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The Effects of Integrated Problem-Based Learning, Predict, Observe, Explain on Problem-Solving Skills and Self-Efficacy

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ABSTRACT

Purpose: This study aimed to investigate the potential effects of problem-based learning (PBL), predict observe explain (POE), and PBLPOE on students' problem-solving skills and self-efficacy in Biology. This research is based on various facts that problem-solving skills and self-efficacy of Indonesian students in biology subjects are still low.

Research Methods: This quasi-experiment employed a pretest-posttest non-equivalent control group design. One hundred and thirty-two (132) tenth graders (aged 15 to 17) from Bengkulu, Indonesia, participated in this study. The participants were homogenous concerning academic abilities. Data were collected using an essay test and observation sheets. The essay test was developed to examine the students' problem-solving skills, and observation sheets were used to evaluate the students' self-efficacy. The data were analyzed using ANCOVA and Least Significant Different (LSD) test.

Findings of the study suggest that PBLPOE has a more significant effect on students' problem-solving skills and self-efficacy compared to PBL, POE, and conventional learning. The highest scores of problem-solving skills and self-efficacy were obtained by students from the PBLPOE class, followed by the PBL, POE, and conventional groups.

Implications for Research and Practice: Based on the results of this study, it is evident that PBLPOE is effective in fostering students' problem-solving skills and self-efficacy; thus, the use of PBLPOE in Biology classrooms is highly recommended.

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Introduction

Problem-solving is a cognitive process through which knowledge, skills, and personal experiences are mobilized to identify problems, find solutions, and resolve conflicts effectively (Hoi, Bao, Nghe & Nga, 2018; Wang, & Chiew, 2010). Udeani and Adeyemo (2011) stated that exploring a curiosity about how to resolve a problem is a cognitive aspect that plays an important role in a problem-solving process. Problem-solving skills are important in the workplace to help employees deal with challenges and innovation. These challenges require them to become a professional content master and a skillful problem solver (Özreçberoglu & Çaganaga, 2018).

A preliminary study conducted to a group of senior high school students from Bengkulu in July 2017 showed students' poor skills in identifying problems and carrying out a plan to solve the problems. However, based on the results of the study, the students' ability to evaluate results and devise a plan was considered sufficient. Other relevant studies by Burns, O'Donnell, and Artman (2010) and Ancel (2016) also indicate students' inadequate skills in identifying problems and evaluating solutions as the result of teacher's lack of assistance in the classroom. Another possible cause of these students' poor problem-solving skills is the inappropriate learning strategies used in the learning process (Aurah, Cassady & McConnell, 2014).

To resolve a conflict, one needs both cognitive intelligence and self-efficacy. The correlation between problem-solving and self-efficacy has been evident (Ancel, Erkal & Gencturk, 2015; Ancel, 2016; Bars & Oral, 2017). Self-efficacy is part of the social cognitive theory, which suggests that to succeed in doing tasks and achieve goals, someone needs to believe in him/herself (Bandura, 2006). Self-efficacy allows someone to take control of specific situations and provide positive outcomes (Geitz, Brinke, & Krischner, 2015). One of the benefits of self-efficacy for self-directed learning is that it influences the extent to which students can get involved in or stick to several challenging tasks. Students with higher self-efficacy are likely to succeed in difficult situations compared to students who have a lack of self-efficacy (Kurtuldu & Bulut, 2017).

In 2017, an observation was carried out in a biology classroom to explain four aspects of self-efficacy possessed by senior high school students from Bengkulu, Indonesia. The students were categorized into a low category on "magnitude" and "generality" aspects and medium category on the "strength" aspect. The students reported low achievement in "magnitude" because of their reluctance to accomplish more difficult tasks. As a result of being used to be dependent much on the teachers in learning, the students obtained low scores in "generality." Overall, it can be concluded that students' self-efficacy needs to be enhanced (Fitriani, Zubaidah, Susilo, & Al Muhdhar, 2018). These self-efficacy issues are not only found in senior high schools but also junior high schools (Suryadi & Santoso, 2017) and even universities (Ancel, 2016).

