Electrochemical learning with a modified writing to teach (WtT) approach to improve the students’ concept mastery

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Abstract. Concept mastery is considered as a requirement that must be possessed by chemistry teacher candidates to teach the students about chemical concepts. The aim of this study is to improve the students’ concept mastery in electrochemistry through school chemistry subject by conducting a modified WtT approach. The study involves twenty students in the fifth semester who commit the subject of school chemistry. The data are obtained through test of concept mastery to obtain information about the concept of mastery of before and after learning. Then, the data are carried out from interview to obtain information about the students’ responses in relation to the implementation of WtT approach in the learning process. The data analysis is accomplished through the N-Gain test to discover the improvement of the implementation of concept mastery and effect size test for paired t-test to determine its effectiveness. Meanwhile, the results of interview are utilized to strengthen the data of concept mastery. The results of the present study reveal that there is an average improvement of the students’ concept mastery. Furthermore, the result of effect size test shows that the WtT approach is considered to be effective to improve the students’ concept mastery in the average level.

1. Introduction

Concept mastery is one of the compulsory students’ requirements based on the learning outcomes in the knowledge aspect of the Indonesian National Qualifications Framework. Then, it is one of the compulsory teachers’ competencies based on the Regulation of the Minister of National Education Number 16/2007 [1] about the academic qualification standard and teacher’ competencies. It is stated that a teacher must be proficient at the material, structure, concepts of the subject being taught and having scientific mindset.

The preliminary observation shows that many students and teachers have difficulties in mastering chemical concepts involving electrochemistry [2-6]. Electrochemistry is a branch of chemistry that deals with the relationship between chemical energy conversion and electrical energy in voltaic cells and electrolysis cells [7, 8]. Based on its concept analysis [9], electrochemistry is classified as an abstract concept with a concrete example. The complexity of studying electrochemistry is often encountered in determining the charge on the cathode and anode [10], the process of electrical energy formation in electrochemical cells [11], explaining the work principle of electrolytic cell [12], determining the electron flow in the external circuit or solution. As a result, those problems cause misconceptions. Some of the common misconceptions arising in studying electrochemistry are electrons flowing in the...
solution, negative stain (on voltaic cell and electrolysis cell) so that the cation moves to their direction, and the electron is transferred through the anion on the salt bridge [11].

Various methods have been widely conducted to improve the students’ concept mastery in chemistry. One of them is by using various models, methods or approaches in learning such as the approach of Writing to Teach (WtT). The approach deals with teaching in the writing skills. The WtT approach combines writing and peer learning activities as a method for changing the standard writing assignments of science which revolves merely on writing summary into explanatory writing [13]. The theoretical framework of the WtT approach is both in the framework of situated cognition theory and in the framework of meaningful learning. They involve the students in the meaningful and authentic learning activities [14]. The situated cognition theory states that one’s knowledge is embedded in the activities bound to related context, treatment, and culture where the knowledge is learned [14]. It is considered suitable for the training of peer learning and writing combination because the learning process acts as a function of the activities, contexts and cultures in which it takes place. The WtT approach consists of four stages, namely planning, writing, peer learning and revision.

Other model or approach utilized to improve the concept mastery in chemistry learning is the implementation of the argument-driven inquiry (ADI). The ADI approach has proven the improvement of the students’ concept mastery [15] and the reflective writing as a hermeneutical cycle which can enhance the students’ understanding of the concepts in the book [16]. The use of multiple representations is also claimed to be able to enhance the learning process [17] and can facilitate the students to master the chemical concepts in depth [18-22].

Based on the explanation afore mentioned, it is known that the concept mastery can be taught through other model, method or approach. Hence, to optimize the students’ concept mastery, the aim of the present study is to improve the students’ concept mastery in electrochemistry using a modified WtT approach. The modification itself is performed at the planning stage by adding some activities such as the analysis of multiple representation activities and argumentative discussion.

2. Methods
The present study applies quasi-experimental method by a one-group pretest-posttest design. The study involves 20 participants of fifth semester which consist of four men and sixteen women aged between 20-21 years old. They take the subject of school chemistry and have completed successfully in the subject of basic chemistry.

The instrument used in this study is a written test on electrochemistry in the form of descriptions to obtain information about the students’ concept mastery. The test is given before and after the lecture is conducted. The other instrument is interview to obtain information about the students’ responses concerning about the implementation of WtT approach in the learning process and its role to learn the material being studied. The data analysis is accomplished by N-gain test to acquire the enhancement of the implementation of concept mastery and effect size test for paired t-test to obtain information about its effectiveness of the WtT approach into the students’ concept mastery. The data is described to reinforce concept mastery data. The results of interview are utilized to strengthen the data of concept mastery.

This study focuses on increasing the students’ concept mastery of electrochemistry in the subject of school chemistry using the WtT approach. The briefing of argumentation, analysis of essential concepts based on the basic competences, presentation and discussion about some topics argumentatively and compiling the outlines is given in the planning/assessment stage. Then, the students are required to write the descriptions of voltaic cell, corrosion and electrolysis cell. Next, peer learning activity is accomplished. At the end, there is revision activity.

