JPII 7 (4) (2018) 458-466

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

THE INFLUENCE OF LEARNING MODELS AND LEARNING RELIANCE ON STUDENTS' SCIENTIFIC LITERACY

Ratini*[1,2], H. Muchtar[3], M. A. Suparman[4], A. H. Tamuri[5], E. Susanto[6]

[1,6]Department of Biology, Faculty of Teacher Training and Education,
Universitas Muhammadiyah Metro, Indonesia
[2,3,4,]Post-Graduate School, Universitas Negeri Jakarta, Indonesia
[5]Universitas Kebangsaan Malaysia

DOI: 10.15294/jpii.v7i4.12489

Accepted: July 14th, 2018. Approved: December 10th, 2018. Published: December 29th, 2018

ABSTRACT

This research aimed to identify the influence of two learning models and learning reliance on students' scientific literacy. The method used was the treatment by 2 x 2 level. The participants were 36 students from the Department of Biology Education who were grouped into two categories based on the reliance questionnaire score, i.e., categories of high and low. The data were collected through scientific literacy tests, data analysis using two-path ANOVA formula followed by the Tukey test. The results showed that there was an influence on the interactions between the learning models and learning reliance on students' scientific literacy seen from the ANOVA test results which obtained $F = 29.88$, $\alpha = 0.05$. The Tukey test analysis identified; (1) Scientific literacy of college students who used the Science, Technology, Society (STS) model was higher than those who adopted the Problem-Based Learning (PBL) Model with $Q = 4{,}74$ at $\alpha = 0.05$; (2) The scientific literacy of students having high learning reliance using the STS learning model was better than those applying the PBL with $Q = 11{,}78$ at $\alpha = 0.05$; (3) The scientific literacy of students having low learning reliance using the STS learning model was lower than those using the PBL with $Q=5.07$ at $\alpha = 0.05$. It concluded that the STS learning model could improve the students' scientific literacy. In other words, the STS learning was more useful for the high reliance students than those with low reliance.

Keywords: learning reliance, STS, scientific literacy

INTRODUCTION

The rapid development of science, technology, and society requires people to have necessary skills beyond reading, writing, and arithmetic skills to survive in life. The ability to read and write through the script, in the past several centuries generally interpreted as "literacy." Through education, it is expected to form science and technology-literate humans, as a bridge connecting to the environment to play a role as a human resource quality. The science referred to in this case is the "Science" concerning the object of nature (IPA), social, and technology. The various abilities of science mentioned above summarized in a concept called "Scientific Literacy." The purpose of scientific literacy education is to build a scientifical literacy society, that is, a social issue. Thus, the importance is not only the science concept mastery but also the thinking skills (Suwono et al., 2017; Holbrook & Rannikmae, 2009). Contended that scientific literacy extends beyond the mastery of foundational knowledge of scientific knowledge and apply it to relevant social contexts. Scientific literacy is a multi-literacy in which

***Correspondence Address**
E-mail: ratini.jamhur@gmail.com

individuals must develop fluency in coordinating these multiple modalities of scientific representation at proper times in the curriculum, and when viewed from a critical standpoint, the science literature also includes the ability to question and appropriate scientific knowledge in personally relevant circumstances (Trauth-Nare, 2015; France, 2011; Toharudin et al., 2011).

Educational experts and practitioners continually strive to find the best solution to help students find the knowledge, skills, and attitudes needed in the life of society. Various learning models are built to get effective and efficient ways to achieve the goals of learning/education, such as learning model of Science, Technology, Society (STS). The STS learning model is a form of learning that combines understanding and utilization of science, technology, and society so that the concept of science can be applied through skills that benefit students and society (Klein et al., 2001; Owen et al., 2012). The STS learning model is developed to increase the literacy of individual scientists to understand how science, technology, and society influence each other, and to improve the ability to use knowledge in making decisions (Putra, 2013). The curriculum of primary education has included a study on the basis of attitudes, personality, and knowledge development like sanitation, nutrition, and health. Therefore, environmental literacy is essential to be developed among students. Future teachers are very potential to create the right environment because they will be the agents of change in society. Moreover, future teachers have to pass on ethical values and characters in order to the sustainability of the environment (Farida et al., 2017).

