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PROJECT BASED LEARNING INTEGRATED TO STEM TO ENHANCE ELEMENTARY SCHOOL'S STUDENTS SCIENTIFIC LITERACY

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ABSTRACT

This study was done to depict Project Based Learning (PjBL) integrated with science science, technology, engineering, and mathematics (STEM), to enhance elementary school students' science literation. Theme used in this study was air pollution. Research method was quasi experimental with The Matching-Only Pretest-Posttest Control Group Design. It was conducted in 56 seventh graders of SMP Islam Terpadu, Sukabumi in which 28 students were in experiment class, and 28 students were in control class. Data is collected by pretest and posttest of sciences literacy and students questionaire about PjBL STEM. Based on the data analysis, it was known that the N-Gain averages of sciences literacy were 0,31 in experiment class as middle category and 0,22 in control class as low category. T-test showed that scientific literacy enhancemen in experimental class was more significant than in control class. General students' reponses showed that almost all students was excited to PjBL STEM learning, got impressive experiences during the learning and boost their learning motivation and interest.

Keywords: Project Based Learning, STEM, air pollution

INTRODUCTION

The essence of sciences learning is not only to remember and understand concept found by scientist. More than it, sciences learning gives direct and meaningful learning experiences which can be applied in the daily activities. The means in sciences learning can be acquired through students' sciences literacy which is beneficial in problem solving activity. Sciences literacy needs scientific concept comprehension, ability to apply it based on scientific perspective, and scientific thinking about evidences (OECD, 2010)

PISA *(Programme for International Student Assesment)* gives interest to students' cognitive and afective aspects which can be applied to construct sciences competencies. The cognitive aspect includes students' knowledge and their capacity to effectively use and involve cognitive process as one of sciences characteristics in personal, social and global aspects. The affective aspects are related to problems which can be solved by scientific knowlegde and shape students who can make decission in current situation and for the future (OECD, 2010; OECD, 2013).

Scientific literacy is reputed as the main learning outcome in 15 years old – students' education, aparts from are the students motivated to keep sciences learning or not after that (Toharudin, *et al.*, 2011). Based on scientific litereracy achievement of PISA year 2012 whic involved 65 countries, Indonesia got the socond position from the bottom. The average score of Indonesian student was 382 below PISA average score, 501 (OECD, 2014). Students' low aerage of scientific literacy is one of reason for our goverment to revise 2006 curriculum into 2013 curriculum (Odja

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& Payu, 2014). Therefore It is needed a sciences learning that improve students' scientific literacy.

Sciences learning in curriculum 2013 have given a reference in choosing learning models appropriate to scientific approach. Those learning models involve *Project Based Learning* (PjBL), *Problem Based Learning* (PBL), or *Discovery Learning.*The selection of learning model is given to the teachers by considering learning material characteristic. PjBL is a student centered learning model and it gives meaningful learning experiences to the students. Students' learning experiences or concept acquisition is constructed based on final product produced in the learning.

PjBL implementation in sciences learning was known can improve cognitive learning outcome (Baran & Maskan, 2010), shape environment friendly attitude and behaviour (Kılınç, 2010; Tseng, *et al.*, 2013), scientific process skill (Özer & Özkan, 2012), and effective learning (Cook, *et al.*, 2012; Movahedzadeh, *et al.*, 2012). PjBL is more appropriate in interdiciplinary learning because it naturally involves many different skills, such as reading, writing, matematical and helps conceptual knowledge construction through asimilation of other different subjects (Capraro, *et al.*, 2013) so that it is expected to construct student's scientific literacy.

Beside PjBL, learning nowadays need to go with the trend in globalization era, one of those is by integrating *Science, Technology, Engineering, dan Mathematics* (STEM). Relationship between sciences and technology or other knowledge can not be separated in sciences learning. STEM is science dicipline which is related each other. Sciences need mathematics as data analysis tool, whereas technology and technique are the sciences application. STEM approach in learning is expected to give a meaningful learning to students through systematic integration of knowledge, concept and skills. Some benefits of STEM approach are improving students' problem solving skill, innovators, inventors, independent, logic thinker, and technological literacy (Morrison dalam Stohlmann, *et al.*, 2012). The more comprehensive way to invest all fourth diciplines each other is by teaching them as an integrated subject. For instance, there are contents of technology, technique and mathemathics in sciences, so that sciences teacher will integrate T, E, and M in S (Dugger, 2010)

STEM learning need to emphasize some aspects in learning (NRC, 2011), such as: (1) proposing questions (sciences) and defining problem (engineering); (2) improving and using model; (3) planing and doing investigation; (4) analyzing and interpreting data (mathematics); (5) using mathematics, information technology, computer and thinking computation; (6) building explanation (sciences) and designing solution (engineering); (7) being involved in argument based on evidences; (8) acquiring, evaluating, and communicating information.

