



Improving student problem-solving skill and cognitive learning outcome through the implementation of problem-based learning



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ARTICLE INFO

Article history

Received January 15 2019
Revised Mey 18 2019
Accepted June 20 2019

Keyword:

Cognitive
Learning outcome
Problem-based learning
Problem-solving

ABSTRACT

Problem-solving is one of the competencies in the learning innovation that students must possess to prepare life challenges in the 21st century. This study aimed to improve student problem-solving skill and cognitive learning outcome through the implementation of problem-based learning (PBL) model in learning biology at the senior high school. This research is a quasi-experimental research with pretest and posttest design. Two classes were chosen randomly from five classes of 10th-grade students for conducting research by implementing PBL and direct instruction learning models as an experiment and control (conventional) class, respectively. The problem-solving skill was measured by the essay test as well as the cognitive learning outcome at the end of the research and was analyzed by t-test. The result showed that students in the PBL class have a higher improvement in problem-solving skill. The student skill to problem-solving in the PBL class was also significantly higher than the conventional class. In addition, students in the PBL class have a higher cognitive learning outcome than the conventional class. This finding indicates that the PBL model can be implemented in the learning practices, especially in biology, to develop the problem-solving skill of students.



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Introduction

In the modern era, education is a necessity that must be fulfilled in the process of life because the advance of a country is a reflection of their educational quality. The high quality of education will produce qualified and reliable human resources in solving and anticipating problems encountered. Problem-solving is

one of the learning skills in the 21st century that students should have besides critical thinking, creative thinking, collaborative and communicative skills (Bialik, Fadel, Trilling, Nilsson, & Groff, 2015; Trilling & Fadel, 2009). Formal education includes teaching and learning processes that involve teachers and students to have the largest portion of developing human resources. Education, in

essence, is an absolute requirement for the development of human resources towards a better future. A qualified human resource, who can build himself, society and his people, can be developed through a process of quality education (Sunhaji, 2014). Therefore, the quality of education must always, according to the dynamics of the current world development.

Learning is a process that carried out by someone to obtain a change in the form of new behavior that gained from his/her own experience as interaction with the environment (Slameto, 2013). A high-quality education will be able to guide students optimally for learning and gaining high achievements. Students are the subject and object in learning activities. Therefore, students are the core of learning activities to achieve certain goals. The activeness of students is not only demanded physically but also psychologically. If only students are physically active, but their minds and mental are less active, then the learning objectives are not likely to be achieved (Suprijono, 2013).

The precise learning strategy that teachers used in the classroom affect the learning quality, including in biology (Kusumaningtias, Zubaidah, & Indriwati, 2013). Using the right learning strategy can increase efficiency and effectiveness in the teaching and learning process. The reality in the field was found that many ways to teach biology that teacher use less varies of learning strategy. Most teachers still used conventional teacher-center learning, such as the lecture and question and answer methods. In addition, the teacher has not fully utilized the potency that students have. Thus, it leads students to tend to be passive and less stimulated to think creatively and to solve problems fluently.

Students need to develop their problem-solving skills to face overcome the problems encountered. The teacher is expected to provide sufficient opportunities for students to learn through problem-solving. Through well-designed learning, it is hoped that these abilities can be quickly and more easily mastered by students, so they can solve problems that are well-given and master concepts. In reality, students have difficulty to connect and apply the theoretical knowledge that has been obtained to real problems.

Learning model plays important role in the learning process. It does not only affect

a positive influence on learning outcomes, but also create a fun, meaningful learning atmosphere, and can improve students' understanding and learning outcomes. The problem is in Senior High School 1 North Bengkulu currently that conventional learning models still dominate the learning processes such as lecture, regular discussions methods, and direct instruction. These student-centered learning make students passively in receiving information from the teacher, lack mastery of concepts, and tend only memorize the material given by the teacher. It causes students to be less able to solve problems and the low of students' cognitive learning outcome. This condition was reflected by the average of midterm test results of the last biology subjects (62.65) below the minimum completeness criteria (70) of schools for biology subject.

The application of suitable student-centered learning models is needed to be relevant and support the achievement of teaching goals so that students can think actively and be allowed to try their abilities in various activities (Hasan, Lukitasari, Darmayani, & Santoso, 2019; Siswanto, Maridi, & Marjono, 2012). One of the learning models that can make students learn actively is PBL. This model has been applied elsewhere that enable to improve student critical thinking (Rusdi Hasan & Syatriandi, 2018), problem-solving in mathematics (Kudsiyah, Dantes, & Sariyasa, 2013; Minarni, 2012) and science process skill (Handika & Wangid, 2013). According to Widodo & Widayanti (2013), the PBL model is focused on selected problems so that students not only learn concepts related to the problem but also the scientific method in solving the problem. Therefore, to improve the skill of problem-solving and cognitive learning outcome of students in Senior High School 1 North Bengkulu, PBL model was implemented in biology learning. The learning topic in this research was Environmental Pollution, the exciting topic that student face either contextually at their environment or globally on our planet.

