Problem Based Learning Model Integrated with *Science, Technology, Engineering, and Mathematics* (STEM) on Students' Science Competency Ability

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Keywords: Problem Based Learning (PBL) Learning Model; Science, Technology, Engineering, and Mathematics (STEM); Ability of Science Competence.

Abstract: Approaching the 21st century students are required to be responsive in terms of science and technology development. The poor literacy skills of Indonesian students phenomenon based on PISA results illustrates the need for improvement in education in Indonesia. This research aims to determine *Problem Based Learning* model integrated with *Science, Technology, Engineering, and Mathematics* (STEM) on the ability of Students' Science Competence on Electrochemistry. This research was conducted at SMA Negeri 2 Cikarang Utara in January on sixth semester of academic year 2017/2018 The method used in this research was Quasi Experimental with research design Nonequivalent Control Group Design. Samples were taken by purposive sampling and amounted to each of 32 students i.e. experimental class and control class.Technique of data collecting obtained by instrument of 10 item description test which then analyzed using t-test. The result of hypothesis test using SPSS version 22 software obtained Sig <α data, that is 0,000 < 0,05 so H_0 is rejected and H_1 is accepted. This result shows that there is an influence of Problem Based Learning (PBL) model integrated with Science, Technology, Engineering, and Mathematics (STEM) on students' competence in Electrochemistry.

1 INTRODUCTION

The 21st century is marked by the rapid development of science and technology in the scope of life in the society, especially in information and communication technology (Yuliati, 2017). Based on the statement, education is faced with increasingly difficult challenges, one of them is education is expected to produce competent human resource in facing various challenges in life. The demands of the 21st century make the education system must be in accordance with the changing times. Correia, et. al in their journal said that "*The relevance of such educational issues is confirmed by the United Nations, which declared the years between 2005 and 2014 to be the 'Decade of Education for Sustainable Development*" (Correia, et al, 2010).

The comprehension of science and technology (IPTEK) is an important key in facing future challenges that arise, which is related to improving the quality of life, equity of development, and ability to develop human resources (Khaeroningtyas, et al, 2016).

One of the things that have a role in science and technology progress is science. Science has essential role in improving values, attitudes, and thinking skills to produce quality learners capable of resolving the problems (Sanjaya, et al, 2017). However, the fact that science education in Indonesia is still poor in years that is proven by the results of research conducted by *The Organization for Economic Cooperation and Development* (OECD) through an-internationally recognized assessment program known as PISA (Fitriani, et al., 2016).

OECD study results through the PISA program in 2009 showed that the level of science literacy of Indonesian students is not much different from the results of the study in 2006 with the score of 383 which in fact the score is below average of PISA standard (Bagiarta, et al., 2015). Then in 2012, the PISA test results showed that Indonesia ranks second from bottom with the Indonesian average score below the international average score. Furthermore, in 2015,

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Indonesia is ranked 64th out of the 72 participating countries Yuliati, 2017). The results of the survey in several years shows that the Indonesian students' science literacy ability is still very low.

The poor science literacy skill of Indonesian students is related to the education and teaching system. Science learning that lasted so far only limited the process of delivering information (*transfer of knowledge)* from teacher to students (Abdurrahman, et al., 2013). Today learning still has a major problem that the absorption of learners are still low because learning is conventional and dominated by teachers (Al Tabany, et al., 2014). Science learning is considered as a difficult subject and consequently the ability of science literacy students did not develop because students also lose interest in learning.

Based on the problems that have been exposed, it is required a way of learning that can give a positive influence on science competence of students. Competence or the process of science is one of the scientific literacy dimensions that implies the mental processes involved when answering a question or solving a problem, such as identifying and interpreting evidence and explaining the conclusion (Bahriah, 2015). Science competence is intended as the ability to engage with issues related to science, and with scientific ideas, as a scientific reflection of students about science and technology (OECD, 2015).

The competence of students 'science literacy is on very low criteria, this is caused by the learning process that emphasizes the cognitive aspect only, so the students are not accustomed to answer the problem that requires students to investigate scientific problems, read scientific discourse and make scientific conclusion (Diana, et al., 2015). It is in accordance with Suciati's research that the lowest dimension is the science process or science competence based on the research result can be stated that the average on 3 aspects of students' science literacy ability are poor i.e. content aspect (34,4%), process aspect (32,61%), and the context aspect (35,91%) (Suciati, et al., 2015).

