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THE ANALYSIS OF CONCEPT MASTERY USING REDOX TEACHING MATERIALS WITH MULTIPLE REPRESENTATION AND CONTEXTUAL TEACHING LEARNING APPROACH

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ABSTRACT

Teaching materials are one of the supportive facilities in achieving successful learning. This study employed teaching materials characterized by Multiple Representations and Contextual Teaching Learning. This research intended to reveal the understanding of redox concepts taught in grade X. This study was an implementation of the results referring to the 4D (Define, Design, Develop, and Disseminate) model. The data collection methods adopted were observation, questionnaire, test, and documentation. The data was analyzed by using the descriptive-qualitative method. The teaching materials have been declared valid, practical, and useful. The users also gave a positive response to the teaching materials. Students' conceptual understanding was analyzed through each item and indicator. The overall students' concept mastery was 53.33%, and their understanding of each indicator was 50.214% for interpreting, 77.78% for exemplifying, 53.472% for classifying, 52.78% for guessing, 52.78% for comparing, and 62.5% for explaining.

Keywords: concept mastery, contextual teaching-learning, multiple representations, redox material, teaching materials

INTRODUCTION

The ideal condition of learning is a process in which there are interactions and communication activities between teachers and students to achieve learning objectives. Learning activities that are effective, efficient, fun, challenging, and motivate students to participate actively will produce learning success for students and teaching success for teachers (Hasibuan & Moedjiono, 2000). Student participation can be seen from activities during learning activities. Students can actively participate in activities such as presentations, asking questions, answering questions, discussions, practicum, the practice of making a product, and writing reports. Teaching and learning process not only focuses on the results obtained, but the learning process can also provide a proper understanding that students can apply in their lives. Learning objectives can be achieved if students understand and comprehend the material obtained during learning.

Proper mastery of the material will instill a complete understanding of the concept for students. Understanding is an individual process in receiving and understanding information obtained from learning (Rusman, 2010; 2011; Alighiri et al., 2018). The teacher's role is to make students have a learning experience that is easy and fun so that material that is considered

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difficult can be understood correctly by students. Students who master the concepts can identify and work on new problems that are more varied (Alighiri et al., 2018; Nasution, 2000; Rahhou et al., 2015;). Learning resources that represent learning objectives must support the understanding of the concepts to be achieved. One learning resource that can be used during the learning process is teaching the material (Alighiri et al., 2018).

Teaching materials serve as a source of student learning, so teaching materials must meet the requirements specified to produce quality teaching materials. Teaching materials are expected to facilitate students to learn competencies coherently and systematically so that they can master all competencies as a whole and integrated (Indrayanti & Wijaya, 2016). Excellent teaching materials are teaching materials that pay attention to quality both in terms of content, language, graphic elements, illustrations, and methods of development (Rifai, 2015).

Teaching material that refers to the old curriculum only contains concepts that must be memorized. It also does not invite students to think as a process of constructing their knowledge and experience to find the concepts that must be understood and find meaning and its relation to daily life (Suharyadi et al., 2013). Teaching material developed must concern the involvement of students' roles in finding the concept of material so that it can be stored longer in memory (long term memory) (DePorter& Hemacki, 1999). One of the learning approaches connecting real daily life is the contextual approach (contextual teaching-learning).

Chemistry subject is one part of Natural Sciences that is expected to aid students in learning the meaning and application of lessons in daily life and can explain the phenomena of chemical processes that occur (Stephanie et al., 2011). The subject of chemistry involves the introduction of objects through direct observation, describing at the molecular level, and drawing in the form of symbols. This subject can be achieved by integrating three levels, namely macroscopic, microscopic, and symbolic, to improve students' understanding. The students' understanding at the macroscopic level is higher than that at the microscopic level, so they must have the same portion in their delivery (Rahayu & Kita, 2010). The microscopic representation can be an essential element, not only to explain students'experimental observations but also in the process of evaluating students' knowledge and identifying misconceptions (Alawiyah et al., 2018; Devetak et al., 2009; Drastisianti et al., 2018a). One application of multiple representations is the application of teaching materials that contain macroscopic, microscopic, and symbolic elements. Teaching material with a multiple representation approach will support excellent multiple representations skills, making it easier to solve the chemical problems faced (Drastisianti et al., 2018a; Susilaningsih et al., 2018; Yusuf & Setiawan, 2009).