Method

This research was the non-equivalent group design of quasi-experiment research (Sugiyono, 2007), conducted at Senior High School 1 North North Bengkulu in 2017/2018 academic year. The population

was 10th-grade students consisting of five classes with a total of 132 students. The sample was two classes that randomly chosen for experiment and control classes. PBL was conducted in the experiment class, while conventional (direct instruction) learning was conducted in the control class, respectively. The learning topic in this study was Environmental Pollution.

The student skill in problem solving and cognitive outcome was measured by using an essay test and analyzed

statistically with a t-test. Problem-solving test consisted six components: identifying problems, formulating problems, finding alternative solutions, choosing the best solution, solving and working out the problem, and quality of problem-solving (Paidj, 2008) as shown at Table 1. Cognitive learning outcome essay test consisted of C1-C4 levels question of Bloom' cognitive taxonomy. The essay test was given before and after the learning process conducted as pretest and posttest, respectively.

Table 1. Components and indicators of problem-solving assessment

No	Components	Indicators problem-solving skill
1	Identify problems	Students can determine the problem and show the phenomena that exist in the problem
2	Formulate problems	Students can formulate problems in the form of questions
3	Find alternative solutions	Students can write alternative solutions or how to solve problems that will be solved
4	Choose the best alternative solutions	Students can choose or determine alternative solutions, which can solve problems
5	Solve and complete problems	Students can solve problems that are by the problem
6	Quality of problem-solving	Students succeed in solving problems correctly, rationally, and can be scientifically justified

Results and Discussion

Student' problem solving skill

Both the experiment and control classes have the same number of students. The scores of pretest and posttest of problem-solving skill between the two classes are shown in Table 2. By the mean scores of 37 and 35 between experiment and control classes, the data of pretest of problem-solving normally distribute (sig

0.482>0.05) and homogenous variance (sig 0.839>0.05) as shown at Table 3 and Table 4, respectively. Statistical analysis using t-test shows that students' problem-solving abilities obtain sig (2 tailed) or p-value of 0.418 more than alpha 0.05, t-value of 0.816 less than t-table 2.008 (Table 5). Thus, there is no difference in the initial skill of students' problem-solving skill for both classes.

Table 2. Students problem-solving skill in the experiment and control classes based on the pretest and posttest scores.

	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Number of students	26	26	26	26
Total scores	967.36	919.44	2022.24	1865.94
Highest score	54.17	52.08	87.50	82.64
Lowest score	26.39	25.69	67.36	61.11
Mean	37.21	35.36	77.78	71.77
Improvement	-	-	40.57	36.41

Table 3. Normality test of student's problem-solving skill in the control and experiment classes.

One-Sample Kolmogorov-Smirnov Test 2			
		Unstandardized Residual	
		Pretest	Posttest
N		26	26
Exponential parameter. ^{a,b}	Mean	5.7013166	3,9595106
Most Extreme Differences	Absolute	.233	.225
	Positive	.128	.104
	Negative	-.233	-.225
Kolmogorov-Smirnov Z		.839	.901
Asymp. Sig. (2-tailed)		.482	.391

Table 4. Homogeneity test of student's problem-solving skill in the control and experiment classes.

	Test of Homogeneity of Variances			
	Levene Statistic	df1	df2	Sig.
Pretest	.042	1	50	.839
Posttest	.246	1	50	.622

The average posttest score of problem-solving skill, both experimental and control classes raise to 77.78 and 71.77, respectively (Table 2). The data have a normal distribution ($0.391 > 0.05$) and homogenous variance ($0.622 > 0.05$), as shown in Table 3 and 4, respectively. Statistical analysis using t-test obtained p-value 0,001 less than alpha 0.05 and t-value 3.427 more than t-table 2.008. Thus, there is a significant difference in problem-solving skill between experiment and control classes.