One interesting innovation accompany the paradigm change is found and the implementation of innovative learning model, progressive, and contextual (Al-Tabany, 2014). One of the learning models that can be used is the *problem based learning* model. *Problem Based Learning (PBL)* model is a learning model that is able to find their own knowledge, distinguish the understanding of self-knowledge with others, and rearrange the knowledge more relevant to the experience in learning (Toharudin, et al., 2011).

Problem Based Learning model is a learning model that presents a variety of authentic and meaningful problem situations that can function in the investigation and inquisition of learners (Arends, 2007). In *problem based learning* model, students can construct the knowledge they learn so the students understand the meaning of the material in depth because the students become the centre of learning.

The applied learning approaches are not yet sufficient to develop the human resources that sustain the nation's competitiveness (Firman, 2016). Science learning now that is *Science, Technology, Engineering, and Mathematics* (STEM) become learning alternative. STEM education is able to form human resources that have reasoning and critical, logical, and systematic thinking. Learning through STEM integration can make students more prepared in the field of work, increases their interest and achievements (Khaeroningtyas, 2016). Education in the STEM disciplines also should include the application of these knowledge, skills, and abilities to life situations in STEM-related categories such as health choices, environmental quality, and resource use (Bybee, 2013).

STEM education is an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in real contexts that connect between schools, the world of work, and the global world, building STEM literacy that enables students to compete in the new economic era knowledge-based (Reeve, 2013). STEM education provides opportunities for teachers to show learners in the form of concepts, principles and techniques of science, technology, engineering and mathematics used in an integrated way in the development of products, process, and systems used in their daily life (Firman, 2016).

Research shows that integrative approach with STEM improves students' interest and learning (Becker & Park, 2011). Moore defines the integration of STEM education as an effort to combine some or all of four disciplines i.e. science, technology, engineering and mathematics into one class, unit, or lesson based on the relationship between subjects and real-world problems (Kelley & Knowles, 2016). Integration through STEM provides opportunities for students to learn in more relevant and stimulating experience, encourage higher level usage resulting of critical thinking skills, enhance problem solving skills, and increase retention (Kelley & Knowles, 2016). Learning with STEM integration can be the key of creating the next generation of nations that are able to compete in the global arena so that STEM learning needs to be a framework for the education process.

Based on those things found a number of research results that support the use of problem-based learning that is integrated with STEM. *Problem based learning* that is integrated with STEM can prepare students to utilize and create new technology with their own creativity as a problem solving.

Electrochemical materials in this research were chosen because of the consideration of three basic principles of PISA content selection, namely: (1) electrochemical concept, especially electroplating is relevant to the student's daily condition; (2) the electrochemical concept is expected to remain relevant for at least a decade; and (3) the electrochemical concept is concerned with the competence of the process, it means knowledge not only prioritizes memory and associates certain information (Hayat & Yusuf, 2011).

Therefore, based on the explanation, the researchers are interested to examine the influence of problem based learning model integrated with STEM on students' literacy ability in electrochemistry materials.

2 METHODS

This research was conducted in the sixth semester of academic year 2017/2018 in SMA Negeri 2 North Cikarang. The research method used is *Quasi Experimental design* that is method that has control group but cannot fully function to control the external variables that influence the implementation of experiment (Sugiyono, 2015). Quasi-experimental designs do not include the use of random assignment. Reseachers who employ these design rely instead on other techniques to control (or at least reduce) threats to interna validity (Frankel & Wallen, 2007). The design of research used was Non-equivalent Control Group Design, i.e. design consisting of two groups: the experimental and control groups whom were both given pre-test first, then after the experimental group was given a certain treatment, both groups were given post-test to see the effect of the treatment on experimental group (Suharsaputra, 2014).

Research subjects used are class XII MIA-4 consisting of 32 students as experimental class and class XII MIA-3 consisting of 32 students as control class and the data is taken with Purposive Sampling technique. Purposive Sampling technique is a sampling technique that is adjusted with certain considerations and characteristics (Suharsaputra, 2014). The considerations undertaken in this sampling based on the similarity of the average learning outcomes on both classes, the number of students, and adjustment of subject schedules in each class.

The main research instrument used in this research is the description test consist of 10 items that is made based on students' ability of science literacy competence on science dimension.

The Student Worksheet (LKS) which is organized based on PBL integrated with STEM stage model as supporting instrument functions to see science literacy indicator on any dimension that appears on the PBL integrated with STEM learning process.The test instrument data obtained were tested for normality and homogeneity using SPSS version 22 with a significance level of 5%. Hypothesis testing chosen is Independent Sample T-test to know whether there is influence from application of STEM model problem based learning to ability of science literacy owned by students.

