude that the application of PBL model with a MEA strategy is better than learning that usually carried out in the school.

These results are consistent with the research conducted by Putri & Jatmiko (2018) concluded that learning to use PBL on dynamic fluid material in class XI MIA can improve problem-solving skills. The relevant part of this research centred on students who can improve students' skills in problem-solving. But in prior surveys not using the control class only using two experimental courses, so that when there is an increase in problem-solving skills, there is no comparison with the control class. While the research conducted by researchers uses two experimental groups and one control class, so they can find out the difference in skills of problem-solving, and the research conducted by researchers working the MEA strategy, while in prior surveys without using a process. Same as analysis from Almira (2019), who found that the possibility of problem-solving in the material momentum and impulse by using problem-based learning models is better than the problem-solving abilities of students using conventional learning. The relevant part of this research is that both were using the experimental class and the control class. Still, the value of the experimental class and the control class is equally low. There is the only insignificant difference that shows the experimental group that gets an

average score and the control class receives a low score. The experimental class and the control class both did not pass this material of momentum and impulse. While the research conducted by researchers in the experimental study got a high score, and in control, get the average score, there are significant differences score from the experimental class and the control class.

Caliskan (2010) concludes that learning with problem-solving has a positive impact on students, especially on students' knowledge and abilities during the problem-solving process. The relevant part of this research is the positive impact arising from learning using problem-solving, the positive impact resulting based on research conducted by researchers, namely problem-solving skills and increasing student knowledge. The students' abilities increase because of learning with problem-solving. The teacher has prepared by keep to each procedure, by giving students problems related to the daily life of global warming, then accustomed students to solve problems by being given guidance by the teacher in the work of worksheet by using the MEA strategy. Then the teacher provides poster assignments related to global warming formed in groups and assesses the ability of students from a presentation that shows how the completion of each student contain in the poster displayed. The poster presentation also observes the MEA strategy that they applied in problem-solving with how to identify the current state and goal state, organize sub-goals, and the selection of operators or discussion in problem-solving used by students. A post-test problem given to students proves how to solve the problems of students in global warming phenomena that occurs in daily life. With a post-test student can issue their opinion through writing that will be received by the teacher.

CONCLUSION

Based on research data, analysis, and discussion, it can conclude that the model of problem-based learning (PBL) with the mean ends analysis (MEA) strategy can improve students' problem-solving skills. Students' problem-solving skills are included in the high category using the PBL model with the MEA strategy. In this study, there are several suggestions given that students should understand more phenomena related to physics so that problem-solving skills honed more. This research must require more comprehensive time management so that students read more the literature that given, and the need for direct learning so that researchers and students can be actively involved in education.

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