Problem-solving skills and self-efficacy can be enhanced through an effective and meaningful learning model (Qarareh, 2016). PBL problem-based learning (henceforth referred to as PBL) focuses on developing students' belief in being able to solve problems. An effective learning model can encourage students to construct their knowledge based on situations around them. The examples of effective and meaningful learning models are Problem Based Learning (PBL) and POE (Predict, Observe, and Explain), henceforth referred to as PBLPOE.

Several studies have reported the benefits of PBL application in science classrooms. For example, Sahbaz and Hamurcu (2012) found out that PBL was more effective than traditional learning. PBL can accommodate students’ engagement in knowledge construction and knowledge application in a real-world context (Arends, 2012). PBL can improve students’ problem-solving skills (Balim, Çeliker, Türkoğuz, Evrekli, & Ekici, 2015; Kadir, Abdullah, Anthony, Salleh, & Kamarulzaman, 2016). Özgen and Pesen (2010) used open-ended questions during the completion and evaluation stages of PBL to examine students’ ability to solve problems and found an improvement in the students’ scores. This finding proves that PBL can enhance students’ ability to solve problems. Particularly, PBL can encourage students to play an active role in identifying problems based on the existing phenomena and finding solutions to the problems (Yaman & Yalcin, 2005). When students can deal with life difficulties, their self-efficacy will improve accordingly (Geitz et al., 2015; Gurlen, 2011). However, some studies show that students are frequently faced with difficulties in organizing problems and in believing in their ability to solve the problems (Nijhuis, Segers & Gijselaers, 2005). For example, students lack confidence in analyzing problems in depth. Furthermore, the problems presented are too structured and cannot sufficiently stimulate students' self-efficacy. Students with lower self-efficacy tend to be reluctant to take on the challenges presented in the PBL process (Hsieh, Cho, Liu & Schallert, 2008).

Another constructivist learning model that is expected to be able to improve students’ performance is POE (James, 2010). POE activities help students think scientifically, participate in the process of solving scientific problems, discuss, explore information, and improve student learning performance (Hong, Hwang, Liu, Ho, & Chen, 2014). In POE, students are allowed to predict a phenomenon, conduct an observation, and relate the results of the observation with the prediction (Bilen, Özel, & Köse, 2016). Students reflect on their experiences by understanding a phenomenon before making predictions and discussing these predictions with their classmates, followed by observations to make a scientific explanation. These activities will provide students with a deeper understanding of the solutions found (Bowen & Haysom, 2014). Akamca and Hamurcu (2009) discovered that some components in science education, such as analogies and POE model, could be learning outcomes. Other studies also show that POE can improve problem-solving skills (Kearney, 2004) and self-efficacy (Vadapally, 2014).

The syntax of the POE learning model can complement the syntax of PBL. PBL is a learning model that helps students construct their knowledge based on the context by formulating problems without predicting and comparing the observation and the predictions. Making predictions is beneficial in helping students provide arguments on why things must happen (Karamustafaoglu & Naaman, 2015) and comparing observation results with the predictions requires high self-confidence in making accurate judgment on the problem-solving process (James, 2010; Kala, Yaman, & Ayas, 2013), and in trusting the theoretical truth (Bilen et al., 2016). On the other hand, PBL can add formulation of problems into POE.

As mentioned before, students' problem-solving skills and self-efficacy are still insufficient. Therefore, the combination of PBL and POE is expected to provide a significant contribution to the development of students' problem-solving skills and self-efficacy. The main activities of PBLPOE include (1) problem orientation, (2) students' organization, (3) prediction, (4) investigation/observation, (5) explanation, (6) analysis and evaluation. This study aimed to investigate the effectiveness of PBL, POE, and PBLPOE in promoting students' problem-solving skills and self-efficacy. The research hypotheses for this study were formulated as follows:

Hypothesis 1: PBLPOE affects students' problem-solving skills.