Research on STEM integration in PjBL to scientific literacy was rarely done. Tseng, et al. (2013) revealed that PjBL integrated by STEM can improve students' learning motivation, create meaningful learning, help students in solving daily life's problem, and support future career. Instead of those, STEM in PjBL also gave challenges and motivated students because it trained students to think critically, analytically, and enhanched higher order thinking skill (Capraro, *et al.*, 2013). With STEM learning, students have visible sciences and technology literacy which can be seen from reading, writing, observing, and doing sciences as their skill to live in the society and solving daily life's problem related to STEM (Mayasari, *et al.*, 2014).

National Research Council (2011) stated that in STEM learning, students had a chance to learn sciences, mathematics and technique by solving problems applied in real context. In STEM clasroom, students are demanded to solve real life problem and involved in ill-defined tasks to be well defined outcome in their group (Han, *et al.*, 2014). STEM education becomes the priority in soving global issues dan current real life's problem, such as: gloal warming, air and water pollution, fresh drinking water, as well as food safety (Reeve, 2015)

Air pollution theme is one of learning material which is acomodated in Sciences learning in junior high school. Air pollution becomes a big problem in real life and needs a solution in sciences learning. Air pollution comes from human activities and natural phenomenon. Industry, construction, electricity generator, transportation, and agriculture are some human activities which contribute to the pollution (Glencoe, 2005; Raven, *et al.*, 2013). Therefore, the awareness of the importance to save the environment need to be embeded in early education as a preventive way in facing current environmental issues.

Based on explanation above, the problems in this study are (1) Can PjBL STEM learning enhance students' scientific literacy in air pollution theme?; (2) How is the improvement of students' scientific literacy related to STEM aspects?; (3) How is students response to PjBL STEM learning? . PjBL STEM learning in this study was conducted in five steps (Laboy-Rush, 2010), in-

volved reflection, research stage, discovery stage, application stage, and communication stage.

METHOD

This study was done by quasi-experimental method with *The Matching-Only Pretest-Posttest Control Group Design* (Sukmadinata, 2010; Fraenkel, *et al.*, 2011). Class matching in this research was assumed as a class which had equal ability and taught by the same teacher.

This experiment was done by conducting learning in PjBL STEM model in experimental classs and common used learning in control class. Both classes are given pretest and posttest which are expected to measure students' scientific literacy before and after treatment. Table of conducted experiment is shown by Table 1.

Table 1. The Matching-Only Pretest-Posttest Control Group Reaserch Design

Matching Class	*Pretest*	Treatment	*Posttest*
Experiment	O	X	O
Control	O	C	O

Description:
O : pretest-postest
X: treatment (PjBL STEM Learning)
C: common used learning (CTL)

Based on the table above, it can be seen that questions given in pretest and posttest are the same. Data of students' answer then analysed and statistically tested to know th eimprovement of students' scientific literacy.

Subjects in this research are students of grade VII in semeseter 2 at SMP IT in Sukabumi in academic year 2015/2016. They would have sciences learning of air pollution theme. We took three classes which are chosen based on matching class (Fraenkel, *et al.*, 2011). Class categorization in this school is based on gender, where woman and man are separated. Election of experimental class and control class is based on the subject teacher's recommendation and school's management permission referred to students' competences. Class VII B (woman class) was taken as experimental class where we conducted the PjBL STEM learning, and VII C (woman class) as the control class who was learning concept to be studied,the air pollution.

