How Problem based Learning Integrated STEM Affects to Science Literacy on the Aspect Content of Science

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Abstract: Scientific literacy is one of the 21st century competencies that must be mastered by the pre-service teachers of chemistry in order to compete the challenges in both national and international. One of the aspects of literacy is a science content, namely chemical essential concepts needed to understand natural phenomena and changes towards nature performed by human activity. This research aims to find out the effect of problem-based learning integrated to science, technology, engineering, and mathematics (STEM) towards the enhancement of science literacy particularly on the science content. The content of science that examined are chemical kinetics with indicator: the relationship between the concentration of reactants and time; energy dependence of the rate constants and activation against temperature; and the factors that affect the rate of reaction. The research method used was weak experimental designs through the one-group pretest-posttest design. The research sample is 34 students on the fourth semesters of Chemistry Education in the academic year 2016/2017. Furthermore, the instruments used in this research is an essay test. The data obtained were analyzed by quantitative descriptive technique. The results showed an average rating of 49.2 pre-test and average value of 69.5 posttest with value N-Gain (%) amount to 39.1 (medium). Therefore, the model of problem-based learning integrated science, technology, engineering, and mathematics (STEM) provides a positive contribution towards the enhancement of student's science literacy.

1 INTRODUCTION

The 21st Century is commonly known as the globalization era which influence various aspects of life including the implementation of the education. Furthermore, education is being the important aspect to ensure the students in order to have basic skills to learn and innovate using a technology, understand the information media, be able to work together, and survive by using life skills (Murti, 2015). In addition, the education also should be capable to produce the competent human resources and be able to compete in the real world (Wijaya, et al, 2016). Besides, to enhance the students' ability in the 21st century, the character education must be implemented in the education.

The science literacy is an individual's capacity to use scientific knowledge, identify questions, draw conclusions based on the evidence in order to understand and help the students to make decisions about the natural world and the interaction people to the nature (OECD, 2009; 2013; Bahriah, 2014). Also, it can be defined as person's ability to understand science, communicating science both oral and written form and implement scientific knowledge to solve the problems (Toharudin, 2011). Based on the definition of both the experts we can conclude that science literacy is the ability of a person to be able to solve the problem by using knowledge of science. Miller (1998, in Permanasari, 2016) posited that science literacy can be defined as the ability to read and write about science and technology. A person's ability in science was strongly influenced by the systematic way of thinking, logical and rational, which is highly trained in mathematical potential. Both of these capabilities will be used to conduct a critical analysis of a phenomenon in science, use it anyway at the moment someone doing troubleshooting context-related science. The ability to think logically and rationally is one of the aspects of mathematical literacy. A literat towards mathematics, usually will have the ability to think of the phenomenon that was discovered with a logical, systematic, and troubled by critical thoughts (Permanasari, 2016).

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Therefore, the science literacy is very important to be developed because everyone needs a lot of information and knowledge to determine a correct choice and solve the problems faced in every day. It contributes in the social's life and the household management in the decision-making process (Laugksch, et.al, 1999). According to Hayat (2010) the science literacy is needed to as a rule model to compete the complex problems in this global world. The nature of science literacy is considered by three elements such as knowledge about the content, understand the knowledge and conduct a scientific research (Wenning, 2006).

However, the assessment study conducted by PISA (Program for International Student Assessment) revealed that learning science in Indonesia less successful in enhancing the science literacy ability. This fact was revealed by the results of PISA study in 2000 that ranked Indonesia in the position of 38 from 41 participated countries with the average score of the test for about 393; in 2003 Indonesia was ranked into 38 out of 41 participated countries with an average score 395. While Indonesia was ranked in the position of 57 from 65 countries with the average score of 383 (OECD, 2009), and by the year 2015 Indonesia was only able to occupy a position 64 of 65 countries.

Based on the data of PISA analysis results, it showed that Indonesia got low score in literacy achievement particularly about 29% to 34% for the content, process, and 32% for context (Permanasari, 2016). The content of science is one of the dimensions of scientific literacy refers to essential chemical concepts necessary to understand natural phenomena and changes towards nature performed by human activity (PISA, 2009). According to Ogunkula (2013) the way to to improve the literacy of science in science learning is by connecting a concept of science with emerging topics and interesting in real life.

