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Improving Students' Learning Outcomes in Public Vocational High School by Implementing Problem-Based Learning with Scientific Approach

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Abstract. This study explored the effect of combining a scientific approach with problem-based learning on enhancing students' critical thinking skills. The scientific approach sought to direct learners to understand various materials scientifically from multiple sources. The quantitative study in the experimental design used the nonrandomized control group treated with pre-test post-test design. This study had 48 students who separated into two groups. The experimental group used a problem-based learning and scientific approach (PBL-SA), whereas the control group used a traditional learning approach. According to the findings, the average post-test score for the traditional learning group was 33.33, whereas the average post-test score for the PBL-SA group was 65.42. The traditional learning group had low scores, whereas the average achievement of students in the PBL-SA group increased from 42.08 to 65.42, indicating an improvement. The PBL-SA group outperformed the traditional learning group on the Basic Mechanical Engineering Design with a statistically significant difference.

Keywords: Scientific approach, Problem-based learning

INTRODUCTION

Basic Mechanical Engineering Design subject in Vocational High Schools (VHS) mainly delivered through classical methods and lectures where the teacher is the centered of the class and source of information and, thus, often dominates the learning activities. Since the instructional activities are focused on the teacher, students only listen to their explanations and record essential points. The description, of course, is limited as a product and less of a process. One of the causes of this issue is dense learning materials that be covered as described in the curriculum. However, learning considers the product that matters and the whole process.

On top of that, despite the opportunities given by the teacher, only a small percentage of students in Basic Mechanical Engineering Design classes take the opportunity to ask questions or express opinions. Students are not encouraged to engage in the activities since there is no motivation. As mandated by the national curriculum, the scientific method, as part of the national curriculum, is a suitable alternative for motivating students to take a more active role in their education, shifting from the usual linear, static, and mechanistic learning to the innovative one (Ratnaningsih, 2017). Also, combining PBL-SA greatly improves students' critical thinking skills (Gerde et al., 2013).

Implementing the scientific approach to learning requires a changing setting and a particular form of instruction that differs from traditional learning. This approach aims to direct learners to know and scientifically understand various materials. Information can come from everywhere and at any moment, not only from the instructor (Nugraha & Suherdi, 2017). There was a developed conception that the scientific approach to learning consists of observing, asking, exploring, associating, and communicating. These components be generated in every teaching and learning practice, but they are not a learning cycle. Teachers should first change their mind-set to apply the scientific approach (Wahyono, Ishak Abdulhak, 2017). Furthermore, they need to understand better the meaning of each activity in the scientific method and the relationship between activities. Finally, they should learn from some good examples of implementing the scientific approach appropriate to the subject (Bensley & Murtagh, 2012).

The scientific method in learning entails process skills development such as observing, categorizing, measuring, predicting, explaining, and drawing conclusions. Teacher assistance is necessary for each stage implementation, and however, the aid should be gradually decreased as students' maturity level increases. Science approach in learning has four characteristics, and they are (1) student-centered learning; (2) involving science process skills in developing concepts, laws, and principles; (3) incorporating potential cognitive processes in stimulating students' intellectual development, particularly their higher-order thinking skills; and (4) attempting to develop student's character (Nugraha & Suherdi, 2017).

The scientific approach should be synchronized with the instructional model's structure (syntax). Instructional models should shape scientific and social behaviour and develop a sense of curiosity. Problem-Base Learning (PBL) is one of the most often recommended models. Gress (2013) stated that active learning methods such as PBL, which use ill-structured issues as a stimulant for learning, are becoming more popular. Ill-structured issues are complex problems that cannot be simply solved and do not always have a correct answer but rather demand learners to examine alternatives and present a reasoned argument to support the solution they develop. Senar (2014) claimed that the primary goal of PBL is not to provide students with a vast quantity of information but rather to develop critical thinking and problem-solving skills and the capacity to gain knowledge actively.

PBL involves students solving a problem through scientific methods to acquire knowledge connected to the problem and obtain problem-solving skills. According to Arends (2007) and Savery (2006), PBL has characteristics such as (1) driving questions or problems, (2) focusing on interdisciplinary linkages, (3) factual investigation, (4) production and exhibition, and (5) collaboration. The role of teachers in PBL is to raise real-life problems, ask questions, and facilitate investigation and dialogue.