Instruments used in this study are literacy question which is refered to PISA 2012 which is related to STEM aspects and attitude scale questionaire to explore students' response. Scientific literacy test does not only measure students' comprehension level of scientific knowledge, but also comprehension of sciences competences aspects, ability to applly the knowledge, and scientific attitude, as well as scientific context in students' real context. Whereas, students response questionaire is statements about response's object which can be represented in rating scale or check list. This study used closed-ended questionaire; means the respondents can directly choose prepared answer for each question. There are two kinds of questions in likert scale, those are positive and negative statements. Likert scale is categorized as follow; extremely agree, agree, disagree, and extremely disagree.

Each question was arranged and developed based on learning indicators corresponded to scientific literacy indicators which composed by knowledge and scientific competences related to sciences application context and scientific attitude. The items were consulted and validated by expert lecturer then tested. There were 25 items of multiple choices test for knowledge and competence aspect in air pollution context. Whereas, scientific attitude aspect was measured by 15 statements of Likert scale. Correlation coefficient (r_{xy}) of multiple choice testing was 0.58 and its reliability coefficient was 0.73 (high category). Testing of scientific attitude gives *Cronbach's Alpha reliability* of 0.619 (high category)

Raise of students' scientific literacy after PjBL STEM learning is measured by calculating normalized (N-Gain) average score.The formula used is as follow (Hake, 1998)

$$< g > = \frac{\%(S_f) - \%(S_i)}{100 - \%(S_f)}$$

where $< g >$ is the normalized gain, S_f is average of *postest score,* and S_i is average of *pretes score.* Hake (1998) interpreted average normalized gain as follow; low category when (<g>) < 0,3; medium category 0,3 ≤ (<g>) < 0,7; andhigh category when (<g>) ≥ 0,7 .

After getting average of the normalized gain from both groups, it is then compared each other to see the differences of scientific literacy raise of both classes. If the average of normalized gain average is higher than other from other different learning, it can be said that the learning is more effective to enhance students'scientific literacy skill than other learning. Hypothesis test used here was one tailed t-test for upper class. It is processed by SPSS 17 with two independent samples t-test.

RESULT AND DISCUSSION

Pretest was given before experimental and control class got the treatments to explore students' prior knowledge. Then after treatments they also got the scientific literacy skill for the second time. The raise of students'scientific literacy at in air pollution topic was calculated by normalized gain (N-gain) formula based on pretest and posttest data.

Comparison of students' scientific literacy pretest, post test, gain and N-gain average in aspects of knowledge and competence in experimental and control class at air pollution topic is represented by Graphic of Figure 1.

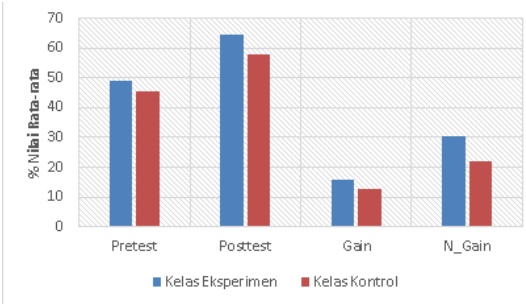

Figure 1. Graphic of Comparison among *Pretest, Posttest, Gain* dan *N-Gain* in Knowledge and Competence Aspects of Scientific literacy.

Figure 1 shows that there is a difference of students scientific literacy score average between experimantal dan control class. The highest pretest score average achievement of knowledge and competence aspects in experimental class was 49.00 of 100, while in control class was 45.29. Posttest score average of experimental class was higher than control class, it is respectively 65.57 and 58.00. The raise of pretest and posttest average in each class was represented by N-gain in percentage where 31 in experimental class (medium category) and 22 in control class (low category). So, it can be concluded that students in experimental class have a higher scientific literacy raise than control class in knowledge and competence aspects.

Scientific attitude aspects score was also different in both class before and after treatment. The raise of students scientific attitude was observed in normalized gain (N-gain). The difference of students scientific attitude in experimental and control class is shown by Table 2.

Table 2 shows that there is a difference between students' scientific attitude achievement in experimental and control class. The highest achievement in pretest, posttest, gain and N-Gain was in experimental class, and the lowest was in control class. The difference of N-Gain from both classes was 12 points. The raise in experimental class was in medium category, while the control class was low category. So, the raise of students' scientific attitude of experimental class was better than control class.