Irregularities in healthy behaviors continue to occur in some communities, for example: adding hazardous ingredients in food management, consuming liquor or drugs, and letting waste pollute the environment. It alleged that such deviations occur because the learning system (especially science) conducted in schools that did not achieve the proper learning objectives of science. The learning model applied only to the development of cognitive ability (textual), while the real problem faced in life is contextual and it has not yet mastered. The further analysis results of the 2009 PISA data for Indonesian children are as follows: (1) The achievement of scientific literacy of students is low, with the average of 32% for the overall aspect consisting of 29% for content, 34% for the process, and 32% for the context; (2) The diversity of students' scientific literacy among provinces in Indonesia is relatively low; and (3) The ability to solve the problem of children in Indonesia is as low as Malaysia, Thailand, or the Philippines.

The level of students' scientific literacy that is considerably low caused by several factors, including school infrastructure, human resources, and school organization and management also influenced students' literacy achievement significantly (Ardianto & Rubini, 2016).

Field observations indicated that the discussion of chemicals in the classroom was limited to the content of the book/literature. There is no clear link between the material learned and the real problems that develop in the community. Derek Hodson Science Education is a form of indoctrination to a particular worldview so that young people do not question the underlying science. Derek Hodson Science education is incomplete if it does not involve students in preparing for and taking action on matters of social and political importance (Giordano, 2017; France, 2011; Sadler & Zeidler, 2009).

The results of interviews with students revealed that chemistry lessons are too abstract and elusive. Chemistry has been called the central science. Hence, the chemistry learning provides a unique context within which to consider the relationship between knowledge and social responsibility. This is what the public conscience of learners examined (Donald & Kovac, 2012). However, in the classroom, the lecturers presented several examples of problems in the community related to chemicals, but the students were not facilitated to investigate until they found a solution to problem-solving. The chemistry final examination results of the 2014/2015 academic year revealed that 113 students obtained the class average score of 50,5; the highest score was 77 and the lowest score was 28. Thus, it is considered necessary to optimize other learning models for enhancing the results of chemistry science learning.

In this study, the researchers believed that the STS learning model contributes to encouraging harmonious knowledge and skills through self-efficacy. Learners are parties who need to feel comfortable and fun in the learning process (Suparman, 2012; Akcay & Yager, 2010). Besides, teachers/lecturers are instrumental in conditioning facilities physically and mentally so that effective learning event is achieved. Learning reliance is seen as a person's autonomous capacity in self-learning. Self-learning does not mean learning alone, yet the self-study or independent learning with or without a teacher (Rusman, 2011; Toyokawa et al., 2017).

METHODS

This research was conducted using the experimental method involving three kinds of variables, namely: scientific literacy as the dependent variable, learning model as the independent variable, and learning reliance as the attribute variable. There were two kinds of learning model applied; STS learning in the experiment class (A1) and Problem-Based Learning (PBL) in the control class (A2). Learning reliance (B) as the attribute variable covered two categories, namely high learning reliance (B1) and low learning reliance (B2). Thus, the design of this research was "Treatment Design by 2 x 2 Level".

The target population in this study was all 930 students majoring in Natural Sciences Education (Mathematics, Physics, and Biology Education), Faculty of Education Sciences, Muhammadiyah Metro University. The available populations were 64 Biology education program students in the second semester of academic year 2015/2016. These students were split into two parallel classes; 32 students in Class A, and 32 students in Class B.

The STS learning model scheme is shown in Figure 1 and the PBL model learning scheme is displayed in Figure 2.

