



An Experimental Comparison of a Problem-Based Learning and a POE-Assisted Project-Based Learning Model of Teaching Scientific Literacy

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ABSTRACT

Although many previous studies are published to be some evidence of the effectiveness of inductive learning models, an experimental comparison of two inductive learning models of teaching scientific literacy remains unavailable. The purpose of this study, therefore, was to investigate 46 secondary students' scientific literacy through a comparison of problem-based learning and project-based learning that is assisted by using a predict-observe-explain strategy on thematic learning. A quasi-experimental method with alternative treatment (pretest and posttest) with nonequivalent groups design was used to assign students into the experimental and the comparison groups, respectively 25 students who had the POE-assisted project-based learning and 21 students who had the problem-based learning. The normalized change and an analysis of covariance with students' pretest scores as covariates were adopted for data analysis. The results revealed that the average normalized change score of both groups was 69 ± 7 and 39 ± 8 , respectively high category for the experimental group and medium category for the comparison group. There were significant differences between both groups' improvement ($F=8.356$; $p<0,006$; and Cohens' $ES d = 0,83$). Thus, the implementation of POE-assisted project-based learning could further improve secondary students' scientific literacy than problem-based learning on thematic learning.

Keywords: *inductive model, POE strategy, scientific literacy*

INTRODUCTION

The National Research Council (1996) defined scientific literacy as the ability to ask, find, or determine answers to the phenomena of everyday life, as well as the ability to describe, explain, and predict natural phenomena. According to the OECD Program for International Student Assessment 2015 (PISA), scientific literacy is the ability to engage with science-related issues and with the ideas of science as a reflective citizen. Scientifically literate individuals use scientific discourse on science and technology to gain competency in (1) explaining phenomena scientifically, (2) evaluating and designing scientific inquiry, and (3) interpreting data and evidence scientifically (OECD, 2013). To achieve this goal, PISA 2015 sets out seven achievement levels (levels 1a, b, up to level 6), which describe students' scientific literacy abilities. These abilities range from basic science skills (corresponding to level 2) to understanding more complex scientific concepts and processes (corresponding to levels 5 and 6) (OECD, 2014).

Based on the results of the last five years of PISA, the average acquisition score of Indonesian students' science literacy was only at level 1 to level 2, showing a decreasing trend from

2006–2012 (OECD, 2014) and a slightly insignificant increase in 2015 (OECD, 2016). Level 2 indicates that students have sufficient scientific knowledge to provide possible explanations in the same context or draw conclusions based on simple investigations. Meanwhile, level 1 indicates students who have limited scientific knowledge and can only apply it to a few similar situations. It shows the fact that the scientific literacy skills of Indonesian students are still far below level 6, in which students must demonstrate the ability to identify, explain, and apply scientific and scientific knowledge in various complex life situations consistently. In other words, learning outcomes in science are still far from the learning objectives set and the expected thinking skills.

Regarding these issues, the current curriculum reflects the findings of Indonesia's PISA score. It encourages teachers to use inductive learning methods developed by Taba, Darkin, Fraenkel, and McNaughton (1971) to improve students' scientific literacy. Inductive learning is a powerful tool that helps students deepen their understanding of content and develop skills in concluding and gathering evidence/data (Silver *et al.*, 2012; Narjaikaew *et al.*, 2010). The current curriculum suggests project-based learning (PBL) and problem-based learning (PBL) as two inductive learning variants.

Project-based learning is learning that provides direct learning experiences to students through scientific inquiry activities carried out by independent students (student-directed scientific inquiry) supported by technology and collaboration to solve real problems in everyday life (real-world problems) (Krajcik *et al.*, 1999). The assumptions underlying this learning are taken from a constructivist social perspective, namely that students need to find solutions to authentic problems by asking and formulating problems, designing, and conducting investigations, collecting and analyzing information and data, interpreting, drawing conclusions, and reporting findings (Blumenfeld *et al.*, 1996; Krajcik *et al.*, 1999). Collaboration and discussion are also included in the essential part of learning because they encourage students to share their understandings and ideas during the learning process.