3 RESULT AND DISCUSSION

From the results of research conducted, the researchers got the data of pre-test and post-test in experiment and control class. The data of pre-test and post-test of experiment and control class can be seen in Figure 1.

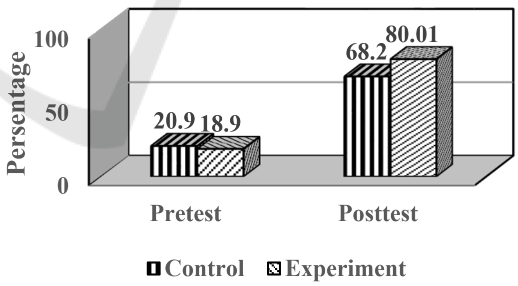


Figure 1. Average of Pre-test and Post-test Value of Control and Experiment Class

Based on Figure 1, the average value of pre-test obtained show that control and experiment student class have almost same level of initial ability. While the average score of post-test show that the average score of experiment class is higher than control class. The overall mean value difference shows that the experimental class with the STEM integrated PBL learning model obtains a higher mean value than the control class using conventional learning model with lecture and question and answer method on electrochemical material. Through Problem Based Learning, learners gain knowledge not only accept but also be able to provide opportunities to solve problem according to individual style of learners (Bahriah, 2015).

STEM-based learning that is supported by problem based learning can actualize the ability of science literacy (Khaeroningtyas, et al., 2016).

Normality, homogeneity, and hypothesis using 5% significance level in experiment and control class tests result can be seen in Table 1.

Table 1. Data Table *Pre-test* and *Post-test* Normality, Homogeneity, Hypothesis Test Results of Experiment and Control Class

Test	***Pre-test***		***Post-test***	
	Experiment	Control	Experiment	Control
Normality (α= 0,05)	0,092	0,200	0,200	0,148
Homogeneity (α= 0,05)	0,524		0,101	
Independent Sample T-test (α= 0,05)	0,524		0,000	

Based on Table 1, obtained pre-test and post-test data in the experimental and control classes are normal and homogeneous, since the results of significant value is greater than 0,05.

The result of pre-test value hypothesis test using T-test independent sample obtained greater data significant value than 0, 05 or H_0 accepted that is 0,524. The significant value is greater than 0, 05 indicates that the average student learning outcomes do not differ significantly. This shows the students' initial ability is equivalent before they are being given treatment.

The result of post-test value hypothesis test obtained by significance value data smaller than 0,05 so it can be concluded that there are the acceptance of H_1 and the rejection of H_0. Based on calculation of hypothesis test using t-test on post-test data of experiment and control group show there are difference in students' science literacy ability on science competence dimension between control and experiment group.

Those results indicate that there is a difference in the average of students' science literacy ability in the experimental and control classes. Thus, PBL integrated STEM learning model influences students' literacy skills. The results of the study conclude that STEM learning can improve students' literacy skills (Khaeroningtyas, et al., 2016). Problem Based Learning integrated with STEM learning model can advance a broader understanding of science and mathematical concepts and their applications to real-life context (Asghar, et al., 2012).

Learning with STEM's intergrated PBL model begins with video viewing as an apperception of metal plating. The given apperception will stimulate students' to work as groups and can follow the given LKS instrument. The study shows that the integration of STEM approaches in learning is possible, with the STEM approach being able to provide students with learning experience, active learning, and contextual meaning (Quang, et al., 2015).

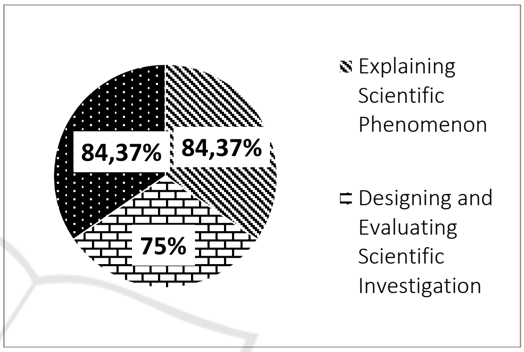
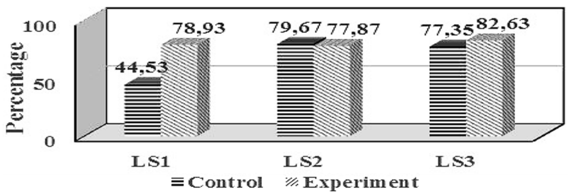


Figure 2. Percentage (%) of Science Competence Indicator based on LKS in Experimental Class

Explaining scientific phenomenon and interpreting data and scientific evidence as science competence indicators have the highest percentage on learning activities. This describes the ability of science literacy is more visible in the ability to recognize and relieve the concept of science and on the ability to process data obtained in the form of tables, diagrams, or graphs (OECD, 2016). In addition, according to Yew et.al 's (2009) research, drafting an inquiry will help students recall the concept that they already have related to the problems encountered, so that the students will choose the appropriate science concepts and match those issues (Yew & Schmidt, 2009).