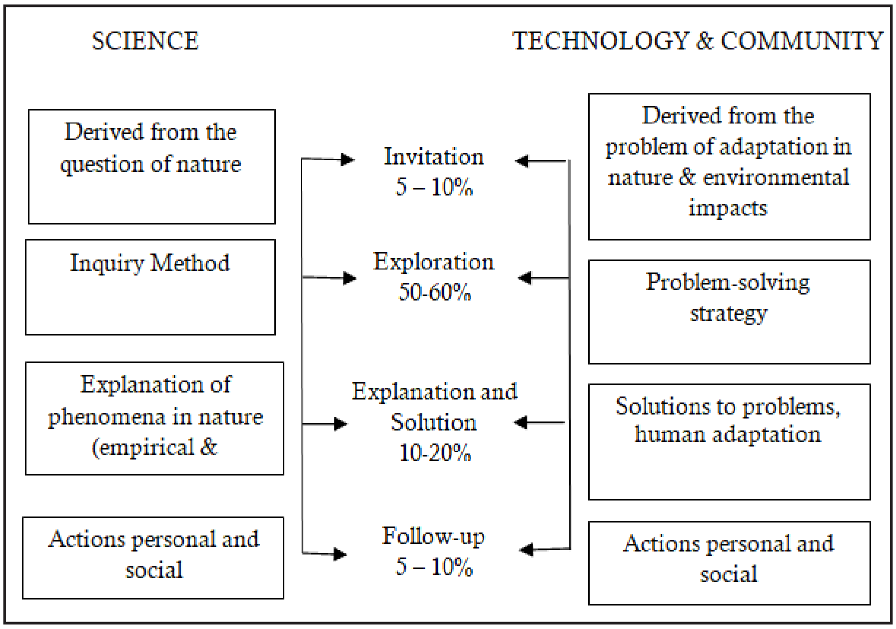

Figure 1. The Scheme of Science Learning Process with STS Model

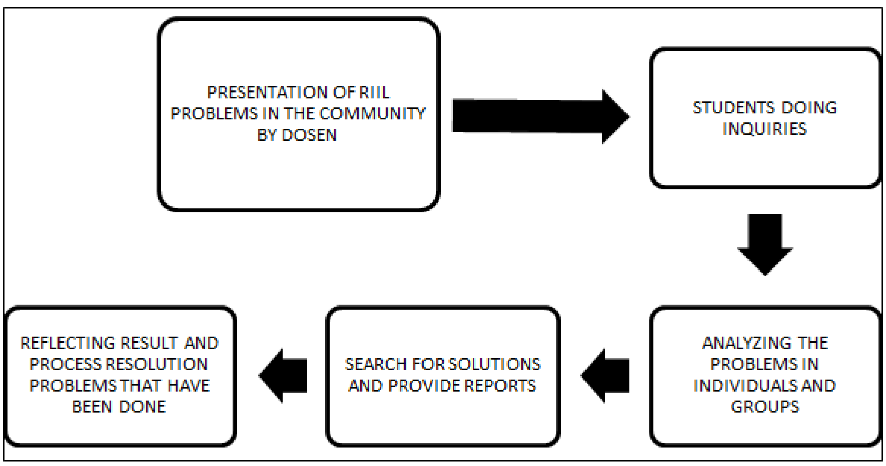

Figure 2. The Scheme of Science Learning Process with PBL Model

The types of data collection instrument employed were: 1) test, to measure scientific literacy through multiple-choice and descriptive questions; and 2) questionnaires, to measure the self-learning data. The validity of data collection instruments was determined through validity and reliability test techniques. The validation tests were performed in two stages; (1) content validation; and (2) empirical validation. The content validation refers to an assessment of the extent to which the instrument represents the desired content.

The empirical validation conducted on the test on 33 Biology Education students in the 3rd semester who have studied carbon compound. The validity of multiple-choice items (dichotomized grains) was calculated using the Biserial Point correlation formula while the reliability coefficient was calculated using the Kuder-Richardson formula 20 (KR-20). The validity of essay test (polytomy items have no discrete score) was computed using Product Moment correlation formula, and its reliability was analyzed employing the Alpha Cronbach formula through a validation test instrument to measure scientific literacy. There were 40 items of valid and reliable multiple-choice items with the coefficient reliability of 0.8961. Moreover, 4 essay items were also valid with the Alpha Cronbach coefficient reliability of 0.4181. Valid questionnaires consisting of 33 items had the coefficient reliability of 0.8947. The learnings were carried out eight times in the experimental class and control class.

The operational differences in the learning between the two models are presented in Table 2. Some elements of learning activities carried out in the experimental class and control class were made similarly for the subject matter of the discussion including the materials (Hydro Carbonyl, Carbonyl, Amine, Benzene) and its derivatives as well as natural and artificial polymer compounds (plastics), Napza, Petroleum, and food additives. The classes were split into eight groups. The learning of each class lasted in 8 x 100 minutes.

Table 2. The Differences in Learning Operations in the Experimental and Control Class

Elements of Learning	Activities	
	Experimental Class	**Control Class**
Learning model	Science Technology Society (STS)	Problem-Based Learning (PBL)
Core activities of learning (group)	Lecturer facilitates the process of problem formulation in the society based on the investigation results.	Lecturer presents community's real problem as a stimulus to generate an investigation.
	Looking for alternative troubleshooting solutions using brainstorming method.	Looking for alternative troubleshooting solutions using discussion method.