Several previous studies have reported evidence of the effectiveness of project-based learning in training problem-solving skills, conceptual understanding, and students' attitudes toward science learning (Surahmadi, 2018; Thomas, 2000; Mills & Treagust, 2003). Other research reports in several fields, such as Astronomy (Wilhelm *et al.*, 2008; Wilhelm, 2014), Science, Technology, Engineering, and Mathematics – STEM (Wilhelm *et al.*, 2008), Mathematics (Nurfitriyanti, 2016), and Biology (Regassa & Morrison-Shetlar, 2009), further strengthens the potential of using project-based learning to enhance students' knowledge and skills. Even Afriana *et al.* (2016) showed evidence of the effectiveness of project-based learning in improving elementary school students' scientific literacy.

Another variant of inductive learning to train scientific literacy is problem-based learning (PBL). As with project-based learning, problem-based learning supports students in the scientific inquiry process through authentic problems or meaningful questions to organize the learning experience. Both are student-centered learning (student-oriented) and prioritize learning experiences (experiential), in which students solve problems by directly applying the scientific concepts they learn (Hmelo-Silver, 2004). The differences between both methods lie in that student project-based learning mainly applies the constructed knowledge, and the final product is the central focus of assignments. Meanwhile, instead of teaching students the required knowledge beforehand, they construct the concepts while solving problems in problem-based learning, and the problem-solving process is more important than the final product (Prince & Felder, 2007).

A large body of research also shows the effectiveness of the PBL model in increasing junior high school students' scientific literacy (Nomika *et al.*, 2015; Imaningtyas *et al.*, 2016; Wulandari & Sholihin, 2015; Lawles & Brown, 2015). Some of them also provide evidence of the effectiveness of PBL when compared to other learning models, such as conventional learning (Mergendoller *et al.*, 2006; Strobel & Barneveld, 2009; van Kampen *et al.*, 2004), direct learning (direct instruction /

experiential learning) for improve content knowledge and science problem-solving abilities of elementary school students (Drake & Long, 2009), contextual learning method to enhance mathematical communication skills (Anim & Saragih, 2019) and direct interactive learning (direct-interactive teaching) to improve science learning outcomes of high school students (Chang, 2001). Making problems a catalyst in learning physics has also proven suitable for teaching students majoring in Physics (Beck & Perkins, 2016; Amundsen *et al.*, 2009; Barry, 2008; Masrhall *et al.*, 2007; Raine & Collett, 2003) and engineering (Radcliffe & Kumar, 2017). Not only does it increase understanding of concepts (Taqwa *et al.*, 2019), but problem-based learning also improves critical and creative thinking skills (Rosa & Pujiati, 2016).

Even though there has been much previous research regarding the reliability of project-based and problem-based learning models, there has never been any authentic evidence comparing the two experimentally apple-to-apple. Moreover, Prince and Felder (2006) stated that although there is a lot of research evidence documenting the effectiveness of inductive models, inductive learning consistently shows results that are at least the same as, and generally more effective than, traditional deductive learning. Therefore, experimental comparisons between these two inductive learning models in improving the same learning skill in the research context, namely students' scientific literacy, are essential to know. This information will be worthy for teachers in determining the right choice of model to be used to teach concepts. In addition, it further strengthens the teacher's understanding of the main differences, strengths, and weaknesses of project-based and problem-based learning.

Based on this rationale, this research investigated the strengths and weaknesses of two inductive learning models to improve scientific literacy through experimental comparison methods. Given that the comparisons must be fair, while the advantages of project-based learning, which tends to focus more on developing creative ideas and knowledge-based development, often leave one weakness in the aspect of constructing student knowledge used to complete project assignments, in the context of this research so that Predict-Observe-Explain (POE) strategy combined with the project-based learning. It aims to involve the stage of knowledge formation in the learning process.

The POE strategy plays a role in constructing concepts in project-based learning. This strategy focuses on teaching students to gain deep conceptual understanding (Champagne *et al.*, 1979; Gunstone & White, 1981). In addition, it aims to increase opportunities to enhance students' knowledge and scientific literacy competencies. The effectiveness of this POE is focused, simple, and easy to apply during learning (Rios, 2002), and an effective conceptual starter for discussion. This strategy has also been widely used and proven to be effective for constructing the conceptual understanding of junior high school students (Berek *et al.*, 2016; Radovanović & Sliško, 2013; Kala *et al.*, 2012; Liew & Treagust, 1995; Tao & Gunstone, 1997; White & Gunstone, 1992).

