Effectiveness problem-based learning (PBL) with reading infusion strategic to improving scientific literacy for high school students on topic global warming

I B Nasution*, W Liliawati and L Hasanah

Department of Physics Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding author’s email: isonamiabn@student.upi.edu

Abstract. The scientific literacy is an important skill to be provided to students as effort of preparing citizens who are able to compete in the 21st century. The scientific literacy has become the main goal of physics learning. However, PISA results show that the scientific literacy of Indonesian student is lower compared to other countries. The aims of this study is to comparing effectiveness PBL with reading infusion and only PBL to improving students’ literacy. The design research of this study was quasi experiment method with pretest-posttest non-equivalent control group design. The subjects of this research consisted of 44 students of XI MIA at a High school in Bandung. The students were divided into 2 groups. The data collection was conducted through scientific literacy instrument that was developed before this study. The data was analyzed using n-gain, T-test and effect size. Results shows that the scientific literacy in experiment group is higher than control group significantly and the implementation PBL with reading infusion strategy has large effect to improving students’ scientific literacy. The results clarify that PBL with reading infusion strategy in physics learning is effective to improving scientific literacy students at high school.

1. Introduction

The rapid of science and technology development in the 21st century not only have a positive impact for humans but also negative impacts. Citizens must be wise to choose and use science and technology [1]. One of the negative impacts of the development of science and technology is global warming. Global warming has become a big issue in the 21st century. Global warming is causing climate change which give negative impact on all living creatures in the earth. All citizens should be equipped with specific competencies called scientific literacy [2-3] to cope with and adapt to the impacts of global warming. One of solution is to equip citizens with scientific literacy through physics education.

The scientific literacy has become a major goal in science education [4-5] without any scientific literacy a person has difficulty making decisions relating to education, scientific and social problems faced daily [6]. The scientific literacy allows a person to make decisions wisely using their knowledge about science and technology to solve their daily problems. The scientific literacy becomes an important ability to be measured as a picture of how successful the curriculum of a country to equip its citizens. One of the assessments measures scientific literacy’ student in some countries is PISA (Program for International Student Assessment). The result of PISA can be reference to know students’ literacy scientific of a country,
Indonesia has been following the PISA program since 2000. From the PISA results from 2000 to the last in 2015 Indonesia is still at the bottom of the countries that follow PISA. Based on the results of the last PISA, 2015, Indonesia is ranked 62nd out of 72 countries participating PISA with a score of 403 [7]. One solution to improve students' scientific literacy is through the learning process. PBL can be used to improve scientific literacy skills through PBL contribute positively to students' ability to identify scientific issues, explain scientific phenomena, and use scientific evidence [8]. Physical learning through PBL provides an opportunity for students to learn how to think analytically to solve problems. This will help students to develop thinking skills, cognitive abilities, and knowledge will be more meaningful to bring a positive effect for the scientific literacy of students [9-11]. However, the PBL will bring positive impact if students have basic science knowledge to solve the problem [12]. Basic science knowledge is needed to solve problem and can be provided to student through creating knowledge such as reading activity [13]. Reading activity can be infused in PBL learning stages to more optimal learning outcomes.

Reading activity is not only can prepare basic science knowledge’ students but also improving scientific literacy. This is based on fact that scientific literacy itself is a ability to understand articles on science in the newspaper and to oppose public opinion in order to create valid conclusions [4]. This is in accordance with Zmach and Fang’ finding that reading is an activity that can increase students’ scientific literacy [14-15]. The purpose of this study is to analyze the effectiveness PBL with reading infusion strategy to improving students’ scientific literacy for high school students on topic global warming. The hypothesis is PBL with reading infusion strategy will be effectively improving students’ scientific literacy than only PBL without reading infusion.

2. Methods

2.1. Participants
The random sampling method was used in this study. The sample was 44 students of class XI at high school in Bandung, distributed into control class and experiment class. Control class used only PBL, while the experimental class used PBL with reading infusion strategy in topic global warming.

2.2. Instrument
The test instrument has developed by researchers before this study begins. The test instrument has been matched to competence domain in PISA 2015, consists of 23 essays related to topic global warming.