The scientific literacy data of the test results were analyzed by descriptive statistics to obtain the mean/standard values, standard deviations, minimum values, and maximum values. The data analysis with inferential statistics was conducted to test the research hypothesis. The data analysis was done on the 2-way ANOVA (Two-Way Analysis of Variance). Before the statistical data analysis was carried out, a pre-requisite analysis was done to test the Normality using the Liliefors while the Homogeneity test adopted the Chi-square formula. As a result, each group of data was normally distributed, and the intergroup comparing had a homogeneous variant.

Table 4. The Scientific Literacy Scores

Self-Reliance Learning (B)	Data	The Scientific Literacy Scores (Y) Based on Learning Model		Total Line
		STS (A_1) (Class Experiments)	**PBL (A_2) (Class Control)**	
Height (B_1)		A_1B_1	A_2B_1	B_1
	n	9	9	18
	Mean	72.00	49.83	60.83
	SD	4.74	8.89	12.35
	Max	79	69	79
	Min	65	40	40

		A_1B_2	A_2B_2	B_2
Low (B_2)	n	9	9	18
	Mean	36.89	46.28	41.94
	SD	6.51	10.41	9.98
	Max	48	62	62
	Min	26	25	25
		A_1	A_2	
Total column	n	18	18	
	Mean	54, 83	47.50	
	SD	16.98	11.08	
	Max	79	69	
	Min	26	25	

RESULTS AND DISCUSSION

Below is presented the detailed explanation based on the data analysis results;

Test of Hypothesis 1

Student Scientific literacy Using the A_1 (STS learning model) was higher if compared to the class using the A_2 (PBL Model).

$A_1 : A_2$

Hypothesis Statistic:

H_0 : $\mu_{A_1} = \mu_{A_2}$

H_1 : $\mu_{A_1} > \mu_{A_2}$

Test Criteria: Reject H_0 if Sig < 0.05

It obtained F=4,75 at the significance level of 5% and F=4,07 at the significance level of 1%. Based on the test criteria, then the H_0 was rejected at 5% and 1% significance level, that was 'The average scientific literacy score of students who learnt using the STS learning model (STS; A_1) was 53,83 or significantly greater than those using the PBL model (PBL: A_2) 47,50.

Test of Hypothesis 2

The ANOVA results obtained p = 0,05; which means that there was an influence of the interaction between learning model and learning reliance to scientific literacy. Thus, it argues that the learning had a significant effect on the value of students' scientific literacy depended on its learning reliance.

After proving that the interaction between learning model and learning reliance affected the scientific literacy, the analysis continued with the Tukey test to test the simple effect, indicated by the mean differences between A in each group B; (A_1B_1 : A_2B_1 and A_1B_2 : A_2B_2).

Test of hypothesis 3

The scientific literacy of students who had higher learning reliance using the STS Learning Model A_1B_1 was higher when compared to those the PBL (A_2B_1) Learning Model.

$A_1B_1 : A_2B_1$

Hypothesis Statistic:

H_0 : $\mu_{A_1B_1} = \mu_{A_2B_1}$

H_1 : $\mu_{A_1B_1} > \mu_{A_2B_1}$

Test Criteria: Reject H_0 if Sig < 0.05

The Tukey test resulted in the Q=11.78 (p 5%) and Q=4.60 (p 1%). Referring to the test criteria, then H_0 was rejected either at the significance level of 5% or 1%, which was: 'The scientific literacy of students having high self-reliance in the class employing the STS learning (STS; A_1B_1)= 72 or significantly higher than those using the PBL (PBL; A_2B_1) = 49.83.

Test of Hypothesis 4

Scientific literacy of students who had low learning reliance using the STS Learning Model (A_1B_2) was lower if compared to those using PBL Model (A_2B_2).

$A_1B_2 : A_2B_2$

Statistical Hypotheses:

H_0 : $\mu_{A_1B_2} = \mu_{A_2B_2}$

H_1 : $\mu_{A_1B_2} < \mu_{A_2B_2}$

Test Criteria: H_0 is rejected if Sig > 0.05

The Tukey test obtained Q=-5.07 (p > 5%) and Q=4.60 (p >1%). Referring to the test criteria, then the H_0 was rejected either at significance level of 5% or 1%, it means that "Scientific literacy of students having low learning reliance in the class applying the STS learning model (STS; A_1B_2)= 36.89 was lower than those in the class using PBL model (PBL; A_2B_2) = 46.28.

