Relevance of Problem Based Learning based on Science Education for Sustainability Development towards Problem Solving Ability

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Abstract

One of the skills that students must master is problem solving abilities, in which students will learn to solve problems in their surroundings. This study aims to determine the effectiveness of the PBL (Problem Based Learning) model integrated with the Science Education for Sustainability Development (SESD) approach to students' problem solving abilities. The use of the SESD-integrated PBL model in problem solving ability is something new that has never been done. The study used a quasi-experimental design quantitative method with a pretest-posttest design. The research sample was 24 students of grade 8th junior high school as an experimental class that applied the integrated PBL model with SESD and 24 students of grade 8th junior high school as the control class that applied the non-PBL model integrated with SESD. Data collection techniques used observation sheets, tests, and questionnaires, which were analyzed using descriptive and inferential statistics. The results of the two-tailed t-test yielded a P-Value of 0.001, where if the P-Value $< \alpha = 5\%$ (0.05), then H0 was rejected. So it shows that there is a significant difference in problem solving ability between the experimental class and the control class. The results of the one-tailed t-test that has been carried out produce a P-Value of 0.001 so that H0 is accepted. The results of the one-tailed t-test also show an estimate for a difference of 13.85. Therefore, the test decision can be stated that the problem solving abilities of students in the experimental class are better than those in the control class. The ANCOVA test shows that the value of Sig. of $0.010 < \alpha$ (0.05) shows that the PBL model integrated with SESD is considered effective for problem solving abilities. So it can be concluded that students' problem solving abilities using integrated PBL models with SESD are more effective than students' problem solving abilities using non-PBL models integrated with SESD.

Keywords: Problem Based Learning, Problem Solving, Science Education for Sustainability Development.

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INTRODUCTION

The context of science learning which investigates and examines the natural surroundings in an organized manner makes science education a vital component to balance the life of an increasingly modern society. The rapid development of science and technology makes science the foundation for developing the learning process. Science covers expertise and proficiency and includes a process in an invention (Pratiwi et al., 2019; Supiyati et al., 2019). The process emphasizes hands-on experience to develop students' process competence. So it can be understood that through science education, students can improve and develop their cognitive, affective, and psychomotor competence.

Through science education, the characteristics of students will indirectly be formed from the experiences they get in everyday life (Pratiwi et al., 2019). Therefore, through science education, students are required to master and understand various skills, including the ability to solve problems. The ability to solve problems is a skill that is synonymous with the process of solving problems, where problems will be solved by feeling through various phenomena in everyday life (Rahma & Windyariani, 2020). In line with Dwiyogo's opinion that a student must have skills and abilities in critical thinking to explore and analyze various information and knowledge (Ariyanto et al., 2020; Rahma & Windyariani, 2020). It can be understood that the skills and abilities possessed will make it easier for students to produce a solution.

The ability of students to problem solving is crucial. According to Pepkin, solving is a model as well as a strategy that focuses on the ability to solve problems with support from other skill areas, and through these skills, students will be assisted and guided to collaborate between knowledge (Roy et al., 2014). That knowledge be used later to generate various creative ideas to solve problems. When students have plunged into the community environment and are faced with a problem, they are indirectly ready and able to develop their mindset by bringing in new and creative ideas to make solutions.

There are four indicators of problem solving skills based on Polya's steps, so that students are said to be proficient in the process of solving problems, namely: a) understanding the problem; b) dividing a plan; c) carrying out the plan; and d) looking at back (Isnaeni et al., 2018). These four indicators will later be used as a basis for helping students create and develop problem-solving processes.

Research by Kelly et al. (2016) shows that problem-solving will be easily formed if students work together and collaborate. High curiosity accompanied by interdisciplinary knowledge, experience, and insight also plays a role in training problem-solving abilities. Safithri et al. (2021) stated that the combination of applying the Problem-Based Learning model and the Project Based Learning model was able to improve students' problem-solving abilities obtained from the results of the pretest and posttest that had been carried out.