2.3. Procedures
The method of this study was experimental research. The research design used pretest-posttest non-equivalent control group design. This study used PBL proposed by Arends [16]. The SQ3R reading method used for reading infusion stage. The SQ3R reading method consists of 5 stages of survey, question, read, recite, and review. The SQ3R method is the most commonly used method for reading force [17]. The SQ3R reading method helps students understand the content of the reading [18]. Table 1 shows the comparing learning stage in control class and experiment.

| Table 1. The comparing learning stage in control class and experiment class |
|-------------------------------------------------------------|
| Experiment Class. | Control Class. |
| Stage 1 | Stage 1 | Oriented students to the problem |
| Reading infusion activity | | |
| Stage 2 | | |
| Oriented students to the problem | Stage 2 | |
| Stage 3 | Organize students for study |
| | Stage 3 |
| Organize students for study | | |
| Stage 4 | Assist independent and group |
| | | |
3. Result and Discussion

3.1. The effectiveness of Improving Students’ Scientific Literacy

The average score of pre-test, post-test and n-gain in control class and experiment class is shown on Table 2.

| Class   | Test   | X    | SD   | X_{min} | X_{max} | <G> | Criteria |
|---------|--------|------|------|---------|---------|-----|----------|
| Experiment | Pretest | 6.73 | 4.01 | 0       | 16.46   | 0.68| Medium   |
|          | Posttest | 69.73 | 11.17 | 53.99 | 84.89 |     |          |
| Control  | Pretest | 7.58 | 6.99 | 0       | 14.94   | 0.51| Medium   |
|          | Posttest | 55.56 | 15.84 | 30.20 | 80.20 |     |          |

Table 2 shows that n-gain for experiment class is higher than control class. It means that increasing of scientific literacy’ student in experiment class higher than control class. But both of classes are in the same criteria that is medium. To determine significant different the topic global warming students’ scientific literacy between the control class and experiment class, used T-test. The result of T-test is shown on Table 3.

| Resource of Data | T_{Hitung} | Df | Sig. | Decision |
|------------------|------------|----|------|----------|
| Gain of scientific literacy | 4.155 | 42 | 0.000 | Significant |

Based on Table 3, it can be seen Sig<0.05 with 95% confidence level were obtained. This means that there are significant differences in students’ scientific literacy between experiment class and control class. Then, we calculated the effect size of implementation of PBL with reading infusion strategy for improving students’ scientific literacy. The result of the effect size calculation shows on Table 4.

| M_E | M_K | SD_E | SD_K | D | Criteria |
|-----|-----|------|------|---|----------|
| 69.73 | 51.45 | 11.17 | 15.84 | 1.33 | Large effect |
Table 4 shows that the implementation PBL with reading infusion strategy have large effect to student scientific literacy. Based on T-test and effect size calculation, they can be concluded that PBL with reading infusion strategy is effectively improving students’ scientific literacy.

3.2 The Improvement in Each Indicator

The figure 2 shows that there is medium improvement on every indicators of scientific literacy both in experiment and control class.

![Graph showing improvement in each indicator](image)

**Figure 1.** Increasing of scientific literacy in each indicator

To determine whether the differences in improvement of the control class and experiment class significant or not, then we used the statistics test analysis to test the hypothesis using t-test. Results of the hypothesis presented in Table 4 shows that the differences categorized as significant.

**Table 5.** The results of t-test scientific literacy in each indicator

| Indicators                                | \( T_{\text{count}} \) | \( \text{Df} \) | \( \text{Sig.} \) | Decision       |
|-------------------------------------------|------------------------|----------------|----------------|----------------|
| Explaining phenomena scientifically       | 5.026                  | 42             | 0.000          | Significant    |
| Evaluating and designing experiments      | 1.346                  | 42             | 0.186          | Not Significant|
| Interpreting data and scientific evidence | 4.780                  | 42             | 0.000          | Significant    |

Table 5 show that there is significantly different improvement of scientific literacy between control and experiment class on explaining phenomena scientifically and Interpreting data and scientific evidence.

3.3 Discussion

In According to Table 5, significant differences are found in explaining scientific phenomena and interpreting scientific data and evidence while there is no significant difference in evaluating and designing scientific inquiries. This is because reading does not trill the ability to evaluate and design scientific inquiry. Evaluating and designing scientific inquiries were trained in experimental and control class when in stage group investigation so that there is no significant difference in improvement evaluating and designing scientific inquiries indicator between the experimental and control classes.
There is significant difference for explain scientific phenomena between the experimental class rather and the control class. PBL have not brought much effect on content knowledge [13, 20, 21] Reading and knowledge are related. Reading activities using material that is related with learning topic help students to have content knowledge. Reading materials used in reading infusion presents global warming phenomena. An example of a reading passage is shown in Figure 2.

The sources of reading material is not only from textbooks but also articles, news, journals and other reliable sources [22]. The reading material is used in reading infusion has good quality and interesting for students. Students also use SQ3R as their reading methods. SQ3R helps student to understand reading material better. Fang, et al [23] stated that the activity of reading quality texts by using relevant reading strategies helped students expand their knowledge of science. Thus, reading infusion activities using materials that contain scientific information and the use of SQ3R reading methods to help students learn to explain a phenomenon scientifically. It causes explain scientific phenomena in experiment class is better than control class.