The results of the study showed that there is a significant influence of the PBL model on increasing students' problem-solving skill in environmental pollution topic in Senior High School 1 North Bengkulu. The increase in problem-solving skill using the PBL model was significantly higher than the conventional class. This finding supports the results of previous research conducted by Amalia, Syarifuddin, & Nilawasti (2014), Siswanto et al. (2012), and Khoiriyah & Husamah (2018) on Junior High School students in Padang, Surakarta, and Malang respectively. This improvement was an effect of the PBL characteristic in which students have been introduced the

problems about the material they learned since the beginning of learning processes. Thus, students from the beginning of learning process were motivated to solve the problem by using their knowledge, seeking new knowledge, developing and constructing that knowledge together with their group under the guidance of the teacher. In this study, we found that students seemed very interested and challenged to solve the environmental pollution problems presented in a contextual manner found in their daily life. Hung (2016) stated that the essential element of PBL is a problem so that the PBL must start with a problem. Whereas Widayati, Prayitno, & Ariyanto (2015) insisted that PBL oriented toward real-life problems that require students to be able to solve existing problems by using their thinking skills and construct the concepts continuously by reasoning through the whole syntax of PBL. Therefore, Amalia et al. (2014) urged that the PBL process is more meaningful because the learning started from real problems, so students are interested in knowing more about solving the problem given.

Table 5. T-test of student's problem-solving skill in the control and experiment classes.

		Independent Samples Test									
		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		
Problem-solving skill	Pretest	Equal variances assumed	.042	.839	.816	50	.418	1.84308	2.25852	-2.69329	6.37945
		Equal variances not assumed			.816	49.997	.418	1.84308	2.25852	-2.69330	6.37946
Problem-solving skill	Posttest	Equal variances assumed	.246	.622	3.427	50	.001	6.01154	1.75418	2.48816	9.53492
		Equal variances not assumed			3.427	49.549	.001	6.01154	1.75418	2.48736	9.53571

PBL can improve students' problem-solving skills because in the learning process students are required to solve the problems presented by collecting as much information as possible, then analyze to find the correct solution of existing problems. The solution to these problems does not have to possess only a single

correct answer, meaning students are also required to learn creatively and independently, especially in exploring solutions in solving problems. Students are expected to be knowledgeable and able to see the relationship of learning with aspects that exist in their environment so that students not only learn the concept

but also see facts in real terms. These conditions supported PBL to have a significant effect on the problem-solving abilities of the student in learning environmental pollution and more effective than the conventional model effect.

The PBL aims to help and direct students to develop their knowledge flexibly in learning experiences through problems solving encountered in their real life (Hmelo-Silver, 2004, 2013). In the PBL class, students were encouraged to investigate problems to find explanations of existing problems, explore and deepen the way they think by using alternative thinking and analyzing data. The student explores multiple learning resources media that available in the class, such as a book, internet through a smartphone to find new knowledge and connect to the problems they encounter. A previous report (Fitriani, Milama, & Irwandi, 2017; Saputri & Febriani, 2017) explained the increasing problem-solving skill was caused by the benefits of the PBL model, where students become more aware and increase their understanding because their knowledge obtained was more close to everyday life. We found that as the lesson conducted, the increasing student focuses on relevant knowledge, encouraging students to think, to find the new knowledge and to find the basis of their arguments based on the data that supports the reasoning. We found that as the lesson conducted, the increasing student focus on the relevant knowledge, encouraging students to think and to find the new knowledge and the basis of their arguments according to the data that supports the reasoning. PBL leads students to develop their thinking skill to improve their problem-solving skill. The Improvement of student' skill to solve problems was better in PBL class also caused by the design of problems contextually assisted by the images that contain the problems presented about real life environmental issue. In the image display, information is included, which makes the problem complex enough to motivate the students to find a solution. The design of the presentation of problems as described above was enough to get students provided various temporary answers. Based on the temporary answers held, each group collected diverse data or information. The different ways of collecting data in each group produced a variety of alternative problem-solving as

well. An alternative solution in solving problems enriches the knowledge of students.

The PBL leads the student's skill to solve problems with high-level thinking. In solving problems, students are expected to have an understanding of what is learned. Learning experiences through direct involvement of students will make them more active in learning. PBL encourages students to learn actively in the learning process to solve the problems. Therefore, in this study, PBL improved students' problem-solving skill in environmental pollution material as compared to the learning with the conventional model. The steps in PBL directed and encouraged students to develop their thinking scientifically to solve problems so as to foster creative and critical thinking in dealing with problems in real life (Avalos, Martín, Pérez-Urria, & Pintos, 2010; Barrett, 2017; Hoi, Bao, Nghe, & Nga, 2018; Khoiriyah & Husamah, 2018; Moutinho, Torres, Fernandes, & Vasconcelos, 2015; Pepper, 2009).

Student' Cognitive Learning Outcome

Table 6 shows the cognitive knowledge score of students at pretest and posttest in both the experiment and control classes. The average score of cognitive knowledge of students prior experiment was started to show comparable result between experiment and control class. The data have a normal distribution ($0.442 > 0.05$) and homogenous variance ($0.346 > 0.05$), as shown in Table 7 and 8, respectively. Statistical analysis using a t-test, as shown in Table 9, was obtained that there was no difference in cognitive score between experiment and control classes obtained before the experiment was started (sig $0.445 > 0.05$).