The use of STS learning model in chemistry learning was more effective than the PBL model in improving the students' scientific literacy particularly in Basic Chemistry of carbon compound materials. The STS learning model has the main characteristic of discussing a community's real issues. The discussed problems are figured by the students as the basis for the next activity: investigation. The STS learning model embraces constructivism learning theory and is implemented through a contextual approach; thus, it makes the experience more relevant to real-life problems in society. Constructivism is a learning process that emphasizes the active, creative, and productive awakening of knowledge by prior knowledge and from meaningful learning experiences (Hosnan, 2014; Bonney et al., 2009). Constructivist views imply that a teacher's role is to co-collaborate, guide, facilitate and coordinate the learning process, while the student's role is to participate in the process of acquiring and constructing knowledge actively. Therefore, it enables students to actively create their knowledge based on their previous and new experience through investigation, questioning, discussing, and reasoning (Zhukova, 2017; OECD 2009; Leonard, 2002; McCoaghan, 2008). In line with that, Richey et al. (2010) stated that learning refers to the relatively permanent change in a person's knowledge or behavior due to experience. The learning model of STS gives the effect of accompaniment in the form of critical thinking skill improvement, higher-level thinking and problem-solving skills covering cognitive, affective, psychomotor, and religious aspects (Wisudawati & Sulistyowati, 2014).

The PBL model facilitates students to take an active role in the class through a series of activities to think about issues related to daily life, find procedures to find needed information, solve problems, and present solutions to the problems (Abidin, 2014; Lewinsohn et al., 2015). The problem-based learning model is similar to the STS learning model in terms of providing an authentic experience, constructing knowledge, and integrating the learning context in real life naturally in order to encourage the active learning process. The PBL and STS learning model place problematic situation as a learning center, attract and retain an interest of learners to be able to express their opinion in multi-perspective. The difference is that the issues discussed in the STS learning were excavated from the students, while the lecturer presents the problems discussed in the PBL lesson. This difference has proven to have a significant effect on the learning process and results.

Literacy of science defines as an understanding of science and its application in solving real problems in society. Many science topics have suggested for science education such as Climate Change, 'greenhouse gas' emissions from factories, modes of transportation, and energy generation stations. However, the researchers pointed out that there are many other science topics in life such as health and social justice, pharmaceuticals, biotechnologies, toxic chemicals, and agricultural research and practices (Dos Santos, 2014; Bencze, 2009; Cronin, 2010). Literacy enables the development of new and more powerful forms of understanding including science, mathematics, and technology (Tobin, 2015). PBL learnings impress as completion of learning tasks given by lecturers, while in the STS learnings, students solve the problem themselves. Scientific literacy development is enhanced when learning contextualized in an exploration of socioscientific issues (Bay et al., 2017). Students are excited about conducting field investigations, tracking information across multiple sources, pursuing several learning methods such as discussion, questioning, experimentation or demonstration. Literacy is constantly evolving, and how teachers must evolve with it (Botzakis, 2014).

The ANOVA test results showed that the significance < α 0,05, which meant that there was a significant interaction between the learning model and the learning reliance on the scientific literacy. The results indicated that learning models and learning reliance determined the succes of students' scientific literacy improvement in learning carbon compound materials. Any different learning model applied to students who have different level of learning reliance will achieve different scientific literacy.

Through the STS learning model, on the discussion of 'properties and benefits of polymer compounds', the students found out the idea that the use of plastics in everyday life is more appropriate for durable equipment. As for packaging of tableware or drinking, it should not use plastic for some reasons: 1) some common materials for food package (e.g., Styrofoam) could release plastic molecule particles when exposed to heat; (2) common plastic food packaging has a lifespan of only for 15 minutes, then disposed of into trash. This would increase the amount of plastic waste on earth; (3) plastic waste has become a real pollutant for the soil and water environment as it is difficult to be decomposed by bacteria; (4) if the plastic is burned, it would cause smoke which is a pollutant of the air.

From this discussion, the students expressed their attitude as an alternative solution to the problems caused by the use of plastics: (1) avoiding plastic materials for packaging, food, and beverage equipment, also; b) avoid using a single-use plastic material (e.g., crackle bags and straws) and replacing it with other (or plastics) durable materials; and c) creating posters to persuade people to use recyclable and decayable materials.

This finding is consistent with the results of previous studies; that STS learning on Colloidal (Chemical) materials at MAN Kuta Baro Aceh could improve learning results and obtain positive responses from the students. In the exploration stage, the students could explore critical issues in a local and global scope. At the concept application stage, they might define how to manage factory exhausting gas, purify water and minimize the use of materials that can cause river pollution. The students were happy to learn the colloid materials. Associated with daily life using STS learning, they were more curious, dared to ask for an opinion. Also, such learning is able to cultivate environmental awareness (Rintayati et al., 2014).