Problem based learning is very effectively implemented. From previous research, it is known that problem based learning will train students' skills in collaborating and critical thinking. In addition, problem based learning, which tends to prepare students to deal with problems in everyday life, also adds to the meaning implied in learning activities. As stated by John Dewey, education will be significant if it is related to the context of everyday life (Sulastri & Pertiwi, 2020).

Based on the initial observation and preliminary data which was carried out through a test with several high order thinking skill questions that were applied to grade 8th at SMPN 2 Jetis Ponorogo. Shows that the average value of the test results that have been carried out is still in the low category. This is indicated by the student's average score of 58.42, which is still below the Minimum Completeness Criteria in Science, which is 75. These data show that the problem solving ability of grade 8 students of SMPN 2 Jetis is still relatively low. Based on the results of interviews conducted with one of the teachers supporting the science subject, the learning methods, models and strategies used at the school are still flexible and conventional. The model or method used has learning activities that are still teacher-centered. In fact, according to the 2013 curriculum reference and scientific literacy in the 21st century, it is better if the center of learning is in the students (student center). Therefore, based on these problems, innovative PBL model effectiveness is offered, integrated with the SESD approach to students' problem solving abilities.

Using the PBL model, students will gain new skills and knowledge and equip students to

be able to think critically, collaborate, communicate, and solve problems (Roy et al., 2014). In line with research conducted by Hmelo-Silver & Barrows, Polk & Knutsson, and Ramadier that the context of PBL is connecting students with an activity carried out as a means to develop critical thinking attitudes to then collaborate with various knowledge to formulate and shape problem solving. The PBL model focuses on the analysis, evaluation, and justification of information involving coordination between theory, data, and patterns of reasoning in argumentation (Kim & Pegg, 2019). It can be understood that the PBL model can train students to develop various attitudes, skills, and build interpersonal relationships and the character of students who always think positively. The SESD (Science Education for Sustainability Development) approach is related to issues that exist in society (Masruroh & Arif, 2021). So, students are expected to be able to explore the process of solving problems by connecting and evaluating data in analysis activities to justify the information obtained. Problem-solving skills must be mastered by students, where students will learn to solve problems in the surrounding environment. As a result, by integrating these models and approaches, it is hoped that in addition to developing skills, it will also train students to prepare for life in the future.

METHOD

This research is a quantitative study which aims to determine the effectiveness of the integrated PBL model with the SESD approach on students' problem solving abilities. Experimental research is a suitable quantitative method used to determine the effect of treatment on results under controlled conditions (Sugiyono, 2019). This type of research uses a quasi-experimental design with a pretest-posttest design in which the researcher will give treatment to a group. Designs can be seen in Table 1.

Table 1. Quasi Experimental Design

Group	Pretest	Treatment	Posttest
Control	O_1	X_1	O_3
Experiment	O_2	X_2	O_4

Information :

X1 : control class (using Non Problem Based Learning based on *Science Education for Sustainability Development* model)

X2 : treatment class (using Problem Based Learning based on *Science Education for Sustainability Development* model)

O1 : Pretest given to control class

O2 : Posttest given to experiment class

O3 : Pretest given to control class

O4 : Posttest given to treatment class

The population in this study were grade 8th students at SMPN 2 Jetis Ponorogo for the 2021/2022 Academic Year. The sample used two classes divided into an experimental group and a control group with a total of 48 students. Data collection techniques and instruments used observation sheets to determine the implementation of learning and student activities, problem solving ability test questions (pretest-posttest), and questionnaires to determine student responses after participating in the learning process using the integrated PBL model with SESD in the form of a Likert scale. The instrument test questions in the form of 8 description questions have been adjusted to the material of the human respiratory system. Each question is grouped based on indicators of problem solving ability. Data analysis techniques in this study were carried out using descriptive quantitative and inferential analysis through statistical tests. Table 2 contains indicators of problem solving ability accompanied by their descriptors.