Interviews with teachers from senior high school 10 (SMA N 10) Semarang, Indonesia obtained information that the learning outcomes of students in the tenth (X) grade of a natural science class on redox material are still low. These outcomes were characterized by the classical completeness of students of around 20-30%, with the Indonesian standard of KKM (minimal completeness criteria) of 77. The low classical completeness can be caused by students' lack of understanding of concepts. Chemical concepts that are abstract require visualization to improve understanding of concepts. This problem could be overcome by visualization through a practicum in the laboratory, animation simulation media, virtual practicum, demonstration, and contextual learning (Ibrahim et al., 2014; Özmen, 2004; Touli et al., 2012). Teaching materials used by students are limited to student worksheets. These worksheets have many shortcomings, such as lack of interactive material and presented incompletely. Moreover, it does not follow the characteristics of students and textbooks.

Redox is one of the materials that require an explanation in macroscopic, microscopic, and symbolic. This explanation is vital to produce a comprehensive understanding of the redox topic. Chemistry concept understanding is the explanation of material from simple levels to more complex levels. Some concepts become more meaningful when utilizing a representation, and some chemical concepts can be explained with more representations, namely macroscopic, microscopic, and symbolic (McDermott & Hand, 2013). Therefore, a diagnosis of conceptual understanding in early students is needed to prevent misunderstanding or misconception.

Chemistry triplet is one of the multiple representation models in chemistry learning proposed by Johnstone (1982). Johnstone (in Lin et al., 2016) divides Chemistry triplets into three representations, namely macroscale (macroscopic), nanoscale (also called micro or sub-micro), and symbolic representations. Incorrect of concept understanding will cause difficulties in understanding the next concept so that a proper basic understanding is needed (Jannah et al., 2013). Learning in class should be connected with daily life so that the material delivered is stored longer in memory. Students are more interested if learning is connected with daily life because students will feel the learning about chemistry is more meaningful. One of the learnings that are connected with daily life is contextual teaching-learning, such as in the research conducted by Drastisianti et al. (2018b), who succeeded in explaining the buffer concept by using teaching material of multiple representations through entrepreneurial chemical products. Furthermore, that was strengthened by recent researches on multiple representations which explain that the use of multiple representation learning materials is important in increasing students' understanding of chemical materials (Nada et al., 2018; Pratiwi et al., 2018; Susilaningsih et al., 2018; 2019). Based on the explanation above, teaching materials with multiple representations and contextual teaching-learning approach are needed.

In our research, we applied multiple representations and contextual teaching-learning approach on redox material in grade ten (X) of natural science class of state senior high school 10 (SMA Negeri 10) Semarang, Indonesia. This study was aimed to determine the students' comprehension of redox concepts.

METHODS

The research was carried out in SMA N 10 Semarang beginning from January 26, 2017, to March 3, 2017. The sampling method was cluster random sampling. Chemical concepts in class X are still considered difficult by students and require a complete understanding because they are needed for mastering the next material which is the redox concept. This study was an implementation of the results product referring to the 4D (Define, Design, Develop, and Disseminate) model. *Define* is the defining stage; it means the preparation to establish and defining research needs by analyzing the research object; it began with observation and interview. *Design* is the stage for designing teaching materials qualified as a facility for students to learn competencies coherently and systematically so that they can master all competencies as a whole and integrated. Test instrument validity was done by expert judgment, and the reliability used Kuder-Richardson21 (KR-21) formula. The result of the design stage was to obtain the teaching materials reviewed to be valid and reliable as an instrument. *Develop* is the phase of development; the instrument that has been evaluated by the expert was tested to the student, and the result was analyzed through the possibility in Table 1 and questionnaire was filled to determine that the instrument could be declared as valid, useful, and practical. The last phase is the *Disseminate.* It is the stage of publication, in this case, through scientific journals.

The research subject was teaching materials on the redox topic with multiple representations and contextual teaching-learning approaches. The research subjects were 36 students from the tenth grade of natural science class (X MIPA 5), SMA Negeri 10 Semarang, Indonesia. The adopted research methods were observation, questionnaire, written test, and documentation. The observation method obtained data on teaching materials redox material used in learning that has not shown multiple representations, and students still had difficulty in determining oxidation numbers.This is reinforced by the existence of documented data on the results of the pretest about redox concepts by the researchers to find out the extent of students' understanding of concepts. Quantitative data were obtained from the written tests and questionnaires. The written test contained 20 problems of three-tier multiple-choice to analyze the conceptual understanding of the students. The questionnaire was used to determine whether the instruments were useful and practical from the point of view of the students, and the employed instruments were the Three Tier Diagnostic Post Test. The combination of answers was referred to analyze the concept mastery, and its interpretation appears in Table 1.