This paper answers the following research questions: (1) is project-based learning supported by POE strategies more effective than problem-based learning in increasing students' scientific literacy? and (2) to what extent is the effectiveness of project-based learning supported by the POE strategy when compared to problem-based learning in increasing the domain knowledge, competencies, and attitudes of scientific literacy? This comparative study applied a thematic learning format. This study used weather and climate change as the learning theme because PISA mentioned that it requires level 6 competency (OECD, 2010). The instrument of this study used PISA-style questions as a benchmark to what extent the effectiveness of the two studies compared in improving knowledge, competence, and scientific attitudes on learning themes that demand high-level abilities in PISA.

METHODOLOGY

This study used a quasi-experimental method with alternative treatment (pretest and posttest) with non-equivalent group designs (Creswell, 2014). The sample came from a population of grade eight students in one of the laboratory schools of the Indonesian University of Education, divided into 25 students in the experimental group who received project-based learning supported by the POE strategy and 21 students in the comparison group who received problem-based learning. Students' scientific literacy in both groups was measured using scientific literacy tests before and after three weeks of learning duration. Each group received the same learning content taught by the same teacher (researcher AJ) with the same instructional time for each meeting (about 80 minutes). There are two meetings a week. Project-based learning supported by the POE strategy (the POE-PjBL) adapted in this study consists of five learning stages. Those are orienting students to study, building concepts, assisting in planning and creating a product, presenting and reporting the project, and reinforcing and evaluating for further study. Meanwhile, problem-based learning (PBL) as a comparative model adapted from Arends (2012) consists of the following stages: orienting students to the problems, organizing students for study, assisting independent and group investigation, developing and presenting work, and analyzing and evaluating problem-solving processes.

Students' scientific literacy in both groups was measured using test and non-test instruments. The test instrument was 37 items in the form of multiple choice questions and yes/no options to measure domain knowledge and scientific literacy competence. The non-test was 42 items of an attitude scale using a Likert scale to measure students' science attitudes. The composition of the instrument items consisted of questions developed by the researchers and several questions from PISA. The use of several PISA items served as anchoring questions to equalize the composition of the items made by the researchers. The experts then justified the equivalence of the items. All indicators, formats, and scoring of test and non-test instruments refer to the 2015 PISA assessment framework.

The thorough quality of the test and non-test instruments is measured through validity and reliability tests, while the quality of each test item is through discrimination indices and difficulty levels (Ding & Beichner, 2009). The content validity of the scientific literacy test instrument and attitude scale is determined using the assessment of four science education experts. There were several suggestions for improvement from experts. However, after being revised, overall instruments were declared feasible for use. Table 1. presents a recapitulation of reliability and all classical test analyses.

Table 1. Recapitulation of classical test theory of scientific literacy test

Evaluation Measure	Obtained average values	Desired values*
Difficulty index (<i>P</i>)	0,40	0.30-0.90
Discrimination index (<i>D</i>)	0,32	≥0.30
Reliability index of the test (<i>r</i> -KR 20)	0,68	0.50-0.60
Reliability index of attitude scale (Cronbach Alpha, α)	0,95	0.50-0.60

**P* and *D* refer to Ding & Beichner (2009), while *r* and *a* refer to Maloney (2001)

Data obtained from students' scientific literacy tests were analyzed using analysis of covariance (ANCOVA) to answer the comparative hypothesis in this study. The gain score (the difference between the posttest and pretest scores) was the response variable. Student's pretest scores became the covariate variable because the characteristics of individual students, in this case, the student's initial abilities as seen from the pretest scores, also influence the science learning process (OECD, 2003). Students' attitude scale scores are analyzed by converting the score (*M*) obtained into percentages and interpreted based on the categories very disinterested ($M \leq 25\%$), not

interested ($25\% < M \leq 42\%$), not very interested ($42\% < M \leq 58\%$), quite interested ($58\% < M \leq 75\%$), and very interested ($M > 75\%$).

Normalized change score analysis (Sriyansyah & Azhari, 2017) was used to obtain an overview of the effectiveness of the two learning models through the improvements shown by students in each domain of knowledge, competence, and attitude. The positive normalized change (c) score indicated the category of increasing scientific literacy, namely the high ($c \geq 70$), the moderate ($30 \leq c < 70$), and the low ($c < 30$) (Hake, 1998). As for measuring the magnitude of the treatment effect between the two groups, Cohen's effect size was used ($d =$ the difference in the average n-change scores of the two classes divided by the combined standard deviation). A positive Effect Size (ES) value indicates that the increase in one group is relatively higher than another group (Cheng et al., 2004). A value of ES less than 0.5 denotes a small effect, one between 0.5 and 0.8 is moderate, and one larger than 0.8 is considerable.