The four indicators of problem solving skills based on Polya's steps used in this study are as follows: a) understanding problems whose descriptors are triggering problems and explaining problems; a) understanding a problem whose descriptor is identifying a problem and explaining the problem; b) dividing plans that have descriptors, namely simplifying problems and designing strategies; c) carrying out the plan whose descriptors are information organizing and strategy implementation; and d) review whose descriptors are using alternative solutions and reconsider (Isnaini, M. Duskri, 2016).

RESULT AND DISCUSION

The research analysis revealed that the research was carried out using the PBL model with syntax, namely, orienting students to problems, organizing students to research and understand, conducting investigations, developing investigation results, and evaluating. As for the implementation, the integration domain of the SESD approach was also raised.

Then the integrated PBL model with the SESD approach is directed towards focusing on student skills, namely problem solving abilities. The indicators of problem solving ability are understanding the problem, developing plans, implementing plans, and reviewing them (Cahyani & Setyawati, 2016).

Research on students' problem solving abilities was carried out by giving test questions at the time of the pretest and posttest in the form of essays that contained natural science subject matter, namely the human respiratory system. The test questions have also been adjusted and linked to the focus of the research, namely indicators of problem solving ability, namely understanding the problem, devising a plan, implementing the plan, and looking at back

The pretest and posttest results were then analyzed through normality tests and homogeneity tests as prerequisite tests assisted by the SPSS 25 for Windows software. As for the normality test, the pretest results for the experimental class obtained a significance of 0.035 and for the control class 0.068, while the normality test for the post-test results showed a significance of 0.189 for the experimental class and a significance of 0.173 for the control class. Based on the results of the analysis of the normality test, it can be stated that the results of the pretest-posttest of the experimental class and the control class come from the distribution of normally distributed data. The results of the pretest-posttest homogeneity test for the experimental class and the control class also showed a significance of 0.632 and 0.458 which could mean that the variance of the pretest-posttest data from the experimental class and the control class was homogeneous.

Based on the results of the prerequisite test that has been carried out through the normality test and homogeneity test, if the data distribution proves normal and homogeneous, then proceed with the inferential statistical test through the t-test hypothesis test. Hypothesis testing was carried out using a two-tailed t-test assisted by Minitab 16 software to see and know that there is an average difference between two independent population groups.

Based on the output of the results of statistical descriptions using Minitab 16, it is known that the results of the two-tailed t-test yield a P-Value of 0.001, referring to the hypothesis that has been made if the P-Value < α = 5% (0.05) then H_0 is rejected, and H_1 is accepted. Because the P-Value (0.001) < α = 5% (0.05), then H_0 is rejected. So, it can be understood that there is a significant difference in problem solving abilities between classes that use PBL models integrated with SESD (experimental class) and classes that use non-PBL models integrated with SESD (control class). Furthermore, to find out whether the interval between groups is better, it is continued with the one-tailed t-test.

Based on the output of the results of the statistical description using Minitab 16, it shows that the results of the one-tailed t-test that has been carried out produce a P-Value of 0.001. Because P-Value (0.001) < α = 5% (0.05), then H_0 is accepted. The results of the one-tailed t-test also show an estimate for a difference of 13.85. Therefore the test decision can be stated that the problem solving abilities of students in the experimental class using the integrated PBL model with SESD are better than the learning outcomes of students' problem solving abilities in the control class using a non-PBL model integrated with SESD.

Tabel 3. *Parameter Estimates* Uji Covarian

Parameter Estimates						
Dependent Variable: Posttest						
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	61.517	6.319	9.735	.000	48.660	74.374
[Model=1]	4.520	9.741	.464	.646	-15.297	24.338

[Model=2]	0ª	.	.	.	.	.
Pretest	.369	.135	2.725	.010	.094	.645
[Model=1] * Pretest	-.006	.191	-.030	.976	-.394	.382
[Model=2] * Pretest	0ª	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Then it is continued with the ANCOVA test to determine whether the PBL model integrated with SESD effectively affects problem solving abilities. The test results can be seen through the parameter estimates presented in Table 3. Table 3 shows that with the value of Sig. of 0.010 < α (0.05), it can be stated that the PBL model integrated with SESD is considered effective for problem solving abilities in the material of the human respiratory system.