Chemical educators have a responsibility to equip students in developing the scientific and technological insights of the social dimension and help improve their ability to devise solutions to their impact. There are many situations in which the society looks to science for accurate information, and guidance. The examples in the modern world include the scientific discourses on the state of the ozone layer, the likelihood of catastrophic earthquakes, tsunamis, or volcanoes, and the threat of radioactive sources in the environment, and current international issues such as solid wastes, atmospheric pollution, deforestation, deforestation, biological warfare and human cloning (Donald & Kovac, 2012).

Further analysis of the ANOVA with Tukey test showed that Qcount = 11.78> Qtable = 3.20 at α 0.05 or 4.60 at α 0.01. Thus, the H0 was rejected, which meant that the scientific literacy average of students who had a high learning reliance using the STS learning model was 71.56, or significantly higher than the scientific literacy average of students who applied the PBL model which amounted to 49.33. In an issue-oriented classroom, students analyze and discuss personal, societal, and global issues that require an application of the relevant scientific evidence. Learning in the context of issues can help people in the global community (Lenz & Willcox, 2012).

The students with high learning reliance set a learning goal to improve the mastery of the materials and determine the success of learning by comparing it with the results that have been achieved by themselves before, not compared to the results achieved by his friend. Self-learning means learning in an initiative with or without a teacher (Rusman, 2011). The students with high learning reliance were more responsible for making decisions in their study groups while the students with low learning reliance were apathetic in their group (Wahyuni & Sunarno, 2012). There were two kinds of factors that influenced the learning reliance; internal and external factors. The internal factors included psychological factors such as self-efficacy, learning motivation, attitudes, interests, a focus on control, self-discipline, and learning habits. Meanwhile, the external factor comprised natural environmental, socioeconomic, teachers, teaching methods, curriculum, subjects, and facilities (Wang et al., 2008; Woolfolk, 2009; Johnson & Johnson, 2009).

This research results showed that the high-reliance students applying the STS learning model reached a greater value of scientific literacy tests than the students who employed the PBL model. In other words, the STS learning model was useful to improve the students' scientific literacy to learn about carbon compounds particularly for those who had a higher score of learning reliance.

On the other hand, the low-reliance students who used the STS learning model had the average scientific literacy score of 36.89, or lower than those adopting the PBL model (46.28). It was evidenced by the Tukey test results of Q = α at 5.07 0.05 significance level, or Q = α 0.01 at 4.60. Hence, it was suggested that in improving scientific literacy, the low-reliance students apply the STS learning model.

Both the STS and PBL model intend to lead the development of real problem-solving skills. As for the difference, the problems discussed in the STS learning model are determined by the students, while the lecturer presents the problems discussed in the PBL model. The two models lead the lecturers/teachers to organize students in groups to conduct an investigation and literature study as the attempts to solve problems. The focus of the course is not on teaching specific topics within specific disciplines, yet on how scientific knowledge is constructed. Students immersed in the entire process of doing science while experiencing firsthand how aspects of Nature of Science (NOS needs to be considered when constructing scientific knowledge (Koenig et al., 2012).

The principle of "Dewey" i.e., learning by doing and experiencing ensures that schools should become a laboratory for search troubleshooting. The PBL was developed based on the cognitive psychological theory, which states that learning is an active process of someone in constructing his knowledge through interactions with a learning environment designed by a teacher/lecturer. Such learning patterns are appropriate for students who have a low learning reliance but less appropriate for those with high learning reliance since they would intentionally select their methods or learning resources they think more appropriate. Vygotsky's zone of proximal concept with the development of the scaffolding idea reinforced with Bruner revealed that learning occurs through a process of social interaction assisted by teachers and peers who are better able to overcome the problems encountered, and the effort to master a skill that slightly above the current level of development (Woolfolk, 2009).

Through the PBL model, the students are expected to be involved in the research process which urges them to identify problems, collect data and use the data to solve problems. Students will be involved very intensively so that motivation to continue learning and keep finding out is increasing. The learning process that gives students the opportunity to be actively involved in building knowledge contributes to the development of thinking skills (Ardianto & Rubini, 2016).