Based on the problems mentioned above, it is very important to develop a model of learning that can enhance the science literacy, particularly on aspects of science content. One of the learning models that can be developed is a problem-based learning model. It becomes one of the learning approaches that serve many contextual issues that can stimulate the creativity of learners to find concepts and solve problems in daily life (Arends, 2007). Through problem-based learning, the students can get various exposure to increase their knowledge and also, they can apply their knowledge in the real life. A significant benefit of problem-based learning provides the opportunity to solve the problem in accordance with individual styles of learners (Sanjaya, 2011). According to the results of the research conducted by Jones (1996b), he concluded that the enhancement of students' ability in learning through problem-based learning model is able to activate the learners' basic knowledge, develop the students' thinking process, becomes more familiar and understand the context in the real world. In addition, it is also a problem-based learning, an emphasis on the learning inquiries (Wang, et.al, 1998).

Further on, problem-based learning is currently need to follow the developments of the age in the era of globalization by integrating Science, Technology, Engineering, and Mathematics (STEM). The link between science and technology as well as other science cannot be separated in the learning of science. STEM is a disciplined science that are closely related to each other. It requires Math as a tool in processing data, while technology and technique application of science. Approach to learning in the STEM is expected to yield meaningful learning for students through the integration of knowledge, concepts, and skills systematically. Some of the benefits of the approach STEM make students to solve problems better, innovators, inventors, independent, logical thinker, and technological literacy (Morrison, 2006, in Stohlmann, Moore, & Roehrig, 2012, p. 29). The application of STEM in learning can encourage learners to design, develop and utilize technology, sharpening cognitive, affective, and manipulative as well as apply the knowledge (Kapila, 2014; Permanasari, 2016).

Therefore, the application of a suitable STEM to the study of science particularly chemistry. STEM-based learning can train students in applying their knowledge to create a design as a form of problem solving related environment by leveraging technology. STEM has been applied in a number of developed countries like the United States, Japan, Finland, Australia and Singapore. Application of the STEM can be supported by a variety of learning methods. The integrative nature of the STEM allows a variety of learning methods can be used to support their application (Permanasari, 2106). Refer to the wedge between science literacy and creativity with the close study found a number of results of research that supports the use of problem-based learning. Problem based learning integrated STEM can give a chance on learners to apply knowledge on issues/problems as a form of problem solving.

The material is selected in this research is chemical kinetics. This is due to the material chemical kinetics are seen meet the three basic principles of election content PISA expressed by Hayat and Yusuf (2010), namely: (1) concepts to be tested must be relevant to everyday life situations that are real; (2) the concept of chemical kinetics is estimated to still be relevant at least for the next decade; and (3) the concept should be related to competency of the process i.e. the knowledge not only rely on the student's memory and deals only with certain information. Chemical kinetics is one of the chemical materials that is abstract but very close to everyday life because of its application.

Based on the exposure, still rare researchers who developed a model of a model of integrated problem-based learning science, technology, engineering, and mathematics (STEM) against science literacy students. Therefore, researchers are interested in researching and developing further on how the development of the model the model integrated problem-based learning science, technology, engineering, and mathematics (STEM) in improving science literacy students on the science content.

2 METHODS

This research is classified into a quantitative research methodology which used weak experimental method through the one-group pretest-posttest design (Fraenkel, et al., 2006).

Table 1: The One-Group Pretest-Postest Design

O_1	X	O_2

O_1 = Pretest; O_2 = Postest; X = Implementation PBL integrated STEM

Furthermore, the writers involved all of the Chemistry Education students in academic year 2016/2017 as the population of this research. As the result, thirty-four students of Chemistry Education in the fourth semester (4B) were chosen to participate in the research. In addition, to collect the data of the research the writers also provided an essay test as the research instrument and questionnaire. It is given twice during conducting the research particularly at the pre-test and the posttest. Therefore, the data was gathered and calculated through N-Gain score. The formula to calculate the N-Gain score was adapted from Meltzer (2002) as follow:

$$N-Gain = \frac{Posttes\ score - Pretest\ score}{Maximum\ score - Pretest\ score}$$

To be more specific, there were 3 categories in %N-Gain result such as high score (g>70), medium score (70≥g≥30) and low score (g<30) (Hake, 1998).

The questionnaire results in the form of student and teacher responses were processed based on a Likert Scale test. After scoring then the data is changed in percentage form. The percentage obtained is then interpreted in sentence form as shown in Table 2 below.