RESULTS AND DISCUSSION

The covariance analysis of student gain scores with the pretest score as the covariate variable indicated the difference in the increase in scientific literacy between the two groups. The results of this study showed that the increase in the experimental class is almost twice that in the control class. The covariance analysis result supported the significance of this increase. The gain scores of the experiment and the comparison groups showed significantly different when the pretest scores were held constant ($F = 8.3546$, $F = 8.3546$, $p > 0.006$, ES $d = 0.83$). The increase in scientific literacy among the experimental group students was significantly higher than that of the comparison class. The results of this analysis answered the proposed research hypothesis that project-based learning supported by the POE strategy is more effective in increasing students' scientific literacy than problem-based learning. Figure 1 compares the percentage of pretest, posttest, and n-change average scores between the experimental and the control groups.

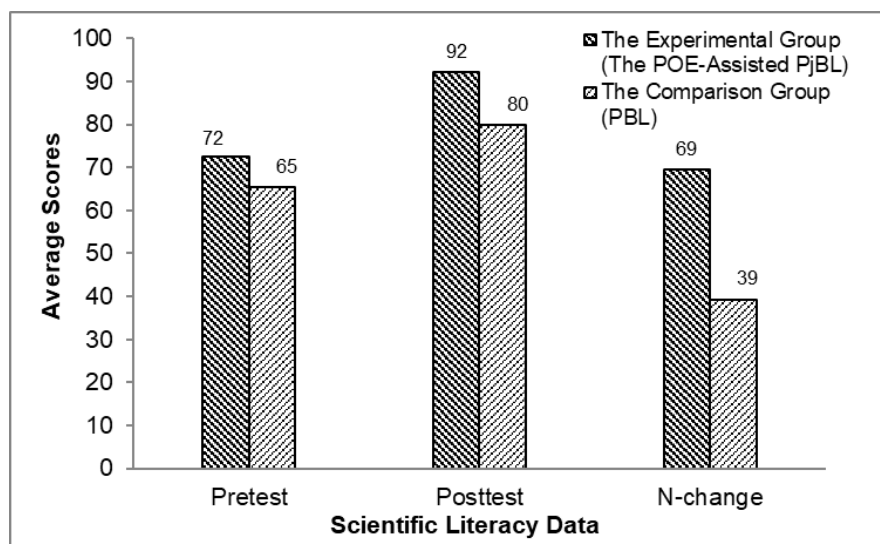


Figure 1. Comparison of the average pre-test, post-test, and n-change in scientific literacy of students of the two groups

The two lessons compared managed to change the attitude of students from those who were quite interested before learning to those who were very interested after learning. The changes in scientific literacy attitudes shown by students in the experimental group (23%) and the comparison group (15%) were diminutive. Before learning, the attitudes of students in both groups were quite interested ($58\% < M \leq 75\%$) towards science, whereas after learning, they changed to

being very interested ($M > 75\%$). Even though the change in attitude between the two groups was diminutive, it was enough to support the fact that learning in both classes was included in the category of active learning.

To see the improvement in students' scientific literacy, further analysis described the performance in each domain of scientific literacy. It is essential to see a more specific comparison of the impact of different learning models on the two groups. In addition, it also depicts students' difficulties in terms of each domain of scientific literacy knowledge, competence, and attitude. The knowledge domain consists of content, procedural, and epistemic knowledge. The competence domain consists of competence in explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically. The science attitudes domain consists of an interest in science and technology, valuing scientific approaches to enquiry, and environmental awareness.

The improvement shown in each indicator of the knowledge and competency domains is related to one another. A comparison of each domain's performance provides an overview of the strengths and weaknesses of the learning applied in the two groups. Project-based learning supported by the POE strategy shows a higher average increase in scientific literacy than problem-based learning. However, both show different improvements in their subdomains, either in knowledge or competency domains. Table 2 presents the results of the covariance analysis for each domain's performance.

Table 2. Results of the covariance analysis of the gain score with the pretest as a covariate.