Hypothesis 2: PBLPOE affects students' self-efficacy.

Method

Research Design

This quasi-experimental study employed a pretest-post-test non-equivalent control group design (Cohen, Manion, & Morrison, 2011, p. 214), which can be seen in Table 1.

Table 1

Research Design

Pretest	Treatment Group	Posttest
O_1	PBLPOE (Problem Based Learning-Predict, Observe, Explain)	O_2
O_3	PBL (Problem Based Learning)	O_4
O_5	POE (Predict, Observe, Explain)	O_6
O_7	Conventional	O_8

Research Sample

The study population contained all the tenth graders in the city of Bengkulu. Samples of this study were selected through the process of determining schools and classes. The school selection process was carried out based on National Examination scores. Ten high schools in the city of Bengkulu, Indonesia, were categorized into schools with high, medium, and low national exam scores. One school from each category was chosen for further determination of the samples. Then, the determination of the samples was conducted by administering a placement test to examine the homogeneity of the classes. The placement test was conducted in 11 classrooms (385 students consisting of 181 male students and 204 female students). Schools participating in the test were SMAN 4, SMAN 5, SMAN 6. The results showed that all the participants were homogeneous concerning academic ability. The names of the classes were written on paper and drawn to select four random classes to receive different treatments. The students were divided into four groups: PBL (36 students), POE (30 students), PBLPOE (34 students), and conventional (32 students). The total number of the research participants was 132 students aged between 15 and 17 years old.

Research Instruments and Procedures

The instruments used to collect the data of this study were syllabus, lesson plans, student worksheets, an essay test, and teacher observation sheets. The observation sheets measured three aspects of the students' self-efficacy, i.e., magnitude, strength, and generality (Bandura, 2006) (Appendix 1), while the essay test was conducted to examine the participants' problem-solving skills. The indicators of the test assessed the students' ability to identify problems, devise a plan, carry out the plan, and evaluate the results (modified from Mourtos, Okamoto, & Rhee, 2004; Greenstein, 2012) (Appendix 2).

The syllabus, lesson plans, student worksheets, essay tests, and teacher observation sheets were validated before they were used. The validation process was conducted by a team of experts that consisted of two university lecturers with a doctorate and one high school teacher. These validity tests were performed to examine the content validity and construct validity of the instruments. Content validity is the accuracy level of the instrument content according to the curriculum, while construct validity is related to the science concept to be tested. Construct validity refers to the suitability of the measuring instrument with the ability to be measured. Identity, core competencies, basic competencies, materials, learning activities, assessment techniques, time allocation, learning resources, consistency, and language use were components to be examined in the syllabus and lesson plans. Format, content, language use, and appearance were components to be tested in the student worksheets, and substance evaluation, construction, and language use are components to be validated in the essay tests and teacher observation sheets.

The validation syllabus, lesson plans, student worksheets, essay test, and teacher observation sheets results were analyzed descriptively to check whether the instruments used in this study complied with one of the following criteria: $1.00 \leq X \leq 1.60$= not valid; $1.60 < X \leq 2.20$= less valid; $2.20 < X \leq 2.80$ = moderately valid; $2.80 < X \leq 3.40$= valid; and $3.40 < X \leq 4.00$= highly valid. The validity scores of the syllabus, lesson plans, student worksheets, essay tests, and teacher observation sheets, and problem-solving skills tests were 95.02, 98.20, 93.12, 94.55, and 93.45, respectively. The validity scores suggest that all instruments are valid and can be used to collect the data. Before conducting the treatments, the instrument used to test students' problem-solving skills was tried out to 35 students from the eleventh grade. The test consisted of 10 items, and the results of the tryout were analyzed using Pearson Correlation Test and Cronbach's Alpha. The results of the analysis showed that out of 10 tryout items.

Nine questions were considered valid, with a significance value of 0.000 <0.05 and reliable with a coefficient of 0.949.