Table 2: Interpretation % (Arikunto, 2006)

Average (%)	Category
80-100	Very well
66-79	Good
56-65	Enaough
40-55	Less
0-39	More less

The research flow can be seen in Figure 1:

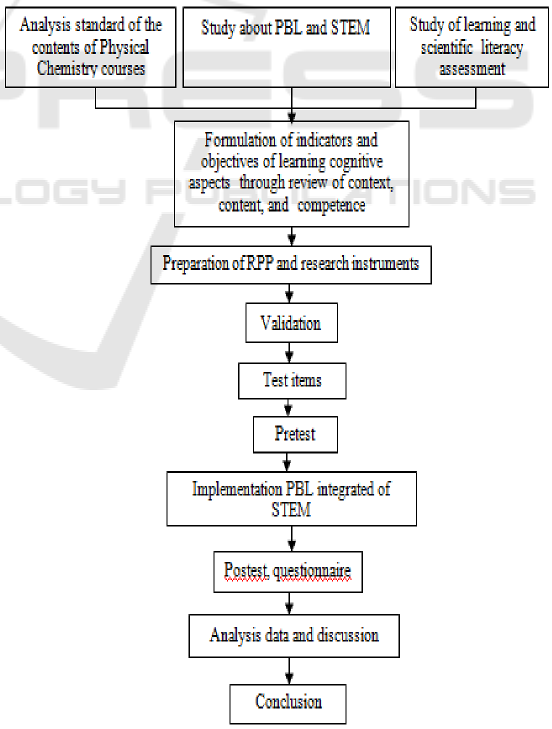


Figure 1: Research Flow

3 RESULT AND DISCUSSION

3.1 Result

To know the learning model that has been implemented whether influence to the result of students' learning, the data will be analyzed by comparing the average of pre-test score and the percentage of N-Gain. The result of the overall students' learning can be seen from following Figure 2.

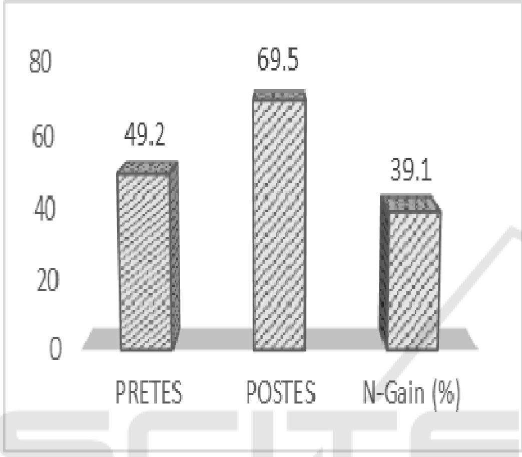
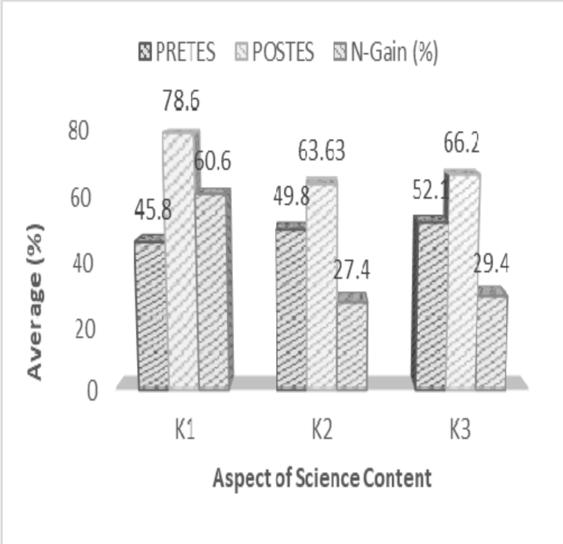


Figure 2: The Result of the Overall Students' Learning

Based on the data above, it can be said that the average score of the pre-test and the posttest is about 49.2 and 69.5 relatively with N-Gain score accounting to 39.1% which is categorized in the medium level (Hake. 1998). It proves that the implementation of problem-based learning model integrated to Science, Technology, Engineering, and Mathematics (STEM) can improve the overall student learning outcomes.