Scientific Literacy Domain	Pretest score		Gain score		ANCOVA results	
	Ave. (SD)		Ave. (SD)		<i>F</i>	<i>P</i>
	POE-PjBL	PBL	POE-PjBL	PBL		
Content Knowledge (K1)	76 (15)	71 (17)	16 (17)	11 (19)	4.780	0.034
Procedural Knowledge (K2)	70 (20)	64 (20)	24 (25)	21 (28)	3.803	0.058
Epistemic Knowledge (K3)	53 (31)	35 (27)	34 (32)	19 (36)	22.171	0.000
Explaining phenomena scientifically (C1)	72 (16)	66 (16)	20 (18)	14 (18)	8.484	0.006
Evaluating and designing scientific enquiry (C2)	76 (19)	58 (25)	15 (19)	17 (29)	7.241	0.010
Interpreting data and evidence scientifically (C3)	62 (42)	81 (25)	28 (58)	12 (31)	0.742	0.394*
Low cognitive level (CL1)	80 (22)	87 (20)	12 (30)	7 (21)	0.064	0.801*
Medium cognitive level (CL2)	70 (15)	61 (16)	20 (16)	15 (20)	9.884	0.003
High cognitive level (CL3)	65 (27)	50 (29)	20 (31)	11 (27)	9.633	0.003
Scientific Literacy Test	72 (15)	65 (16)	20 (16)	14 (19)	8.356	0.006

* $P > 0.05$

In addition to assessing the three domains of knowledge, competence, and attitudes in specific contexts, PISA 2015 has a feature called the level of cognitive demand. It is different from the level of difficulty of the items. The difficulty index describes the proportion of the test taker that answered the questions correctly and assessed the amount of knowledge possessed by the test taker. Meanwhile, the cognitive level refers to the mental process type required (Davis & Buckendahl, 2011). There are three cognitive levels defined in PISA 2015, namely low (L), medium (M), and high (H) levels (OECD, 2013). Figure 2 shows the comparative description of the increase in each domain for the two groups.

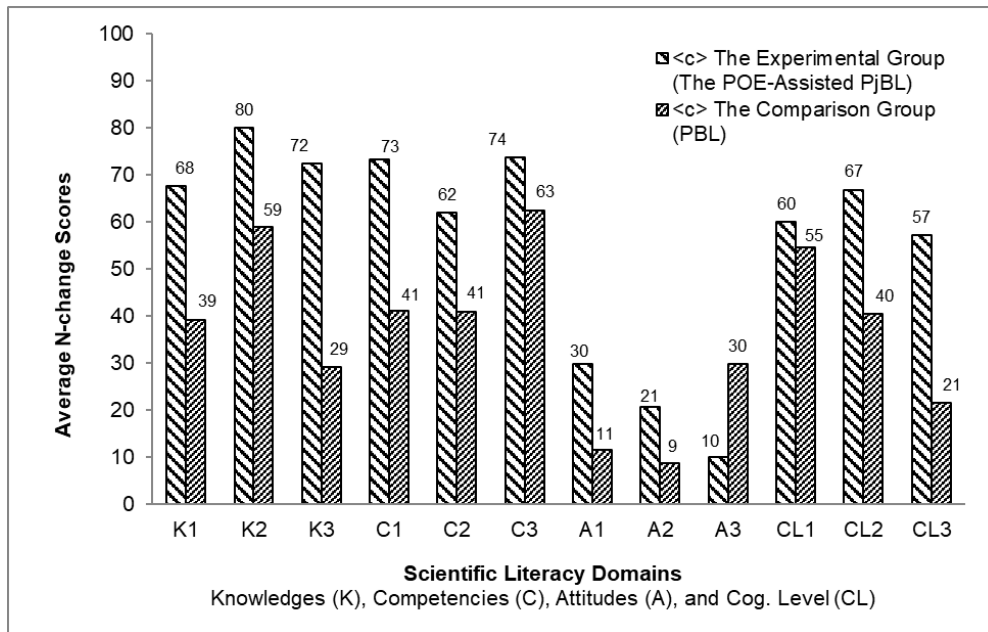


Figure 2. Comparison of the average n-change scores for each domain of student scientific literacy for the two groups

The PISA assessment is not a context assessment but assesses competency and knowledge in a specific context. The choice of this context refers to the knowledge and competency that students as young as 15 may have (OECD, 2013). The increase in scientific literacy of the two groups was in the moderate improvement category, according to Hake (1998), respectively 69 ± 7 for the experimental group and 39 ± 8 for the comparison group. According to previous research, the measure of effective active learning to increase conceptual understanding was 35–70 (Hake, 1998; Redish & Steinberg, 1999). Thus, the results shown by both classes support the conclusions of previous meta-analytic studies that inductive learning, which teaches students to classify information and how to build and test a hypothesis—two core skills in inductive models—improves student learning outcomes (Dean *et al.*, 2012). This research provides empirical evidence that both learning models are active learning to increase conceptual understanding. The choice between project- and problem-based learning depends on the context and specific learning objectives, the teacher's experience, the teacher's knowledge, the background of the students, and the availability of resources (Colley, 2008).