There also a significant difference for interpreting data and scientific evidence between experiment class and control class. It is because the reading material does not only present verbal information but there are forms of representation such as tables, graphics, images and others. An example of a reading passage that presents an explanation of material-related phenomena with graphical representation is shown in Figure 3.
The forms of representation displayed on the reading materials help students interpret a representation displayed on the reading. The more often students read the reading that contains the forms of representation then the students will be more accustomed to interpret a representation. The ability of students to interpret a form of representation is influenced by the intensity of students interpreting a representation [24]. So that, students who read reading more often that contain forms of representation will have the ability to interpret superior scientific data and evidence.

4. Conclusion
Implementation of PBL with reading infusion strategy can effectively improve the scientific literacy in indicator explaining phenomena scientifically and indicator interpreting data and scientific evidence.

5. References
[1] Hobson, A 2008 The Surprising Effectiveness of College College Scientific Literacy Courses 2008 The Physics Teacher 46
[2] Liu, X 2009 Beyond Science Literacy: Science and The Public International Journal of Environment & Science Education 4 3 301-311
[3] Turiman P., et al 2012 Fostering The 21st Century Skills Through Scientific Literacy and Science Process Skill Precedia-Social and Behavioural Sciences 59 110-116
[4] NRC 1996 National Science Educational Standard (Washington: National Academy Press)
[5] Millar, R 2011 The Twenty First Century Science: Insight from The Design and Implementation of Scientific Literacy Approach In School Science International Journal Of Science Education 28 13 1499-1521
[6] Glynn, M Shawn & Muth, K Denise 1994 Reading and Writing to Learn Science: Achieving Scientific Literacy. Journal of Research In Science Teaching. 31 9 1057-1073
[7] OECD. 2015. PISA 2015 Results in Focus. France: OECD Publishing
[8] Ardianto, D & Rubini, B 2016 Comparison of Student’ Scientifc In Integrated Science Learning Through Model of Guided Discovery And Problem Based Learning. Jurnal Pendidikan Ipa Indonesia. 5 1 31-37.
[9] Brickman, P., et al 2009 Effects of Inquiry-Based Learning on Students’science Literacy Skills and Confidence International Journal for the Scholarship of Teaching and Learning 3 2
[10] Alfiery, L., Brooks, P.J & Aldrich, J.N 2011 Does Discovery-Based Instruction Enhance Learning? Journal of educational psychology 103 11-18
[11] Nbin, J. B 2013 The Relative Effectiveness of Guided Discovery And Demonstration Teaching Methods On Achievement Of Chemistry Students Of Different Levels Of Scientific Literacy Journal of Research in Education and Society 4 1 8-13.
[12] Arends, R. I 2012 Learning to Teach, Ninth Edition. Mc Graw hill: New York.
[13] Yeo, J, & Tan, S.S 2014 Redesigning Problem-Based Learning In The Knowledge Creation Paradigm For School Science Learning Instructional Science 42 5745-7755.
[14] Zmack, CC., Sander, Jennifer., Patrick, J D., Dedeoglu, H., Charbonnet, S., Henkel, M., Fang, Z., Lamme, L L., & Pringle, R 2007 Infusing Reading into Science. Literacy. Alexandria: Educ Leadership.
[15] Fang, Z. dan Wei, Youhua 2010 Improving Middle School Student’ Science Literacy Through Reading Infusion the Of Educational Research 103 4: 262-273
[16] Li, Liang Yi., Fan, C.Y., Huang, D.W., Chen. G.D. 2012 The Effect Of E-Book System With The Reading Guidance And The Annotation Map On The Reading Performance Of College Students. Educational Technology & Society 17 1 320-331
[17] Artis, Andrew B 2008 Improving Marketing Students’ Reading Comprehension with SQ3R Method. Journal of Marketing Education 30 2 130-137
[18] Cohen, J 1969 Statistical Power Analysis for Behavioral Sciences. NY: Academiic Press
[19] Colliver, J 2000 Effectiveness of problem-based learning curricula. Research and theory Academic Medicine 75 259–266.
[21] Strobel, J., & Van Barneveld, A. 2009 When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-based Learning*, 3 1 44–58

[22] Liliawati W, et all 2018 The Effectiveness of learning materials based on multiple intelligence on the understanding of global warming Journal of Physics: Conf. Series 1013 012049

[23] Ainsworth, Shaaron. 2008 The Educational Value of Multiple-representations when Learning Complex Scientific Concepts Visualization: Theory and practice in science education. Dordrecht: Springer

[24] Fang, Z., Lamme, L., Pringle, R, Patrick, J, et al 2008 Integrating Reading into Middle School Science: What We Did, Found And Learned. *International journal of science education* 30 15 2067-2089

**Acknowledgments**

The author would like to thank to my advisors and physics teacher who assisted in implementation of this study and students who participated in this study.