However, the more the freedom is given to the students in problem-based learning, the more the supervision is needed. The mistakes made in identifying problems have made the students anxious about finding new information. Similarly, in the stage of analysis and report writing, the students were not yet used to think holistically; so, they experienced difficulties in taking the conclusion. In such circumstances, lecturers are very necessary to provide assistance. It appeared that the low-reliance students tended to do only learning activities which assigned to him. They were less initiative to select another learning resource. Based on some of the above description, the low-reliance students could learn and achieve better when learning with the PBL model. As a result, the high-reliance students' scientific literacy was lower when studying using the STS learning model.

CONCLUSIONS

The overall results of the hypothesis testing showed that there was an influence of the interaction between the learning model and learning reliance on scientific literacy. In sum, the STS model was more useful for improving the students' scientific literacy in comparison with the PBL model. The high-reliance students' scientific literacy was better when studying using the STS learning model, on the other hand, the low-reliance students were suggested to apply the PBL model in order to enhance their scientific literacy. The researchers expected that future studies creatively modify the picked learning model so that it will be suitable for the students' state of reliance in relation to the enhancement of scientific literacy.

REFERENCES

Abidin, Y. (2014). *Desain Sistem Pembelajaran dalam konteks Kurikulum 2013*. Bandung: Refika Aditama.

Akcay, H., & Yager, R. E. (2010). The Impact of a Science/Technology/Society Teaching Approach on Student Learning in Five Domains. *Journal of Science Education and Technology*, *19*(6), 602-611.

Ardianto, D., & Rubini, B. (2016). Comparison of Student's Scientific Literacy in Integrated Science Learning Through Model of Guided Discovery and Problem Based Learning. *Jurnal Pendidikan IPA Indonesia, 5*(1), 31–37.

Bay, J. L., Vickers, M. H., Mora, H. A., Sloboda, D. M., & Morton, S. M. (2017). Adolescents as Agents of Healthful Change through Scientific Literacy Development: A School-University Partnership Program in New Zealand. *International Journal of STEM Education, 4*(1), 15-35.

Bencze, J. L. (2009). "Polite Directiveness" in Science Inquiry: A Contradiction in Terms? *Cultural Studies of Science Education*, *4*(4), 855-864.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen Science: a Developing Tool for Expanding Science Knowledge and Scientific Literacy. *BioScience*, *59*(11), 977-984.

Botzakis, S., Burns, L. D., & Hall, L. A. (2014). Literacy Reform and Common Core State Standards: Recycling the Autonomous Model. *Language Arts, 91*(4), 223-235.

Cronin, K. (2010). The "Citizen Scientist": Reflections on the Public Role of Scientists in Response to Emerging Biotechnologies in New Zealand. *East Asian Science, Technology, and Society, 4*(4), 503–519.

Donald, K. J., & Kovac, J. (2012). The Scientist's Education and a Civic Conscience. *Science and Engineering Ethics*, *19*(3), 1229-1240.

dos Santos, W. L. P. (2014). Debate on Global Warming as a Socio-Scientific Issue: Science Teaching towards Political Literacy. *Cultural Studies of Science Education*, *9*(3), 663-674.

Farida, I., Hadiansyah, H., Mahmud, M., & Munandar, A. (2017). Project-Based Learning Design for Internalization of Environmental Literacy with Islamic Values. *Jurnal Pendidikan IPA Indonesia, 6*(2), 277–284.

France, A. (2011). Speaking about Scientific Literacy. In *Scientific Literacy Under the Microscope* (pp. 101-109). SensePublishers.

Giordano, S. (2017). Feminists Increasing Public Understandings of Science: A Feminist Approach to Developing Critical Scientific Literacy Skills. *Frontiers: A Journal of Women Studies*, *38*(1), 100-123.

Holbrook, J., & Rannikmae, M. (2009). The Meaning of Scientific Literacy. *International Journal of Environmental and Science Education*, *4*(3), 275-288.

Hosnan, M. (2014). *Pendekatan Saintifik dan Kontekstual dalam Pembelajaran Abad 21: Kunci Sukses Implementasi Kurikulum 2013*. Ghalia Indonesia.

Johnson, D. W., & Johnson, R. T. (2009). An Educational Psychology Success Story: Social Interdependence Theory and Cooperative Learning. *Educational researcher*, *38*(5), 365-379.

Klein, J. T., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R. W., & Welti, M. (Eds.). (2001). *Transdisciplinarity: Joint Problem Solving Among Science, Technology, and Society: An Effective Way for Managing Complexity*. Springer Science & Business Media.

Koenig, K., Schen, M., & Bao, L. (2012). Explicitly Targeting Pre-Service Teacher Scientific Reasoning Abilities and Understanding of Nature of Science through an Introductory Science Course. *Science Educator, 21*(2), 1–9.