Project-based learning with a POE strategy is more effective than problem-based learning. The higher increase in scientific literacy in the experimental group is the impact of implementing project-based learning with the POE strategy. The integration of the POE strategy into learning is able to instill concepts well before working on the project and at the same time stimulate students' ideas through the activity of making a prediction accompanied by arguments for a phenomenon, then observing demonstrations and explaining the phenomenon, whether it is in line with the predictions that have been made. A cognitive conflict that arises as a result when there is a contradiction between observations and predictions made by students becomes an opportunity for assimilation and/or construction of concepts that students want to instill in their minds (Tregust *et al.*, 2014). The advantages of project-based learning which emphasizes the aspects of scientific skills and attitudes through inquiry activities, combined with POE strategies that focus on aspects of knowledge formation, make the combination of the two a complete learning design to teach the three aspects of scientific literacy, namely knowledge, skills, and attitudes of science. The advantage lies in the aspects of skills, attitudes, and creative ideas.

Even though project-based learning is statistically more effective, the average posttest for students who taught using the problem-based learning model is relatively high at 80, while project-based learning is at 92. It explains that problem-based learning can instill concepts in students quite well through the context of the problem. If project-based learning mainly applies knowledge that has previously been obtained in the concept construction stage with the POE strategy and the final product is the central focus of the assignment, then problem-based learning inculcates the concept to students along with the problem-solving process during problem-solving is more important than the final product (Prince & Felder, 2007).

In problem-based learning, the teacher must explicitly emphasize the key concepts students should have mastered after solving the problems at the end of the lesson. The observed weakness lies in the student's ability to infer the key concepts. This section also often gets a relatively short time allocation and is not carried out explicitly intensively. However, the teacher expects students to be able to grasp the concept that the teacher wants to teach themselves through this problem without reviewing it in more detail. Unlike problem-based learning, project-based learning separates the stages of constructing and strengthening concepts. Separation of these stages is beneficial when students do not understand the concepts at the end of the concept planting stage, so students can refine and strengthen concepts when discussing ideas and working on projects. The differences in the increase in each domain of scientific literacy can also explain the strengths and weaknesses of the two learning observed during this study.

The highest increases for both groups in the domain of knowledge and competence were in the same subdomain, namely procedural knowledge (K2) and competence in interpreting data and evidence scientifically (C3). The competence in interpreting data and evidence scientifically in the two classes was not significantly different ($P > 0.05$). This competency requires all three forms of scientific knowledge. However, the possible rationale behind these findings is that students who demonstrate competency in interpreting data and evidence scientifically should be able to translate the meaning of scientific evidence and its implications for specific audiences using their own words, diagrams, or other appropriate representations. This competency requires mathematical tools to analyze data summaries and the ability to use standard methods to transform data into different data representations. Therefore, it is in accordance with the procedural knowledge required in all forms of scientific inquiry, including representing, transforming, and interpreting scientific data.

In addition, this highest increase indicates that both the experimental and comparison groups' learning emphasized the same competencies and knowledge. The change in attitude shown by each group shows the opposite. The experimental group showed a significant improvement in interest in science and technology, while the comparison group showed environmental awareness. Through the project assignments given, the experimental group's students were more motivated to study science and technology. It is understandable because the learning they receive emphasizes presenting phenomena to be predicted and scientifically explained. The project idea, which is also related to the concept application in the use of simple technology to solve problems, also adds to students' interest in science and technology. As for the comparison group, environmental awareness showed a significant improvement. The possible rationale explains these findings because the learning they receive is problem-based learning, where the context of the problem given is dominant regarding regional and global environmental conditions. Thus, it is natural for students in the comparison group to show a significant change in attitude towards environment awareness indicators.