3. Result and Discussion
Figure 1 reveals the grade result of the students’ concept mastery in electrochemistry consisting of voltaic cell, corrosion and electrolysis cell.
In the pretest, the average of the students’ concept mastery on those three materials is categorized in the low level because the grade is under 4.5 on a scale of 0 to 10. In the posttest, there is a great improvement of the students’ concept mastery for voltaic cell and corrosion in the range of 6.6 to 8.5. However, the students’ concept mastery for electrolysis cell is categorized in the average level because the grade is in the range of 4.6 to 6.6. In the posttest, the highest grade of the concept mastery is the voltaic cell and followed by corrosion. Then, the lowest grade is electrolysis cell.

In the voltaic cell material, the cause of the students’ lowest grade is in describing the role of salt bridge concept (4.0) and their highest grade is in determining the cathode and anode based on voltaic cell notation (10). The cause of their lowest concept mastery is the students’ incompetencies to explain how the salt bridge can balance the load in solution. The students state merely that “the function of a salt bridge is to balance the load in both solutions”. Other answer about function of the salt bridge is “so that the ions in the solution can move”. This statement is not in accordance with the explanation [7] which states that the function of salt is to balance the load in the solution by flowing the ions from the salt bridge to the solution. The results of interview show that some students is difficult to understand how the salt bridge work to balance the ions in solution. They only recognize that its function is to balance the solution.

In the corrosion material, the cause of the students’ lowest grade is in explaining how to prevent rust through the cathodic protection (5.6) and their highest grade is in analyzing the most rapid corrosion reaction based on the factors that influences the corrosion (6.1). The cause of their lowest concept mastery is the incompleteness of the students’ answers. They only mention that “iron is associated with metal which is more reactive or it is associated with metal which is more easily oxidized”. This answer does not explain further what kind of metal is more reactive or easily oxidized. One of the student’s correct answer is "iron is associated with more reactive metal such as Mg which has a standard reduction potential value (PRS) < from PRS Fe, so that the metal will be more easily oxidized (acts as an anode) than iron metal". Based on the results of interviews, they indicate that the students focus only on how to protect the iron metal from the corrosion through the cathodic protection. However, they do not express completely how its process because the answer ““iron is associated with metal which is more reactive or it is associated with metal which is more easily oxidized” is considered sufficient.

In the electrolysis cell material, the cause of the students’ lowest grade is in composing a reaction that does not occur spontaneously to occur (4.6). Some related answers with that statement are "by providing an electric current; connected with a battery; or used as an electrolysis cell”. Those answers do not express how to add the electricity, how to install the batteries, or how to convert them to electrolytic cells. In the results of interview to the students whose the lowest grades, most students consider that their answers are sufficient to answer the questions. The rest of the students only know that the procedure to carry out the reactions that do not work spontaneously is to add the electricity. They do not know how to add the electricity and what its criteria is. Furthermore, the students’ highest grade is in analyzing the chemical reaction that occur in the electrodes in the electrolytic cell which are arranged in the form of series (8.7). The most correct answer to obtain the highest answer which is in
accordance with the answer rubric is “each specimen is written down and determines the reaction that occurs at each electrode which refers to the connection of positive and negative poles that are attached to the electrode”.

In Figure 1, it can be seen that there is an improvement of the students’ concept mastery in all sub-materials from pretest to posttest. The improvement is categorized in the average level. The N-Gain of the voltaic sub-material reaches 0.59. The N-Gain of the corrosion material is 0.45. At last, the N-Gain of the electrolysis cell reaches 0.65. These results are illustrated in the Figure 2.

The effect size test of Cohen [23] is conducted to discover the effectiveness of the WtT approach to improve the students’ concept mastery. The test is intended to determine the effectiveness of a treatment. The sample size involves 20 students who have previously been given a pretest, then a training with the WtT approach. In the end, they are given a posttest. The type of the effect size test applied in this study is the paired sample t-test of Cohen. Before the effect size test is conducted, the paired sample t-test is accomplished firstly because the sample consists of one group and has two data (pretest and posttest). The result of the effect size (Eta squared) for the paired sample t-test can be seen in Figure 3. Based on the results of the the effect size test, the value of the voltaic cell material reaches 0.92. Then, the value of the corrosion material is 0. At last, the value of the electrolysis cell material achieves 0.89. These results indicate that the effectiveness of the WtT approach is considered in the average level to improve the students’ concept mastery.
Based on the results of interview, the students consider that the WtT approach can assist them in the concept mastery. They generally argue that several activities such as multiple representation analysis, argumentative discussion and writing at the planning stage can assist them to understand the concept better. It is caused by they are required to show the three representations of concepts learned and provide the evidence and justification for the statements in the argumentative discussion. Writing and peer learning in the WtT approach contribute as well to the success of the students’ concept mastery. They learn more systematically in the writing activity because they have to write the material orderly. On the other side, they gain additional knowledge or understand the material after they review their colleagues’ writings in the peer learning activity. At the same time, they can also provide the feedback to the author regarding its writing. Furthermore, the result of the test and interview strengthen the result of this study which states that the WtT approach can improve the students’ concept mastery [13]. Next, the modified stages by adding some activities contribute to the students’ improvement. The results are similar with the statements stating that “multiple representation can support the students in mastering the concept in depth [18-22] and argumentative discussion can improve the students’ concept mastery [15].

4. Conclusion
The WtT approach is considered as a potential approach to be utilized to improve the students’ concept mastery in the learning process. The modified planning activities through the addition of multiple representation analysis and argumentative discussion, writing and peer learning can be utilized as a means of increasing the students’ concept mastery. The results of this study show that there is improvement of the students’ concept mastery for all sub-materials of electrochemistry in the average level. This approach is considered in the average level as an approach to increase the students’ concept mastery.

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