Hypothesis test used to know tha raise of students' scientific literacy after PjBL STEM learning treatment was average N-Gain difference test to compare two independent samples. Based on prerequisite test of normality and homogeneity, data of scientific literacy N-Gain used t-test. Result of scientific literacy N-Gain t test is shown in Table 3. Hypothesis thest of scientific literacy raise is as follow.

H_0: There is no difference between the raise of scientific literacy between experimantal and control class

H_1: There is a difference between the raise of scientific literacy between experimantal and control class

Reject H_0 if p-value/2, (sig.)< α = 0,05, and accept H_0 if p-value/2, (sig.) $\geq \alpha$ = 0,05

Table 3 describes that the significance value acquired from students' N-gain scientific literacy data of experimental dan cntrol class in experimental and control class in aspects of knowledge

Table 2. Recapitulation of Students' scientific literacy in Scientific attitude aspects

Class	Pretest	Posttest	Gain	% *N-Gain*	Category
Experimental	70.89*	82.32*	11.43*	40*	Medium
Control	69.82	78.39	8.57	28	Low

*the highest percentage

Table 3. Result of Students' scientific literacy N-Gain t-test

Data of Scietific literacy N-Gain	*Sig. Value (2-tailed)*	*Sig.*	α	Interpretation
Knowledge and Competencies	0.053	0.026	0.05	Significantly different
Scientific attitude	0.001	0.000		

an d scientific ciompetence are smaller *sig.* = p-value/2 = 0,053/2 = 0,026) from α (*sig*. 0,026 < (α) 0,05), so H_0 is rejected and H_1 is accepted. It means, there is a significance different in the raise of students scienctific literacy in aspects of knowledge and competence. While, with the students' scientific attitude N-Gain of *sig.* 0,000 < (α) 0,05, it accepts H_1, means there is a diffenrence between experimental and control class. Generally, it can be concluded that the raise of students' scientific literacy in experimental classs with PjBL STEM sciences learning is better than control class witl CTL. Similar study was done by Afriana, et al. (2015) which revelaed that students scientific literacy skill in experimental class with greenhouse miniatur project was significantly different to control class.

Students of experimental class and control class which compared here are all female. Experimental class and control class are the matching class based on gender and pretest of scientific literacy. Learning model in both class is assumed can enhance students' scientific literacy, where PjBL STEM was implemented in experimental class and CTL in control class. Research of Dewaters & Powers (2006), revealed that PjBL can enhance scientific literacy by active involvement of K-12 students as well as students' interest and competences in STEM concept. While, CTL approach with its seventh's stages applied in sciences learning can build students' scientific literacy (Toharudin, *et al.*, 2011).

Learning applied in this study combined other scientific field to teach sciences. Integration of technology, engineering and mathematics were learned in air pollution topic. STEM aspects are already integrated in leearnin so it needed to be measured to know the raise of STEM aspects cohesiveness. In order to measure STEM aspects raise, the scientifical literacy questions developed were related to STEM indicator. Th ecohesiveness of the questions included sciences aspect (S) , sciences – tecnology (S-T), science – mathematics (S – M), sciences – technology – engineering (S-T-E). The raises of STEM aspects of each question' indicator are represented by Figure 2.

Figure 2 describes the raise of STEM aspects combined with students' scientific literacy questions. Experimental class was superior in indicator of S, S-T and S-T-E, while control class was superior in S-M indicator. It showed that sciences learning generally had combined mathematics in doing calculation as well as associating experimental data. Result of an experiment in sciences always use mathemathic either in analyzing or presenting data.