Furthermore, the N-gain test was carried out on each indicator of problem solving ability to compare the results of both the pretest and post-test in the experimental class, which is presented in Figure 1.
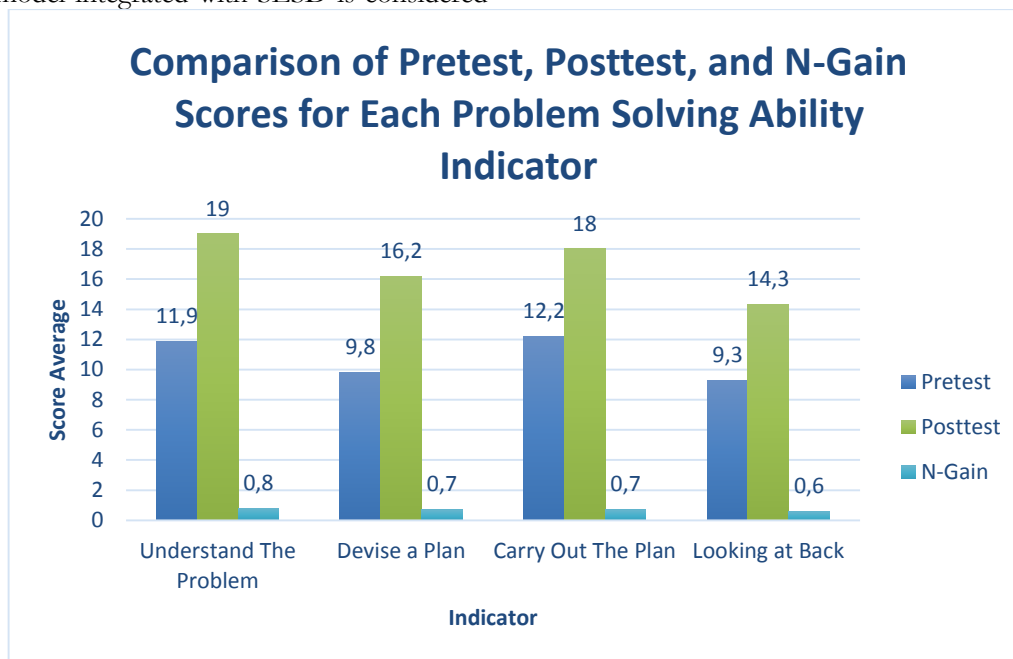

Figure 1. Comparison of Pretest, Posttest, and N-Gain Scores for Each Problem Solving Ability Indicator

Figure 1 shows that the N-Gain test has been carried out on the results of the pretest and posttest tests, which refer to each indicator of problem solving ability in the experimental class. It is known that the indicator of understanding the problem gets an N-Gain Score of 0.8, making plans of 0.7, implementing plans of 0.7, and the indicator of reviewing obtains an N-Gain Score of 0.6. The results of the comparison of the average pretest and posttest scores contained in Figure 3 show that the test results for each indicator of problem solving ability have increased. First, the indicator of understanding the problem gets an average score of 11.9 for the pretest score, then increases to 19.0 for the post-test score. Second, the previous planning indicator at the time of the pretest got an average of 9.8, then at the time of the posttest it increased to 16.2. Third, the indicator of carrying out the previous plan during the pretest got an average of 12.2, then at the time of the posttest, it increased to 18.0. Fourth, the review indicator gets an average score of 9.3 for the pretest score, then increases to 14.3 for the post-test score.

The highest average pretest value is found in the indicator of implementing plans, with an average of 12.2, while the lowest pretest value is found in the indicator of making plans, with an average of 9.3. The highest posttest score was found in the indicator of understanding the problem with an average of 19.0, while the lowest posttest score is found in the review indicator with an average of 14.3.