The experiment was carried out for one semester (February-June 2018) in the academic year of 2017/2018. Materials taught during that semester were Plants, Animals, Ecosystem, and Environmental Pollution. The main activities of each treatment group (PBL, POE, PBLPOE, and conventional) are described as follows. Learning in the PBL classroom was performed in five stages: (1) the students were asked to formulate several questions based on a phenomenon provided on the worksheet, (2) they were divided into groups and the teacher-directed them to formulate the problem based on the learning objectives, (3) they conducted an investigation in groups. The teacher assisted them in collecting relevant information, (4) they presented the results of the investigation, (5) together, they did self-reflection and provided feedback on the work.

Unlike the PBL group, learning in the POE classroom was conducted through three steps. *First*, the teacher delivered the background of the problem and let the students make predictions based on questions that had been determined by the teacher. *Second,* the students did an observation with the teacher's assistance to justify their predictions. *Third,* the students presented the results of the observation and compared them with their initial predictions.

As it resulted from the combination of PBL and POE, the PBLPOE learning consisted of the following six phases: (1) the students actively formulated as many questions as possible based on texts found in the worksheet, (2) the teacher guided the students to sit in groups and to formulate problems relevant to the learning objectives, (3) the students made predictions in groups, (4) they did an investigation and sought for various information to help them determine the solution to the problem, (5) they presented the results and compared their predictions with the results, (6) together, the teacher and the students analyzed and evaluated the resolved problem.

Learning in the conventional classroom was not specifically categorized into stages. The process was begun with the teacher's delivering materials, followed by a question and answer session, and closed by a classroom discussion. At the end of the meeting, the teacher assigned the students to read the materials required for the next meeting.

Data Analysis

Before proceeding with data analysis, normality and homogeneity tests were conducted. The normality test showed that the research data were distributed normally with an average score of 0.056 (problem-solving skills) and 0.086 (self-efficacy). The data were also considered homogeneous as problem-solving skills scored 0.053, and self-efficacy obtained 0.268 on the homogeneity test. The ANCOVA and Least Significant Differences (LSD) test analyses were performed to determine the effectiveness of PBL, POE, and PBLPOE in improving students' problem-solving skills and self-efficacy. ANCOVA is the most highly recommended statistics analysis for an experiment with a pretest-posttest control group design, while the LSD test can be used to determine the classroom with the most significant difference after receiving a particular treatment (learning model in this case) (Creswell, 2012).

Results

1. The Effectiveness of Learning Models in Improving Students' Problem-Solving Skills

The effects of learning models on the students' problem-solving skills are presented in Table 2.

Table 2

The Results of the ANCOVA Analysis on the Effects of Learning Models on Students' Problem-Solving Skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	23487.039[a]	4	5871.76	66.40	.000
Intercept	36248.709	1	36248.70	409.92	.000
Problem-solving	.080	1	.080	.001	.976
Class	22927.194	3	7642.39	86.42	.000
Error	8223.748	93	88.42		
Total	512060.600	98			
Total average	31710.788	97			

Table 2 showed that the p-value was smaller than alpha 0.05 (p<0.05) with a significance level of 0.000; hence, hypothesis 1 "Learning models affect students' problem-solving skills" was accepted. The results of the LSD test, which was conducted after the ANCOVA analysis, were recorded in Table 3.

Table 3

The Results of the LSD Test of the Effectiveness of Learning Models in Improving Students' Problem-Solving Skills

Model	Pretest	Posttest	Difference	Improvement (%)	Average Score	LSD Notation
Conventional	25.20	52.16	26.95	106.93	52.15	a
POE	23.39	64.10	40.70	173.99	64.10	b
PBL	22.85	73.35	50.50	221.01	73.36	c
PBLPOE	28.01	94.44	66.42	237.07	94.43	d

As shown in Table 3, PBLPOE was significantly different from POE, PBL, and conventional in improving the students' problem-solving skills. The highest score of problem-solving skills was observed in the PBLPOE class (94.43). The PBL class ranked second with an average score of 73.37 and was followed by the POE class with an average score of 64.10. The lowest problem-solving score was reported by the conventional group. The average problem-solving skills scores of the PBL, POE, PBLPOE, and conventional groups of students were summarized in Figure 1.