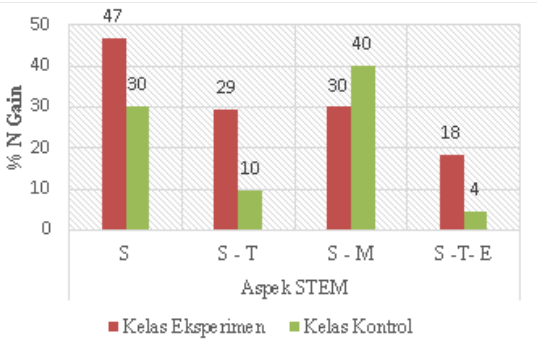

Figure 2. Graphic of average N-Gain for each STEM aspects indicator

The lowest achievement of experimental class and control class was at S-T-E indicator with each raise respectively 18% for experimental class adn 4% for control class.In experimental class, this indicated that technology and engineering were in very initial stage of introduction to students through PjBL STEM learning. Students are not used to get it and it was the their first experience to have a different learning model. Morgan, et al. (2013), stated that engineering serves a good context to represent other concepts because it discuss about real world problems, but it could be also hard for students to visualize it. In addition, *, the way pupils commence, progress, and complete their project demonstrates that creative thinking in technology is a combination of vertical and lateral thinking*(Waks; Barak & Doppelt; dalamDoppelt, 2005). Thereby, PjBL STEM learning in this study was a way to train students think critically. Compared to control class, learning stage in CTL approach had not integrated STEM. As stated by Dwivedi (2014), PjBL for STEM education is an interesting and effective way to learn about sciences, thechnology, and mathematics. So that, PjBL STEM could be an alternative learning model for teachers to conceive implementation of technology and engineering in the classroom.

Questionnaire of attitude scale was used to know students' response to PjBL STEM learning implementation in air pollution topic. Students' response questionnaire was given after PjBL STEM learning step fully done. Distribution of students response questionnaire in this topic was divided into four indicators; fun and more motivate students by implementing model; helping to unsderstand the concept, building creativity and awareness to save environment; enjoy working in a group; having intention to implement the learning model in other topics. Questionnaire was given to collect data of students' responses to the learning to get a tendency of students' attitude

after learning in the experimental class. Attitude scale used was composed by 10 positive statements. Recapitulation of Students' attitude scale to the learning is represented in Table 4.

Table 4. Recapitulation of Students' attitude scale analysis of PjBL STEM implementation

Indicator	% Average
Students enjoy and motivate to learn air pollution with PjBL STEM	79,31
Students had na notion that PjBL STEM implementation can help understanding air pollution theme, build creativity, and more aware to save the environtment	81,68
Students enjoy ctivities in their group	81,03
Students wants to have PjBL STEM learning in other topics	81,03
Average	80,77

Based on general analysis of the instruments, it is known that almost all students is agree with implementation of PjBL STEM model in learning air pollution. Other studies support this by stating that PjBL is an interesting and joyful learning (Yalçin *et al.,* 2009; Kemdikbud, 2014). Thereby, by implementing PjBL STEM it is expected to give students a new learning experience so that improve students motivation in learning air pollution

CONCLUSION

Project based learning integrated with STEM in experimental class was significanly enhance students' scientific literacy skill in air pollution concept. The raise basen on N-Gain average score for experimental class and control class were respectively 0.31 an 0.2. Aspect of knowledge, competence, and scientific attitude in experimental class was in medium category and control class was in low category. The raise of scientific literacy which accmodated by STEM aspects in experimental class is superior in indicators of sciences (S), sciences-technology (S-T), and sciences-technology-engineering (S-T-E). While control class, was superior in sciences-mathematic indicator (S-M). The findings of students' response questionnaire for PjBL STEM implementation in air pollution concept showed that precentage average in all categories are positive and agree with the PjBL implementation. It revealed that the learning applied was interesting and motivated the students, help topic comprehension, buid creativity, make students more aware about the importance of saving environment, and have a will to reuse PjBL STEM learning model.

PjVL STEM can be implemented in sciences concept which related to technology and engineering to solve real lifeproblems. PjBL STEM stage starting from planning to making project which lets the studets to use material and tool (techological aspect), arranging solution (engineering aspect), and communicating the result in a table/graphic (mathematics) gives a direct meaningful sciences learning. Direct and meaningful learning in acquiring knowledge will influnce students scientific literacy. Moreover, findings in this study also support previous findings and research on PjBL as well as PjBL STEM to enhence stundents scientific literacy.

Not maximal achievement of students' scientific literacy indicated that learnig process quality was not opmtimal yet because students were not used to get through each stsge of PjBL STEM. Students were more focused on final product to finished at time given. So, the further implementation needs a better time managemnet. This study can be advanced by other methods or other topic which is appropriate to STEM characteristic. Subject in this study is all female, so the gender difference needs to be explored in further PjBL STEM learning implementation.

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