After collecting the data, the writers analyzed the students' learning outcomes in each aspect of science content. It was carried out during the pre-test and the posttest of the implementation of problem-based learning integrated to Science, Technology, Engineering and Mathematics (STEM). Therefore, the result of students' learning outcomes in each aspect of science content can be explained through the Figure 3 below:



Note:
K1: The relationship between the reactant concentration and its time
K2: The activation of an energy and the dependence of a constant rate towards its temperature
K3: The factors that can influence the reaction rate

Figure 3: The Students' Learning Outcomes in Each Aspect of the Science Content

Based on the Figure: 3 above, it proved that all of the science content aspect increased drastically shown by the average score of N-Gain for about 60.6% in K1 which explaining about the relationship between the reactant concentration and the time.

The responses of students to problem based learning learning integrated with STEM are as follows:

Table 3: Student Response to Learning conducted

No	Indicator	Average %	Category
1	Students' attitude towards learning the Chemical Kinetics Concept	69.85	Good
2	Students' attitude towards learning with Integrated Problem Based Learning Science, Technology, Engineering, and Mathematics (STEM)	71.32	Good
	Average	70.59	Good

Based on table 3. its can be seen that the average value of student responses to learning that has been done is good. This is indicated by the average score on indicator 1. Students 'Chemical Kinetics Concept attitude towards learning was 69.85 (Good) and on indicators 2. Students' attitude towards learning with Integrated Problem Based Learning Science, Technology, Engineering, and Mathematics (STEM) of 71.32 (Good).

3.2 Discussion

Learning by using Integrated Problem Based Learning Science, Technology, Engineering, and Mathematics (STEM) was conducted on the concept of Chemical Kinetics for 4 meetings. The first meeting students were given a 20-minute pretest. The second and third meetings were the implementation of learning for 3x50 minutes and the fourth meeting was conducted at the same time as a questionnaire.

The scientific literacy dimension measured in this study is science content. Content of science is one of the dimensions of scientific literacy that refers to essential chemical concepts needed to understand natural phenomena and changes to nature carried out by human activities (PISA, 2009).

Therefore the aim of this research is to know the enhancement of the students' science literacy on the aspect of science content through the problem-based learning integrated to the STEM.

Problem-based learning model is one learning model that presents contextual problems that can stimulate students' creativity to find concepts and solve problems in everyday life (Arends, 2007). Problem-based learning focuses on real-world problem solving (Johnson & Lamb, 2007).Syntac of problem based learning is.

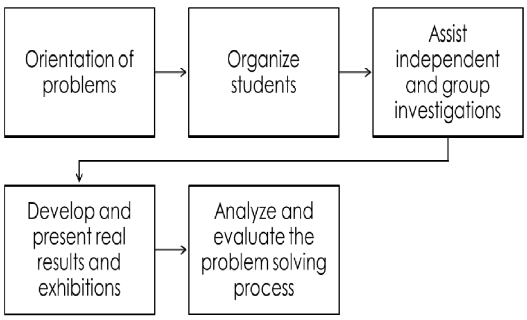


Figure 4: Syntac PBL (Arends, 2007)

The STEM approach in the learning process in this study is carried out with an integrated or integrated approach. That is an approach that integrates two or more disciplines and is the best approach for STEM learning (Winarni, 2016). The implementation of problem based learning learning integrated STEM is a STEM component, namely Science, Technology, Engineering, and Mathematics integrated into the stages of problem based learning. The component of science is the concept of kinetics in life. The technology comon is the use of ICT in learning, both as a learning medium and as a learning resource. Engineering component is learning through the practicum of the concept of chemical kinetics. Where students are asked to determine tools and materials and design experiments. The mathematical component is the formula of the kinetics concept in determining the reaction order, reaction rate constants, concentration and others.

Based on the graph 2, the average score of N-Gain (%) obtained amounted to 39.1 (medium) with an average rating of 49.2 pre-test and posttest of 69.5. Whereas, Hake (1998) stated that the N-Gain score is not included in medium score. Therefore, it showed that the learning process using an integrated problem-based learning approach in Science, Technology, Engineering, and Mathematics (STEM) learning outcomes can improve overall student for about 39.1%.

Beside analyzing the overall result of the students' learning, the writers also carried out the analysis of the students learning outcomes based on each aspect of science content. Specifically, the writers focused on several aspects of science content to be measured. For instance, the relationship between the reactant concentration and its time (K1), the activation of an energy and the dependence of a constant rate towards its temperature (K2), and the factors that can influence the reaction rate (K3). Further on, the content was taught by using the context that exists in everyday life, such as: benefits of iodine, catalysis, the cooking process, and others. Moreover, this was due to the integration of context into learning concepts in creating the teaching and learning process becomes more interactive, innovative (Ramsden, in Jong, 2006) and easy to be understood (Johnson, 2007). This statement was in line to the result of the research conducted by Bahriah (2012) and Asniar (2012) which stated that the use of the surrounded context can enhance the students' science literacy in teaching and learning process.