Stages of PBL, according to Savery (2006), Arends (2007), Hung et al. (2008), are: (1) orienting students to the issue, (2) arranging students to do research, (3) helping personal and group investigations, (4) creating artifacts and exhibitions, and (5) assessing and evaluating the problem-solving process. The stages systematically to help students solve problems and acquire knowledge according to specific essential competencies. The scientific approach activities according to the characteristics of the national curriculum. Design PBL-SA steps are d on Table 1.

Table 1. PBL-SA steps

Steps	Teacher Activities	Student Activities
Student orientation on the problem	The teacher presents the problem in groups. The issues raised should be contextual. Students by reading or through activity sheets can find problems	The group observes and understands the problem presented by the teacher or obtained from the suggested reading material.
Learners are organized to learn	The teacher ensures that each member of the group understands their respective duties.	Students discuss and divide tasks to find data/materials/tools needed to solve problems.
The teacher guides individual and group investigations.	The teacher monitors the involvement of students in data collection during the investigation process	Students conduct an investigation (search for data/references/sources) for group discussion material.
Develop and present the work.	The teacher monitors the discussion and presentation of students.	Groups conduct discussions to produce problem-solving solutions and the results are presented/presented in the form of works.
Analyze and evaluate the problem-solving process.	The teacher guides student presentations and encourages groups to give awards and input to other groups. The teacher and students conclude the material.	The Group makes a presentation and other groups give appreciation. The activity by summarizing/making conclusions according to the input obtained from other groups.

Here, PBL was used as a reference for developing the instructional materials for Basic Mechanical Engineering Design subject in Public Vocational High School 1 Singosari. The implementation's goal was to actively inspire pupils to engage in learning activities and was expected to improve the instructional practices in vocational high schools favorably.

METHODS

Design

This study was an experimental research with a nonrandomized control group handled using a pre-test post-test design. The experimental group (PBL group) was taught problem-based learning and scientific approach (PBL-SA) materials and learning syntax. The control group (traditional learning group) received the traditional learning or teacher-centered approach.

Participant

This research was conducted at VHS 1 Singosari Malang in their Mechanical Engineering Department. Both groups consisted of 24 students. The PBL group received education using PBL-SA, whereas the traditional learning group received instruction using a traditional learning strategy (teacher-centred teaching).

Instruments and Data Collecting Technique

The instrument used to collect data on student learning achievement was a series of tests, and pre-test and post-test scores were compared to see if there was a difference in learning efficacy. The instrument were given in 25 items questions.

Reliability Test

The value of the alpha (α) stability coefficient was used to determine whether or not an instrument was dependable.

Validity Test

The test was performed to determine the validity of each instrument item and is obtained from the Parson Product Moment correlation test.

Normality

The Kolmogorov-Smirnov test was utilized to find the normal data distribution.

Data Analysis Method

Two groups were compared in terms of their pre-and post-test scores using a T-test to see whether there was a difference in learning efficacy

RESULTS

Reliability and Validity test

The results of the reliability and validity tests are as Tabel 2 follows.

Table 2. The Reliability Test

Cronbach's Alpha	N of items
0.866	25

Hence, the instrument items were reliable. The validity test results with the test-retest correlation coefficient for the scale ranged from 0.458 to 0.803.

Normality

On Table 3, concludes that the data from the population were normally distributed.

Table 3. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.171	48	.121	.903	48	.127
Posttest	.158	48	.122	.923	48	.102

Then, the following tables present the pre-test and post-test results and compare the differences in pre-test and post-test scores of two groups who took the Machine System and Energy Conversion subjects as the school. Table 4 shows the average of the PBL and traditional learning groups' pre-test scores. Table 5 summarizes the differences between the pre-test findings of PBL-SA and traditional learning groups. The average post-test score for the PBL-SA and traditional learning in Table 6. Table 7 compares the PBL-SA and traditional learning groups' post-test outcomes.

Table 4. Average Pre-test Score

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
Pre-test Score	Traditional learning	24	38.54	8.782	1.793
	PBL-SA	24	42.08	7.790	1.590

As stated in Table 4, the traditional learning group's average pre-test score was 38.54, while the PBL-SA group was 42.08. The students earned low scores because they had to take Basic Mechanical Engineering Design subject.