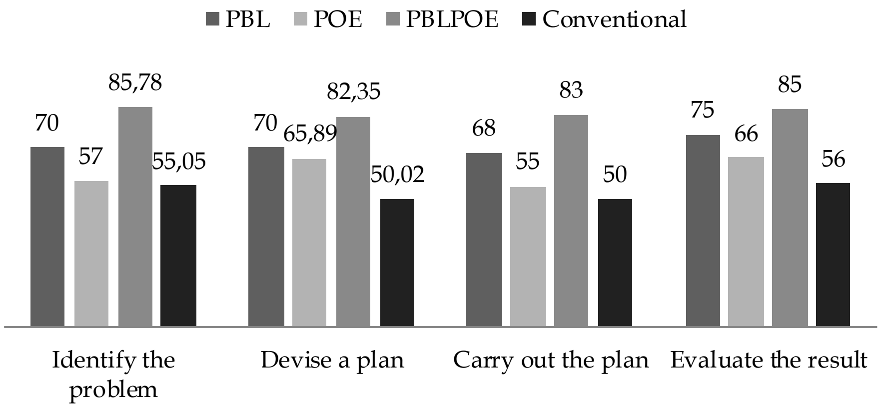

Figure 1. The Average Problem-Solving Skills Score of the POE, PBLPOE, and Conventional Groups of the Students

2. The Effectiveness of Learning Models in Improving Students' Self-Efficacy

The effects of learning models on the students' self-efficacy were analyzed using ANCOVA. The results are presented in Table 4.

Table 4

The Results of the ANCOVA on the Effects of Learning Models on Students' Self-Efficacy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	10016.272[a]	4	2504.068	114.15	.000
Intercept	5713.525	1	5713.525	260.45	.000
Self-efficacy	1.878	1	1.878	.086	.771
Class	8353.026	3	2784.342	126.92	.000
Error	2040.105	93	21.937		
Total	588179.293	98			
Total average	12056.377	97			

a. R Squared = .831 (Adjusted R Squared = .824)

As shown in 7, the p-value was smaller than alpha 0.05 (p<0.05) with a significance level of 0.000; hence, hypothesis 2 "Learning models affect students' self-efficacy" was accepted. The difference in the effectiveness of each learning model (PBL, POE, PBLPOE, and conventional) in improving the students' self-efficacy is shown in Table 5.

Table 5

The Results of the LSD Test of the Effectiveness of Learning Models in Improving Students' Self-Efficacy

Model	Pretest	Post-test	Differ-ence	Improve-ment	Average Score	LSD Notation
Conventional	49.44	63.48	14.03	28.39%	63.55	a
POE	51.50	75.77	24.27	47.13%	75.79	b
PBL	53.15	77.74	24.59	46.27%	77.72	b
PBLPOE	55.78	91.80	36.02	64.58%	91.71	c

Table 5 indicated that there was a significant difference in the effectiveness of PBL, POE, PBLPOE, and conventional learning in improving the students' self-efficacy. The highest self-efficacy score was found in the PBLPOE class (91.72), followed by the PBL (77.73), POE (75.79), and conventional (63.56) classes. The average self-efficacy scores of the PBL, POE, PBLPOE, and conventional groups of students are summarized in Figure 2.