Choo, *et. al* (2011) and Yew, *et. al* (2010) added working in groups will help students to learn the concept better because there is an exchange of ideas between group members and this can help students recall the concept that they have learned (Choo, et al., 2011).



Notes: LS1= Explaining scientific phenomenon; LS2= Designing and evaluating scientific investigation; and LS3= Interpreting data and scientific evidence

Figure 3. Percentage of Student Achievement on Science Competency Indicators

On Figure 3 above can be seen that the highest percentage of achievement of students' science literacy indicators is on interpreting data and scientific evidence with very good category in experimental class. Meanwhile, the indicators that have the lowest percentage in control class is explaining the scientific with the less category and in experimental class is designing and evaluating scientific investigation with good category.

Based on the figure, it shows that from each indicator of science literacy on the competence dimension is greater in experimental group than in the control group. This is caused on problem based learning students do some learning stages that can develop those three indicators. Problem-based learning has five stages i.e. student orientation on issues, organizing students for learning, guiding individual and group investigation, developing and presenting the work and evaluating problem-solving process (Arends, 2007).

Percentage of the indicators explain that scientific phenomenon belongs to less category in control group. This is caused on the time of learning, students tend to receive information without obtaining scientific explanation directly and independently. Larger results in experimental group were caused when the learning process, researchers did individual and group investigation stage. Through this stage teachers encourage students to obtain appropriate, accurate information, carry out experiments and seek explanations and solutions (Toharudin, et al., 2011). Parallel with the study, concept of knowledge that students have affect their ability on describing or interpreting scientific phenomenon (Wulandari, & Wulandari, 2016). The "less" category obtained on explaining scientific phenomenon indicator illustrates students' lack of optimal ability in explaining scientific phenomena triggered by several factors that will influence the achievement of scientific literacy ability.

The cause of the low achievement of this indicator in the control class is the students have not fully understood metal plating material so that students have not been able to provide scientific explanation of the given phenomenon. The lack of student training in working on the problems associated in various sources of information and linked in various life situations. More developed knowledge and understanding is required to achieve this indicator. The cause of this indicator become low that students still seem to have difficulties in explaining the science concept and its relation to the application in everyday life (Nadhifatuzzahro, et al., 2015).

On the indicator of interpreting data and scientific evidence, it shows excellent categories in the experimental group. This is caused students in experimental group perform the learning stages of developing and presenting the work and evaluating the problem-solving process. In developing and presenting the work stage, students are directly involved with the evidence obtained based on the experiment that they had done. Then students create experimental reports in groups, involving some evidence of data that has been processed into graph, conclusion, and etc. before they present them. Students are expected to be trained in using scientific data as an evidence and able to present them. In accordance with the existing theory which states that through problem-based learning students present their ideas, students is trained to reflect their opinions, argue and communicate their opinions to other parties so that teachers understand the student thinking process (Rusman, 2018).

Science literacy brings skills for achieving knowledge rather than teaching existing knowledge to students (Güçlüer & Kesercioğlu, 2012). Skills acquired will be important on several occasions such as problem-solving and making crucial decision on their life where students will face on their future lives.

Based on science literacy indicators description from experimental and control class, it can be concluded after the post-test, the experimental class has higher value than the control class. Because on experimental class, the students are accustomed to get problem of a case that is solved by problem-based learning model stage which can strengthen the science concept, so the students in the experimental class have higher scientific literacy ability than the control class.

4 CONCLUSION AND SUGGESTION

Based on the result of the research, it can be concluded that problem based learning integrated with STEM influences the students' science literacy ability on science competence dimension in electrochemical material.

As the follow-up of this research, the following suggestions can be put forward: (1) Problem Based Learning (PBL) integrated with Science, Technology, Engineering and Mathematics (STEM) model is one of learning model that can develop students' science competency skill. Thus, it should be applied as a variation of the learning model. (2) The implementation of PBL learning model takes amount of time; therefore the teachers who want to apply this learning model can manage their time well so that the PBL learning model stages are implemented optimally (3) As for the other researchers, this PBL learning model needed to be done on other chemistry materials that has potential to develop students' science literacy skills.

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