Table 5. Analysis Result of Differences in Pre-test Scores

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre-test Score	Equal variances assumed	1.090	.302	-1.478	46	.146	-3.542	2.396	-8.365	1.282
	Equal variances not assumed			-1.478	45.355	.146	-3.542	2.,96	-8.367	1.284

The t-test comparison of pre-test scores between the PBL-SA and traditional learning groups yielded t = -1.478 (p = 0.302) in Table 5. Table 5 shows no significant difference in pre-test scores between both groups (p> 0.05). In other words, in Basic Mechanical Engineering Design subject, the pre-test score of students taught using the PBL-SA methodology was not statistically different from those taught using the traditional learning.

The traditional learning group's average post-test score was 33.33, as indicated in Table 6, while the PBL-SA group was 65.42. The students in the traditional learning group received low grades, even though they had taken the Basic Mechanical Engineering Design subject on energy conversion. In contrast, there was an improvement in the PBL-SA, from 42.08 in the pre-test to 65.42 in the post-test.

Table 6. Average Post-test Score

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
Posttest Score	Traditional learning	24	33.33	9.168	1.871
	PBL-SA	24	65.42	12.504	2.552

Table 7. Analysis Result of Differences in Pre-test Scores

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post-test Score	Equal variances assumed	2.455	.124	-10.137	46	.000	-32.083	3.165	-38.454	-25.713
	Equal variances not assumed			-10.137	42.186	.000	-32.083	3.165	-38.470	-25.697

Table 7 reveals that the t-test analysis of post-test scores between the PBL-SA and traditional learning groups produced t = -10.137 (p=0.000). There was a statistically significant difference (p> 0.05) in post-test scores, as shown in Table 4.4. Or, to put it another way, the accomplishment of students taught using the PBL-SA method in the Basic Mechanical Engineering Design topic at the school was considerably different from the achievement of those taught using the traditional learning (teacher-centered learning).

DISCUSSIONS

Students in the traditional learning group scored an average of 33.33 on the post-test, whereas those in the PBL-SA group scored 65.42 on average. The PBL-SA group outperformed the traditional learning group in student performance. Students taught using the PBL-SA had significantly higher post-test results than those with the traditional approach. A previous study (Drake & Long, 2009) found that students in the PBL group's mean post-test scores exposed to PBL were 12.50 points higher than in the traditional learning group. The result was in good agreement with (Akınoğlu & Tandoğan, 2007), and it has been shown that PBL has a favourable impact on students' success, attitudes, and learning concepts (Abanikannda, 2016).

Applying the PBL-SA in Basic Mechanical Engineering Design subject required students to solve problems. They investigated the issues in a group, presented the investigation results, and discussed and evaluated the problem-solving process (Bédard et al., 2012). This learning model expects students to learn independently to better absorb and understand the content of learning materials in depth. It concurs well with (Hmelo-Silver, 2004), who explains that PBL is particularly advantageous to improve learning achievement in the form of problem-solving competencies. The problem-solving process makes students comprehend the course content. Another study by (Yidana, 2018) further pointed out that PBL significantly affected student achievement in Economics, indicated by high average scores of the control class.

PBL implementation also improves the mastery of concepts and active student involvement in learning. A study conducted by Yew & Goh (2016) looked at the implementation of PBL and found that there were disparities in student learning outcomes when both learning models were used. Furthermore, Abanikannda (2016) and Firman et al. (2018) concluded that PBL influenced learning achievement.

This study showed that implementing the PBL approach in the Basic Mechanical Engineering Design subject improved higher-order thinking skills because students to solve problems given by the teacher independently or in groups. The study conducted by Barrows (1992) and Tosun and Taskesenligil (2013) confirmed that this method had been proven to improve higher-order thinking skills and increase motivation and problem-solving skills. Similarly, according to Sagala and Simanjuntak (2017), using the PBL paradigm substantially impacts problem-solving skills and learning accomplishment. Ali et al. (2010) found that students who participated in the PBL program outperformed those exposed to traditional learning in a test of problem-solving abilities.

CONCLUSION

The traditional learning group's average post-test score was 33.33, whereas the PBL-SA group was 65.42. The students in the traditional learning group earned low scores even though they had taken the Basic Mechanical Engineering Design subject in energy conversion. The average performance of students in the PBL-SA group, on the other hand, increased from 42.08 to 65.42, indicating an improvement. In other words, there was a statistically significant difference in student accomplishment in the Basic Mechanical Engineering Design course between the PBL-SA and the traditional learning groups in this study.

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