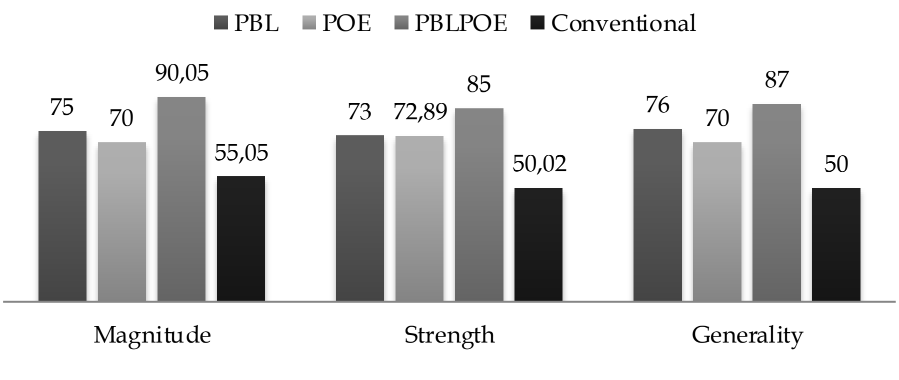

Figure 2. The Average Self-Efficacy Scores of the PBL, POE, PBLPOE, and Conventional Groups of Students

Discussion, Conclusion, and Recommendations

The results of this study showed that the combination of PBL and POE (PBLPOE) had a significant effect on the students' problem-solving skills. This study has proven that the first phase of PBLPOE (problem orientation) allows students to work on several reading comprehension questions related to Plantae (plants), Animalia (animals), ecosystem, and environmental pollution. These questions are formulated in such a way to challenge students to be able to construct their prior knowledge by identifying as many problems as possible. The presentation of problems encourages students to improve their problem-solving skills (Syed & Feyzollah, 2012) because one of the indicators of problem-solving skills in identifying problems (Greenstein, 2012).

Students' problem-solving skills can also be enhanced through the investigation/observation activity accommodated in PBLPOE. At this stage, students are required to be actively involved in a collaborative process of exploring various resources to find a solution to the problem and collect data to justify their predictions. This activity helps students develop the skills to devise a problem-solving plan and carry out the plan. Based on the results of this study, the students could obtain high scores in both indicators. In "devise a plan," students need to elaborate several alternative solutions; then, select the most appropriate one in "carry out the plan." These activities can be found in the observation process. Confirmed by Yuksel and Ates (2017), an observation activity can help develop students' skills in resolving conflict because, to obtain relevant information, students need to involve all senses during the process.

Findings suggest that there is a difference between PBLPOE and PBL in improving students' problem-solving skills. In the PBLPOE class, students need to make predictions and conduct observations. The "making predictions" stage of PBLPOE, which contains the "devise a plan" activity, can improve students' problem-solving skills. During the "making predictions" process, students generate strong arguments and plan solutions to the problem based on their prior knowledge. The student worksheet can guide students in doing these activities. Making predictions allows students to develop ideas and devise a plan to solve the problem (Kala et al., 2013). Making predictions also involves the activity of formulating questions that need to be answered through observations. According to Vadapally (2014), an observation is conducted to find answers to questions, provide space for students to work on their ideas, plan solutions, and select the best solution to be executed. Karamustafaoglu and Naaman (2015) explain that one can acquire new knowledge if one can make assumptions of a problem before proceeding with the exploration of information sources.

The reason why the POE group could not perform better than the PBLPOE group in problem-solving maybe that POE does not facilitate the early stage of a problem-solving process, which is identifying problems. In POE, instead, the problem is already introduced in the beginning by the teacher, and the students only need to make predictions based on the information given. Research conducted by Mourtos et al. (2004) suggests that one's problem-solving skills are reflected in the way s/he detects the problem. In short, identifying problems is crucial in problem-solving since it leads to knowledge discovery.

This study also found a difference between PBL and POE in promoting students' problem-solving skills. The difference lies in the syntax of PBL, which supports the success of a problem-solving process. The PBL students' abilities to identify problems, devise a plan, carry out the plan, and evaluate the result were in the medium score category. PBL helps students develop their problem-solving skills because, during the learning process, the students are required to be active in identifying problems, finding the solutions, and evaluating them. Similar results were reported by Udeani and Adeyemo (2011), who confirmed the effectiveness of PBL in developing students' problem-solving skills.