Cognitive learning outcome scores increased at posttest in either experiment or control classes by 40.39 and 32.39, respectively (Table 6). The average score of experiment class was more than ten points higher in the experiment class compared to control. The data have a normal distribution (sig $0.51 > 0.05$) and homogenous variance ($0.436 > 0.05$), as shown in Table 7 and 8, respectively. Based on the t-test, p-value 0.004 less than alpha 0.05 and t-value 3.035 more than t-table 2.008 (Table 9), thus the cognitive learning score significantly different between the experiment and the control class. PBL

implementation significantly improves experiment class compared to conventional cognitive learning outcome at the learning in biology.

Table 6. The cognitive learning outcome of students in the experiment and control classes based on the pretest and posttest scores.

	Pretest		Posttests	
	Experiment	Control	Experiment	Control
Number of students	26	26	26	26
Total scores	1050	980	2100	1820
Highest score	60	62	100	91
Lowest score	21	20	62	50
Mean	40.38	37.69	80.77	70
Improvement	-	-	40.39	32.39

Table 7. Normality test of student learning outcome in the control and experiment classes.

One-Sample Kolmogorov-Smirnov Test 2			
		Unstandardized Residual	
		Pretest	Posttest
N		26	26
Exponential parameter. ^{a,b}	Mean	10.0402299	10.4453441
Most Extreme Differences	Absolute	.250	.238
	Positive	.153	.106
	Negative	-.250	-.228
Kolmogorov-Smirnov Z		.866	.821
Asymp. Sig. (2-tailed)		.441	.510

Table 8. Homogeneity test of student learning outcome in the control and experiment classes.

Test of Homogeneity of Variances				
	Levene Statistic	df1	df2	Sig.
Pretest	.042	1	50	.346
Posttest	.618	1	50	.436

The improvement of learning outcome in the experimental class occurred because the PBL model can generate students' thinking skills based on existing problems so that the learning process seem more active and collaboration among students appeared in the group. In addition, the material that was used suited the PBL due to it was encountered in their daily life. Thus, the implementation of learning with the PBL model had a positive impact on the achievement of student learning outcomes. Students did not just accept material but can make an understanding of their own material. Previous research found that the improvement of the student learning outcomes in the PBL class was in relation to student activeness (Widodo & Widayanti, 2013) as a positive impact of getting used to in solving of a complex problem (Fitri & Ramdiah, 2017). PBL has advantages over conventional learning since, during the learning process, PBL directed students to learn deeply rather than surface learning (Pepper, 2009) so that the student remember more easily the lessons. In contrast, conventional learning was dominated by the teachers so the students

only as passive listeners, which caused students difficult to remember the lessons.

PBL can improve student learning outcome through the steps in PBL that stimulate students to learn to solve problems. These steps include expressing ideas, cooperating in groups, seeking information, asking questions or opinions, answering questions, and communicating the results of discussions. Based on the observations during the learning process students in the experimental class are more active than the control class seen in the process of discussion in small groups to solve problems and students are more active in giving back responses to answers given by friends and in answering questions that have been given by the teacher. Collaboration among students in the groups was very visible from the way they work out the tasks in the form of problems they must resolve. Whereas in the student control class it was not as active as the PBL class due to the teacher-centered learning was not encourage students to learn actively in the learning process.

Table 9. T-test of student learning outcome in the control and experiment classes.

		Independent Samples Test									
		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		
Student learning outcome	Pretest	Equal variances assumed	.905	.346	.769	50	.445	2.69231	3.49894	-4.33553	9.72014
		Equal variances not assumed			.769	49.275	.445	2.69231	3.49894	-4.33809	9.72271
	Posttest	Equal variances assumed	.618	.436	3.035	50	.004	10.769	3.548	3.642	17.897
		Equal variances not assumed			3.035	49.746	.004	10.769	3.548	3.641	17.897

Conclusion

The PBL model improved problem-solving skill of students than the conventional model due to the students in PBL class were encouraged to solve problems by using the knowledge they already have, explore to find new knowledge, and elaborating the knowledge to find explanations of existing problems. Cognitive learning outcomes of students in the experimental class are superior to the conventional class because students acquire essential knowledge and concepts from the subject matter, and students are also more skilled at developing ideas. The activity of students influenced the learning outcomes because it makes them more aware of the material being studied. Students who were active in the learning process both at the time of observation, discussion and giving ideas for problem-solving and during the presentation, the level of understanding will be better knowledge and learning outcome gained. This result shows that PBL successfully to improve the student' problem-solving skill and cognitive learning outcome in the environmental pollution topic. Further implementation of PBL on other suitable topic needs to be approved.

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