Based on the data, all of the aspects of science content had increased significantly shown by the average score of N-Gain in general. The increasing average score was rose by the content entitled the relationship between the reactant concentration and the time for about 60.6% and established in the medium level. This content contained a lot of concepts requiring to analyze and understand in depth. In contrast, the content entitled the activation of an energy and the dependence of a constant rate towards its temperature increased slowly only for about 27.4% and included to the low level. In accordance with the results of the study Sinaga (2006, in Nazar) states that almost 50% of students have difficulty understanding the concept of the effect of catalysts and temperature on the reaction rate. A lot of students faced a cognitive conflict and a misunderstanding about the reaction rate in first order, second order and the relationship to the activation of the energy. While the content on "factors that affect the reaction rate" ascended to 29.4% and is included in the low category. It was caused by the existence of various concepts which needed the implementation in our daily life. So, they can be easier to catch up the materials and find their own concept and answer the questions given to the posttest.

The level of students' understanding of the concept of kinetics kinetics can also be seen from the results of practical activities. Practical activities are conducted to see how the integration process of integrated STEM problem based learning models and to determine student performance. The following is the data on student lab results.

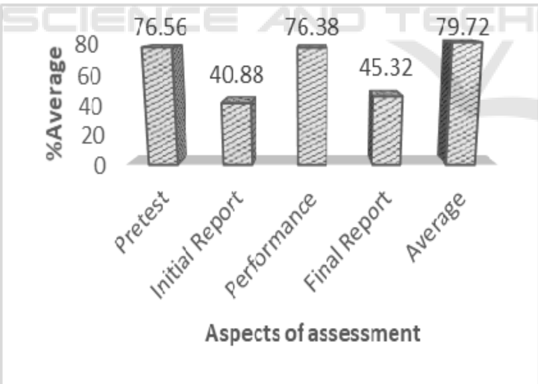


Figure 5: Data Practicum Activity

Practical activities are assessed from several aspects, namely: the value of the pretest, initial report, performance, final report, and average value. The average value of the pretest is 76.56; the average value of the initial report is 40.88; performance value of 76.38; the final report value is 45.32. The average value of the overall student practicum is based on 79.72.

As the result, it could be concluded that each science content rose significantly. On the other words, the model of problem-based learning integrated to Science, Technology, Engineering, and Mathematics (STEM) provided a positive effect to the teaching and learning process which became more interactive and innovative, and also enhance the students' science literacy. STEM education can develop when it is associated with the environment, so that a learning is realized that presents the real world experienced by students in everyday life (NRC, 2011). In line to the Lam, D.M et al (2008) statement that the learners were involved in contextual learning and hands-on learning activities through STEM approach. So, it can be an appropriate approach to motivate learners in learning and acquiring new knowledge. Gutherie et al. (2000) also stated that the integration of STEM in learning can improve the learning motivation of students and develop the students' critical thinking ability. Asghar, Ellington, Rice, Johnson and Prime (2012) also state the integration of STEM (Science, Technology, Engineering, and Mathematics) with the perception of Problem Based Learning education that encourages students to learn about nature through exploration, investigation, and problem solving through experience.

This is strengthened based on the recapitulation of student responses to learning that is used in general giving a positive response to learning using problem-based learning (Problem Based Learning) Integrated Science, Technology, Engineering, and Mathematics (STEM). This can be shown by the average score of 70.59 in the good category (Arikunto, 2006). This means that the attitude of students towards the basic courses shows an open and enthusiastic attitude to explore further. So that students are interested in finding, exploring, and digging information from various sources about the material being studied and the material they are studying.

4 CONCLUSIONS

Based on the data analysis and the research findings, it can be concluded that the implementation of problem-based learning integrated to Science, Technology, Engineering, and Mathematics (STEM) can enhance the students' science literacy particularly in the science aspect for about 39.1%.

Research can be continued by using more samples and the control class, using a virtual lab or linking technology in learning. Problem based learning can be integrated using the approach of

Science, Technology, Engineering, and Mathematics (STEM) in the learning of science.

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