The three distinctive learning models, namely PBL, POE, and PBLPOE, are significantly different from conventional learning in improving students' problem-solving skills. Conventional learning is characterized by the transfer of knowledge from teachers to students. As a result, the students cannot learn how to solve problems by themselves, and the students become less active. In other words, conventional learning is not very effective in promoting students' problem-solving skills. Mahanal, Zubaidah, Bahri, and Dinnuriya (2016) also argue that an effective learning model should be able to help students analyze a problem, find solutions to the problem, and do a reflection on the process.

The findings of this study have justified that the combination of PBL and POE, or the so-called PBLPOE, is effective in promoting students' self-efficacy. At the "predict" phase of PBLPOE, students are allowed to make temporary predictions based on the problem presented in the worksheet. This activity encourages students to shape confidence in their own opinions and rationales related to the identified problem. Thus, students' self-efficacy, particularly the strength aspect, can be improved to a higher level. As a result, students can easily construct new knowledge and develop a higher degree of self-efficacy (Aurah et al., 2014; Kala et al., 2013; Yuksel & Ates, 2017).

The results of the analysis suggest that PBLPOE is significantly different from PBL, POE, and conventional learning in improving students' self-efficacy. Students' self-efficacy has been promoted at an early stage of PBLPOE that is prediction making. Prediction making requires students to believe in their judgment about the problem (James, 2010). The next activity that students should do in PBLPOE is to investigate. The results of this study showed students' high magnitude scores, which indicate students' optimism and determination. During the investigation process, students wander to collect resources or related literature that can support their predicted solutions to the problem. Similarly, Bars and Oral (2017) revealed that students' self-efficacy could be improved during investigations they conducted to find evidence to prove their assumptions. Students with high self-efficacy scores are more confident in solving a problem compared to students with low or weak self-efficacy (Hsieh et al., 2008).

The "explanation" activity can also contribute to improving students' self-efficacy, especially the "generality" and "strength" aspects. The "generality" aspect measures students' mastery of the topics and students' ability to interact with other students and teacher in presenting the results of the investigation, while the "strength" aspect evaluates students' perseverance and self-consistency in presenting the research data obtained during the observation and in displaying the comparison between the investigation results and the predictions. Other factors that may affect students' self-efficacy include self-achievement, social interactions, experiences, and physiological aspects (Zimmerman, 2000).

There is no significant difference between PBL and POE in improving students' self-efficacy because both learning models can accommodate students' active participation in doing an investigation of the predetermined topics. In line with Gurlen (2011), during an investigation process, students develop strong self-confidence in seeking the right solution to the problem. Both PBL and POE also facilitate peer discussions, which allow students to present their findings to other friends in front of the classroom and get feedback from other pupils. The active classroom discussion may lead to the improvement of students' self-efficacy (Hamidi & Shirdel, 2015) and rich performance in accomplishing a task (Honicke & Broadbent, 2016; Richardson, Abraham & Bond, 2012).

PBL, POE, and PBLPOE are significantly different from conventional learning in improving students' self-efficacy, proven by the low scores obtained by the conventional group of students in magnitude, strength, and generality. On the other hand, conventional learning is more teacher-centered. This type of learning does not provide an opportunity for students to resolve conflicts independently but to merely receive the information being delivered by the teacher. Usher (2009) suggests the students' self-efficacy cannot be properly developed during the learning process. If students are not given any chance to do an investigation or to search for information by themselves, their self-efficacy cannot be promoted. Research conducted by Altunsoy, Cimen, Ekici, Atik, and Gokmen (2010) showed that students who were taught with traditional methods were likely to possess low self-efficacy.

The development of students' problem-solving skills and self-efficacy is indeed influenced by learning models implemented in the classroom. The combination of PBL and POE or PBLPOE has been proven highly effective in improving students' problem-solving skills and self-efficacy compared to PBL or POE alone or conventional learning. It is important that students can develop problem-solving skills and self-efficacy at an early age because of the 21st-century demand. Therefore, the use of PBLPOE in biology classrooms is strongly recommended. This study has revealed the effects of PBLPOE on students' problem-solving skills and self-efficacy; however, some limitations should be acknowledged: (1) this study only involved students from the tenth grade of senior high school, (2) this study was conducted for a semester only or in 12 meetings, and (3) this study only focused on one particular school subject that is Biology.