The results of the data analysis stated that the indicator of understanding the problem has a higher average compared to the other indicators and is included in the effective

category. This is because the indicator of understanding the problem on students' problem-solving abilities is in accordance with the PBL syntax, namely organizing students to investigate and understand problems. Implementing this syntax involves students being given problems through the articles listed in the Student Worksheet. Therefore, through Student Worksheets adapted to the PBL syntax students can understand the problems given as well as possible. The use of problem-based student worksheets can improve problem solving abilities and learning outcomes, and this is because students can identify and solve problems (Melawati & Halim, 2022; Rini, 2020). Student worksheets are also seen as increasing student activity. Student worksheets based on PBL syntax can make students active in learning because students are directed to solve problems related to the learning topics given and are taught how to solve problems (Kardena & Mawardi, 2021; Umbaryati, 2016; Yanto, 2019). In addition, the reason why the indicator understands the problem of getting the highest N-Gain score is because, at this indicator stage, students also receive guidance and direction from the teacher. This is because directing and guiding indirectly will result in an understanding related to the interests of students (Batuadji et al., 2015; Hidayati et al., 2021; Priyanto & Permatasari, 2022). It can be understood that the learning process also determines student development.

The lowest indicator is found in the review indicator. The review indicator is the lowest indicator because when applying the syntax of the PBL model students are less able to make these indicators actually materialize in an activity. In fact, if examined more deeply, the indicators of reviewing it are not just checking the results of discussions or mere analysis. But if it is connected with the evaluation syntax in the PBL model, this indicator is really very influential in the problem solving process. In line with the opinion of Hixson, Ravitz, and Whisman, reviewing is one of the direction skills in which students take responsibility for their learning process by re-identifying learning topics (Siahaan & Meilani, 2019). From the analysis of this statement, it can be understood that as a student in following the learning process, one cannot simply ignore the small things. Accuracy and foresight need to be instilled in students, and they must understand and understand the learning topics given, especially to form

solutions to solving problems (Ediansyah et al., 2019). The review indicator is basically considered quite effective, but students seem to ignore things that should be the key to a solution.

As for other indicators, such as making plans and carrying out plans based on data analysis carried out, the results of the N-Gain test were obtained above the review indicator. Obtaining the N-Gain score also shows the significance of an effective value. This is because there is also an influence from the syntax of the PBL model. As for the implementation to achieve the indicators of planning and implementing this plan, it has been adapted to student activities that are in the syntax of the PBL model, namely conducting investigations and developing the results of investigations. It can be understood that the stage of investigation and development of results is something that is at the core of the problem solving process. This is because, in the process of investigation and development, students discuss and work together. In line with the opinion of Kelly, et al. that working in groups and collaborating with others can improve the quality of learning outcomes (Kelly et al., 2016).

The integration of the SESD approach with the PBL model towards students' problem-solving abilities in this study provides a distinctive feature in which students are directed to use a variety of interdisciplinary knowledge. In accordance with research by Kelly that the multidimensional variety of knowledge, in addition to adding insight, also leads students to be able to solve a problem by looking at it from various points of view (Kelly et al., 2016). It can be understood that the integration of various knowledge is very effective in making decisions to shape problem solving. In addition, the integration of the SESD approach into the PBL model also adds its own points in realizing the achievement of indicators in problem solving ability. Its connection with contextual learning, which is the hallmark of PBL learning, makes the learning achievement process of students' problem-solving abilities more effective. In line with what was expressed by Elly, integrating the SESD approach is able to train students to provide opportunities to understand various issues or topical issues directly (Eilks, 2015). Based on this statement, it can be understood that the integrated PBL model with SESD is effectively used to support science learning (Eilks, 2015). Based on this statement, the

integrated PBL model with SESD is effectively used to support science learning.

CONCLUSION

The results of the two-tailed t-test show a significant difference in the ability to solve problems between groups that use PBL models integrated with SESD and those that use non-PBL models integrated with SESD. Therefore the one-tailed t-test decision can be stated that the problem-solving abilities of students in the group with the integrated PBL model with SESD are better than the problem-solving abilities of students in the control group using non-PBL models integrated with SESD. The ANCOVA test shows that the PBL model integrated with SESD is considered effective for problem solving abilities.

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