Lenz, L., & Willcox, M. K. (2012). Issue-Oriented Science: Using Socioscientific Issues to Engage Biology Students. *The American Biology Teacher, 74*(8), 551–556.

Leonard, D. C. (2002). *Learning Theories, A to Z*. London: Greenwood Press.

Lewinsohn, T. M., Attayde, J. L., Fonseca, C. R., Ganade, G., Jorge, L. R., Kollmann, J., ... & da Rocha, P. L. (2015). Ecological Literacy and Beyond: Problem-Based Learning for Future Professionals. *Ambio*, *44*(2), 154-162.

McCaughan, K. L. (2008). *Problem-Based Learning Tutors' Beliefs and Challenges* (Doctoral Dissertation, Faculty of Education-Simon Fraser University).

Organization for Economic Co-operation and Development. (2009, September 8). *Education at a Glance 2009 : OECD indicators.* OECD. Retrieved from http://www.oecd.org/education/skills-beyond-school/educationataglance2009oecdindicators.htm

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible Research And Innovation: From Science in Society to Science for Society, with Society. *Science And Public Policy*, *39*(6), 751-760.

Putra, S. R. (2013). *Desain Belajar Mengajar Kreatif Berbasis Sains*. Yogyakarta: DIVA.

Richey, R. C., Klein, J. D., & Tracey, M. W. (2010). *The Instructional Design Knowledge Base: Theory, Research, and Practice*. Routledge.

Rintayati, P., & Putro, S. P. (2014). Meningkatkan Aktivitas Belajar (Active Learning) Siswa Berkarakter Cerdas dengan Pendekatan Sains Teknologi (STS). *Didaktika Dwija Indria*, *1*(2), 1-24.

Rusman. (2011). *Model-Model Pembelajaran: Mengembangkan Profesionalisme Guru*. Jakarta: Rajawali Pers/PT Raja Grafindo Persada.

Sadler, T. D., & Zeidler, D. L. (2009). Scientific Literacy, PISA, and Socioscientific Discourse: Assessment for Progressive Aims of Science Education. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *46*(8), 909-921.

Suparman, M. A. (2012). *Desain Instruksional Modern: Panduan Para Pengajat dan Inovator Pendidikan*. Jakarta: Erlangga.

Suwono, H., Pratiwi, H. E., Susanto, H., & Susilo, H. (2017). Enhancement of Students' Biological Literacy and Critical Thinking of Biology through Socio-Biological Case-Based Learning. *Jurnal Pendidikan IPA Indonesia, 6*(2), 213–220.

Tobin, K. (2015). *Handbook Pengajaran dan Pembelajaran Sains*. Bandung: Nusa Media.

Toharudin, U., Hendrawati, S., & Rustaman, A. (2011). Membangun Literasi Sains Peserta Didik. *Bandung: Humaniora*.

Toyokawa, W., Saito, Y., & Kameda, T. (2017). Individual Differences in Learning Behaviours in Humans: Asocial Exploration Tendency Does Not Predict Reliance on Social Learning. *Evolution and Human Behavior*, *38*(3), 325–333.

Trauth-Nare, A. (2015). Re-Envisioning Scientific Literacy as Relational, Participatory Thinking and Doing. *Cultural Studies of Science Education*, *11*(2), 327-334.

Wahyuni, E. T., & Sunarno, W. (2012). Pembelajaran Biologi dengan Pendekatan Contextual Teaching and Learning melalui Metode Observasi Laboratorium dan Lingkungan ditinjau dari Keingintahuan dan Kemandirian Belajar Siswa. *Jurnal Inkuiri*, *1*(1), 1-9.

Wang, Y., Peng, H., Huang, R., Hou, Y., & Wang, J. (2008). Characteristics of Distance Learners: Research on Relationships of Learning Motivation, Learning Strategy, Self-Efficacy, Attribution and Learning Results. *Open Learning*, *23*(1), 17-28.

Wisudawati, A. W., & Sulistyowati, E. (2014). *Metodologi Pembelajaran IPA*. Jakarta: Bumi Aksara.

Woolfolk, A. (2009). *Educational Psychology: Active Learning Edition.* Boston: Allyn & Bacon.

Zhukova, O. (2017). Novice Teachers' Beliefs about Problem-Based Learning Approach, and Teaching Practices. In *CBU International Conference Proceedings.* (Vol. 5, p. 901). Central Bohemia University.