Table 1. The Interpretation of Test Answer Combination Using a Three-Tier Diagnostic Post-Test Applied in Grade X of Natural Science Class, SMA Negeri 10 Semarang

Phase 1	Phase 2	Phase 3	Category
Correct	Correct	Sure	Properly Understand
Correct	Correct	Not Sure	Less Understand
Correct	Incorrect	Sure	Misconception
Correct	Incorrect	Not Sure	Guessing
Incorrect	Correct	Sure	Misconception
Incorrect	Correct	Not Sure	Guessing
Incorrect	Incorrect	Sure	Misconception
Incorrect	Incorrect	Not Sure	No Understanding

(Suhendiet al., 2014)

RESULTS AND DISCUSSION

Before the application, the Three-Tier Diagnostic Test items were examined for its difficulty index, power differences, validity, and reliability. There were 25 three-step multiple choices or reasoned MCQs. The effectiveness of teaching materials was reviewed from classical completeness and students' understanding of concepts. The teaching materials developed have been declared effective as 28 of 36 students completed them. Eight students did not complete the teaching material because they were not familiar with the pictures (symbols) in it, they were accustomed to the detailed words so that it took longer to translate and understand the pictures into words.The analysis of concept mastery understanding was based on the conceptual understanding recapitulation of each item and indicator. Indicators and items are formulated based on the results of initial observations. Observation results show that the concepts of redox material were still poorly understood by students, especially in determining oxidation numbers and equalizing redox reactions. The formulated questions are expected to be able to explore students' abilities in associating a concept with other concepts. The used indicators are presented in Table 2.

Table 2. Item Indicator of Redox Material with Multiple Representations and Contextual Teaching-Learning Approach in Grade X of Natural Science Class, SMA Negeri 10 Semarang, Indonesia.

No	Indicator	Item
1.	Development of redox reaction	1, 2, 3
2.	Determination of oxidation number	7, 8, 10, 14
3.	Determination of oxidation and reduction reaction	6, 15, 25
4.	Determination of oxidizer and reductant	11, 12
5.	Determination of redox, disproportionation, proportionate, and non-redox reactions	5, 9, 13, 24
6.	Chemical nomenclature	16, 17, 18, 19, 20, 23
7.	Application of redox reaction	4, 21, 22

The analysis of each item shows that item number 12 was understood by 22.22% of the students. This low result was due to a big misconception on the item, which was 52.78%. Furthermore, some of them did not comprehend the concepts. The misconception took place when the students answered which material is not an oxidizer. The explanation about materials that cannot be functioned as either oxidizer or reductant has not been clear. Instead, the teaching materials only provide reports about the definition. Item number 7, 8, 11, 17, 24, 9, 15, and 21 were answered correctly by almost half of the students, as presented in Figure 1.

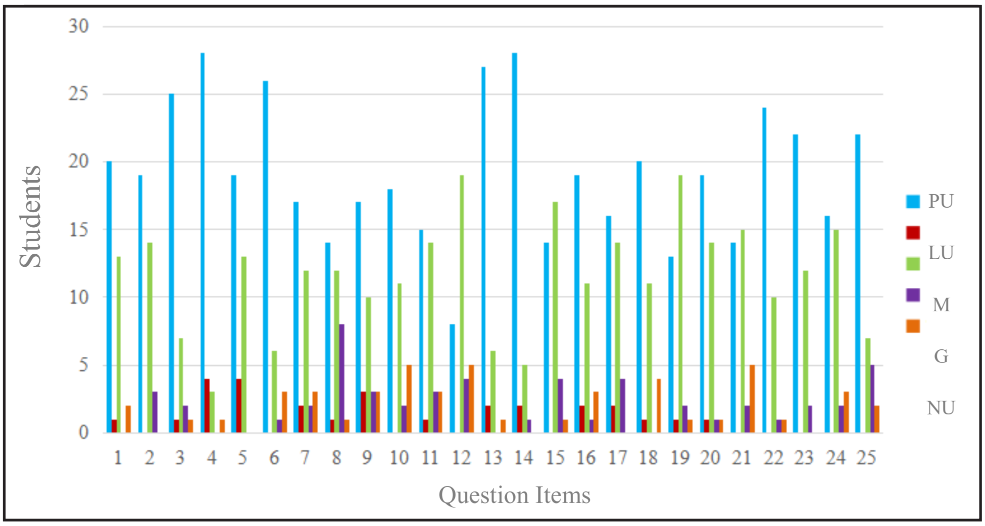

Figure 1. Recapitulation of Concept Mastery on Each Item of Grade X, Natural Science Class, SMA Negeri 10 Semarang, Indonesia Using Multiple Representations and Contextual Teaching-Learning Approach Redox Material

Similarly, item number 10 was understood by the 18/36 of the students. Based on the analysis, it was found that students are still not consistent in determining the oxidation numbers of O and H, which are sometimes still confusing, as the oxidation number O becomes +1, and the oxidation number H becomes -2. Students also still experienced errors in calculating the oxidation numbers of polyatomic ions, such as NH_4^+, SO_4^{2-}, and PO_4^{3-} as they counted the number of oxidation numbers equal to 0 rather than the ion charge. Item number 6, 18, 23, 25, 5, 13, 20, 22, 2, 16, 1, 3 reveals that most of the students understood the concepts. Based on item 6 and 25, students were able to identify oxidation and reduction reactions based on oxygen binding and release, electron reception and release, and increasing and decreasing oxidation numbers. Moreover, item number 4 indicates that almost all of the students comprehended the concepts.