Conclusions and Suggestions

Based on the results of this study, it can be concluded that PBL, POE, and the combination of both as PBLPOE has an effect on senior high school students' problem-solving skills and self-efficacy. Among all, PBLPOE is considered the most effective in promoting students' problem-solving skills and self-efficacy. Therefore, the use of PBLPOE in the classroom is very advisable. It is also recommended for future researchers to consider performing a more in-depth investigation on the same topic to more diverse population targets, such as a group of students from a different level of education or a group of students who study other subjects.

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Appendix 1

Self-Efficacy Aspects

No	Aspect	Score	Description
1	Magnitude	4	1. Show an optimistic behavior in accomplishing tasks. 2. Able to accomplish either easy or difficult tasks. 3. Able to finish the most difficult tasks. 4. Show a maximum effort in accomplishing tasks.
		3	Contain 3 out of 4 indicators
		2	Contain 2 out of 4 indicators
		1	Contain 1 out of 4 indicators
2	Strength	4	1. Show perseverance in learning. 2. Show pertinence in accomplishing tasks. 3. Show self-consistency 4. Show high self-confidence in learning.
		3	Contain 3 out of 4 indicators
		2	Contain 2 out of 4 indicators
		1	Contain 1 out of 4 indicators
3	Generality	4	1. Have good time management. 2. Perform content mastery. 3. Perform mastery of tasks. 4. Able to deal with various situations and conditions.
		3	Contain 3 out of 4 indicators
		2	Contain 2 out of 4 indicators

(Source: Bandura, 2006, p. 313)

Appendix 2

Indicators of Problem-Solving Skills

No	Indicator	Score	Description
1	Identify problems	4	1. Provide a clear description of the problem. 2. Mention all related facts. 3. Determine concepts or categories. 4. Provide information/data relevant to the problem.
		3	Contain 3 out of 4 indicators
		2	Contain 2 out of 4 indicators
		1	Contain 1 out of 4 indicators
		0	No answer
2	Devise a plan	4	1. Develop a plan to solve the problem. 2. Propose four alternative solutions. 3. Select relevant theories and principles to solve the problem.
		3	1. Develop a plan to solve the problem. 2. Propose three alternative solutions. 3. Select relevant theories and principles to solve the problem.
		2	1. Develop a plan to solve the problem. 2. Propose two alternative solutions 3. Select relevant theories and principles to solve the problem.
		1	1. Develop a plan to solve the problem. 2. Propose only one solution. 3. Select relevant theories and principles to solve the problem.
		0	No answer
3	Carry out the plan	4	1. List all possible solutions to the problem. 2. Evaluate and analyze the possibility of each option before executing the plan. 3. Determine parties that need to be contacted to obtain information related to the execution of the plan.
		3	1. List all possible solutions to the problem. 2. Make a rational decision on selecting one alternative solution.

			3. Determine parties that need to be contacted to obtain information related to the execution of the plan.
		2	1. List all possible solutions to the problem. 2. Select one alternative solution without any rationale. 3. Determine parties that need to be contacted to obtain information related to the execution of the plan.
		1	1. List all possible solutions to the problem. 2. Cannot make any decision on which plan should be executed. 3. Do not determine parties that need to be contacted to obtain information related to the execution of the plan.
		0	No answer
4	Evaluate the results	4	1. Examine the aptness of the solution. 2. Make an assumption relevant to the solution. 3. Predict the results. 4. Select an appropriate medium to communicate the solution.
		3	Contain 3 out of 4 indicators
		2	Contain 2 out of 4 indicators
		1	Contain 1 out of 4 indicators
		0	No answer

(Source: Modified from Mourtos et al., 2004, p. 2; Greenstein, 2012, p. 70)