In contrast to the highest increase, the two classes showed the lowest increase in different scientific literacy subdomains. For the knowledge domain, the experimental group showed the lowest increase in content knowledge, while the control class showed epistemic knowledge. Content knowledge includes scientific concepts and ideas in multidiscipline such as Physics, Chemistry, and Biology. Epistemic knowledge describes the understanding of how the claim is justified in science. A low increase in content knowledge becomes an evaluation of the implementation of the POE

strategy during learning. Students encountered difficulties in giving explanations from the predictions they made or from the demonstrations of the phenomena they observed. The possible rationale is that students were not used to strategies that required them to give scientific arguments. Even though it is the subdomain with the lowest increase, the increase rate is still in the moderate category.

The lowest increase in the competency domain of the two groups lies in the same competency, namely evaluating and designing scientific investigations (C2). In the comparison group, the increase in explaining phenomena scientifically competence was also the same as the increase in competence in evaluating and designing scientific investigations. It means that the competence to explain phenomena scientifically is also the lowest increase in the comparison group. What is interesting to examine further lies in the interconnection between the lowest increase in the competency and the attitude domains. The attitude of environmental awareness showed a poor improvement in the experimental group, while in the comparison group, it was the attitude of using a scientific approach to investigation. The lowest increase in the competency domain of this comparison class was consistent with the slightest change in the attitude indicator they showed. This attitude indicates that learning in the comparison group does little to change their interest in using a scientific approach in investigations.

Even though the changes in students' attitudes in this study were relatively low after learning, the findings of previous studies support these results. Previous studies reported that several countries with high scientific literacy outcomes tended to show lower interest in science (Bybee & McCrae, 2011; Drechsel *et al.*, 2011). Other reports also state that junior high school student's interests are generally specific to certain subjects (Baumert & Köller, 1998; Daniels, 2008; Gardner, 1985; Osborne *et al.*, 2003). The data obtained shows that many students tend to lose their interest in science during learning. Students' interest in Physics and Chemistry was lower than in Biology (Osborne *et al.*, 2003). Female students were also less interested than male students (Haeussler & Hoffmann, 1998).

Other findings also showed that the highest increase was in the moderate cognitive level for the experimental group and the low level for the comparison group. These results reinforce the claim that project-based learning teaches competencies with a higher level of cognitive demand better than problem-based learning. However, there was no difference in the abilities of students in the two groups in answering questions with a low level of cognitive demand. In other words, the students of both groups have the same ability when they answer questions with a low level of cognitive demand. Low cognitive demand refers to problems with one step of completion, such as recalling laws, facts, and concepts or taking one piece of information from a table or graph. Medium cognitive demand refers to questions that require students to use and apply conceptual knowledge to describe or explain phenomena, choose appropriate procedures involving two or more steps, display or organize data, and interpret or use data sets or simple graphs. High cognitive demands require students to analyze complex information or data, synthesize or evaluate evidence, justify, give reasons from various sources, and devise a plan or sequence of steps to solve a problem.

The findings of this study provide a clearer picture of what 15-year-old students can do and how the practice of learning science in class has been so far. Students were most likely not to recognize the PISA-style assessment because teachers also have not taught and incorporated the scientific literacy domain intensively in their classroom practices. The use of various contexts in this study, such as technology and the environment, can increase students' interest in science in both classes. Context becomes a basis for introducing science and technology. Science teachers should choose contexts and topics that will engage students and enable them to become confident in encountering real-world problems that involve science and technology. It will then determine the design of curricula and selection of instructional strategies, as well as what students learn and the competencies they develop.

CONCLUSIONS

Overall, the two scrutinized lessons in this study significantly increased students' scientific literacy. Project-based learning supported by a predict-observe-explain strategy is statistically more effective than problem-based learning. Both showed the highest increase in the same knowledge and competency subdomains, namely procedural knowledge (K2) and competence in interpreting data and evidence scientifically (C3). Both also changed students' attitudes towards science, from being quite interested in becoming very interested in science after learning. Project-based learning with the POE strategy makes students more interested in science and technology, while problem-based learning increases students' environmental awareness.

The results of this study are enough to prove the effectiveness of the two scrutinized learning models so that they can be alternative models for training scientific literacy. Project-based learning emphasizes students choosing and investigating their questions to produce a product, and problem-based learning focuses on learning how to understand and solve problems using ill-defined cases. The choice between project-based and problem-based learning depends on the context and specific learning objectives, the teacher's knowledge and experiences, the background of the students, and the availability of resources.

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