The highest concept understanding was on item number 4 and 14, which were understood by 28/36 of the students. Item number 4 was about redox application in daily life. The high comprehension was facilitated by a sufficient explanation about redox provided in the teaching materials aided with Chemistry Info. Item number 14, which gained the same number of correct answers, asked about the non-reducted Br element. The high understanding rate was supported by the exercises on oxidation number determination given in the teaching materials. The analysis of concept mastery reveals that 53.33% of the students had a proper understanding of the concepts, 3.11% of the students less understood the concepts, 32.22% of the students faced misconception, 5.899% of them answered based on their guess, and 5.44% of the students did not understand the concepts. Suharyadi et al., (2013) performed developmental research on a contextual-based textbook about acid and base and found out that 56% of the students gained sufficient knowledge for learning using the book. Moreover, Özmen (2008) carried out a study about students' alternative concepts of chemical equilibrium and turned out that 48.8% understood the taught concepts well. The students' recapitulation of concept mastery on each item is presented in Figure 1.

According to the analysis results, the students' concept mastery on the indicator of interpreting was 50.214%, exemplifying was 77.78%, classifying was 53.472%, guessing was 52.78%, comparing was 52.78%, and explaining was 62.5%. The recapitulation of the students' concept comprehension on each indicator (%) is shown in Figure 2.

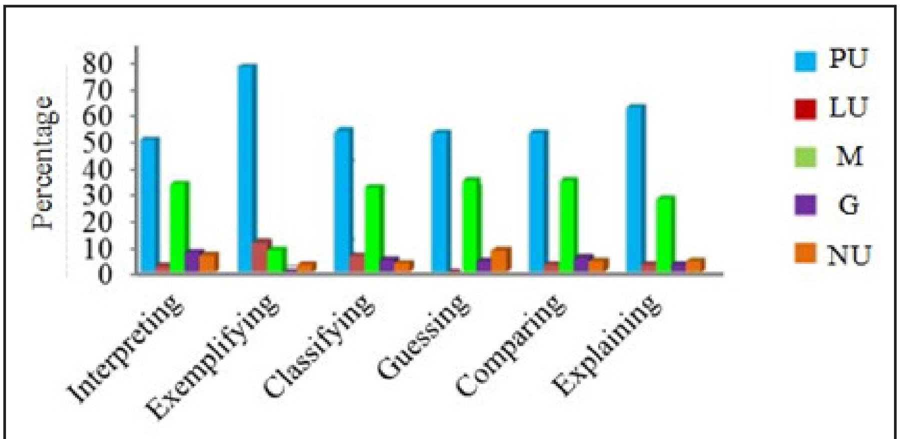

Figure 2. The Recapitulation of Concept Mastery an Each Indicator of Grade X, Natural Science Class, SMA Negeri 10 Semarang, Indonesia by Using Multiple Representations and Contextual Teaching-Learning Approach on Redox Material

Based on the analysis of each indicator, the highest score was on the example provision (77.78%). This top result was supported by the complete examples of teaching materials on redox reactions in daily life. The examples did not only appear in the introduction but also in Chemistry Info. Thus, it has been proven to help the students to know more profoundly about redox application. The students were also trained to construct their own experience about redox implementation to help them understand more thoroughly. The students gained knowledge by building their own understanding of the experience. The students found and set ideas obtained during the learning process. This process is called constructivism, which is one of the components of the contextual teaching-learning approach. The interpreting indicator obtains the lowest percentage. This shows that the ability to interpret the graph is still low. This is due to the students' difficulty in connecting the ability of their concepts by pouring them into graphs.

The students are trained and required to come up with ideas in designing and solving problems in learning. Learning activities also train the students to gain knowledge by building their own understanding of the experience gained. They found and set ideas obtained during the learning process. The interpreting indicator obtained the lowest percentage. This shows that the ability to interpret the graph is still low, and the students have difficulty in connecting the ability of the concept by pouring it into the graph. On the indicator guessed, the results were obtained from students who still guessed the oxidation numbers as seen from the answers in which they wrote different oxidation numbers for one atom.

CONCLUSION

Referring to the analysis results of the concept understanding by using redox teaching materials with multiple representations and contextual teaching-learning approach, it can be concluded that the overall students' concept understanding was 53.33%. The students' concept understanding of the indicator was 50.214% interpreting, 77.78% exemplifying, 53.472% classifying, 52.78% guessing, comparing 52.78%, and 62.5% explaining.

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