Development of Teaching Material Oxidation-Reduction Reactions through Four Steps Teaching Material Development (4S TMD)

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Abstract. This research aims to develop oxidation-reduction reactions (redox) teaching material used the Four Steps Teaching Material Development (4S TMD) method consists of four steps: selection, structuring, characterization and didactical reduction. This paper is the first part of the development of teaching material that includes selection and structuring steps. At the selection step, the development of teaching material begins with the development concept of redox based on curriculum demands, then the development of fundamental concepts sourced from the international textbook, and last is the development of values or skills can be integrated with redox concepts. The results of this selection step are the subject matter of the redox concept and values can be integrated with it. In the structuring step was developed concept map that provide on the relationship between redox concepts; Macro structure that guide systematic on the writing of teaching material; And multiple representations which are the development of teaching material that connect on between macroscopic, submicroscopic, and symbolic level representations. The result of the two steps in this first part of the study produced a draft of teaching material. Evaluation of the draft of teaching material is done by an expert lecturer in the field of chemical education to assess the feasibility of teaching material.

1. Introduction

The learning process has three main components that are interrelated, that is teachers, students and teaching materials. The interactions of these three components form an integrated process entity, where there is a transformation of knowledge from the teacher to the learner so that the student gains the learning experience [1]. Therefore, the feasibility of a teaching material should receive serious attention, because teaching material is one of the main components in the learning process.

Teaching material for teachers serves to direct the learning activities as well as the substance of competence that should be taught to students. While for students, teaching materials have a function as a guide in the learning process and is a substance of competence that should be studied and as an evaluation tool of learning achievement [2].

Development of teaching material should pay attention to several aspects in order to help students learn independently and get mastery in the learning process, such as: giving examples or illustrations in accordance with the intended learning materials, giving practice questions or tasks as feedback for students to measure mastery of contextual, contextual based, and The use of simple language to make it easier for students to understand the material materials independently [3]. Therefore, the authors do the development of teaching materials through the method of 4S TMD (selection, structuring,
characterization and didactic reduction), because through this method of teaching material that meet the criteria of a teaching material from the aspect of the suitability of the curriculum, true scientifically, has the value of usefulness for students, And the censoring of concepts [1]. This paper is the first part of the development of teaching materials that includes the selection and structuring steps to obtain a draft of teaching materials. Some studies suggest that students have difficulty in studying redox [4][5] in understanding the theory of oxygen binding and release, electron transfer, and changes in oxidation numbers. This is because the redox phenomenon is abstract and difficult to observe that it is difficult to convey both the concept and its application. It can be caused by the materials used. Teaching materials that connect theory with its application make it easier for students to understand the concept, by showing macroscopic, microscopic and symbolic [6][7]. Therefore, it is needed a teaching material that can facilitate user to understand it, so this research proposes to develop redox teaching materials through 4S TMD method. [8] The development of teaching materials is done by paying attention to aspects of concepts, linguistics and presentation that have an important role in realizing the teaching materials in accordance with the demands of education.

2. Experimental Method
Development of teaching materials is done through 4S TMD method. This article is the first part of the development of teaching materials that includes the selection and structuring steps. At the selection step, the development of teaching material begins with the selection of the concept of developing oxidation-reducing material (redox) based on curriculum demands, development of indicators, then development of basic concepts sourced from basic chemistry books, school chemistry books and international textbooks Related (concept identification), and the last is the development of values or skills that can be developed through redox material. The concept that has been selected is reviewed by an expert lecturer. The structural step includes concept maps, macro structures, and multiple representations of the oxidation-reduction reaction material that results in draft material.

This research uses the first type of Development Research design that is aimed not only to design and develop from a product but also to evaluate it [9]. This research procedure consists of three steps, namely design, production and evaluation steps. The Design step begins by conducting a literature review of the chemical concepts that students often have difficulty learning. Based on the results of literature review found that one such concept is redox. Literal analysis was then done to find out some of the causes of student learning difficulties. Based on the analysis it is found that one of the causes of students’ difficulties in studying chemistry is the teaching materials used. At the production step, the procedure used is the teaching materials development procedure. In this research, the method chosen to develop teaching materials is Four Steps Teaching Material method known as 4S TMD. There are four steps: selection, structuring, characterization, and didactic reduction. But in this paper is the first part of the development of teaching material that includes selection and structuring steps. Evaluation of the draft of teaching materials is done by an expert lecturer in the field of chemical education to assess the feasibility of draft teaching material.

3. Result and Discussion

3.1 Selection Step
Selection step included the development of indicators, concepts selection and value selection. At the selection step, the development of teaching materials covered the development of the scope of the oxidation-reduction reaction (redox) material based on curriculum demands and it was begun by selection of Basic Competence (KD). The most important aspect in designing the development of teaching materials, namely attention to the demands of the curriculum [10]. This means that teaching materials must be prepared in accordance with the applicable curriculum. In the redox subject there are two KD given by Depdiknas, that is:

3.9 Analyzing the development of the concept of oxidation-reduction reactions and determining the oxidation number of atoms in molecules or ions.
3.10 Implementing IUPAC rules for naming inorganic and organic compounds.

First step of selection step obtained that KD 3.9 will be developed in teaching materials because the KD contain main concept of redox while KD 3.10 contain the nomenclature of a compound and it is not related to the concept of redox. After the curriculum analysis was done, the next step was the development of indicators. It aimed to measure the achievement of KD and as a guide in the development of teaching material. The development of indicators obtained are listed in Table 1.

| KD | Indicator | Concept Label |
|----|-----------|---------------|
| Analyzing the development of the concept of oxidation-reduction reactions and determining the oxidation number of atoms in molecules or ions. | 1. Explaining the Phlogiston theory | 1. Phlogiston theory |
| | 2. Explaining oxidation and reduction reactions based on the binding and release of oxygen (Redox) based on: | 2. oxidation and reduction reactions based on: |
| | 3. Explaining oxidation and reduction reactions based on the release and binding of electrons | a. binding and release of oxygen |
| | 4. Explaining oxidation and reduction reactions based on changes in oxidation numbers | b. binding and release of electron |
| | 5. Explaining oxidation number | c. the changing of oxidation numbers |
| | 6. Determining oxidation number of an atom in a molecule or ion | 3. Oxidation number |
| | 7. Determining oxidizer and the reducing agent in the redox reaction | 4. OxidatordanReductor |
| | 8. Explaining autoredox reactions | 5. Autoredox |
| | 9. Explaining application of the concept of redox in daily life | 6. application of the concept of redox in daily life |

Table 1 shows that there are 9 indicators that developed in redox subject matter. The concept of the flogiston theory is included because it relates to the redox concept development as the beginning of the term oxidation. The results of this step of selection are the subject matter of the redox concept of the theory of flogiston, redox based on the binding and release of oxygen, redox based on the release and binding of electrons, and redox based on changes in oxidation numbers, oxidation numbers and applications in daily life. The next step was to identify the concept label in accordance with the indicators developed. The concepts were defined by textbooks so that the compilation of redox reaction material was obtained. Material selection begins by selecting the material source. In this study the source material in the form of basic chemistry books and international textbooks. Books that used as a reference are:

1. Bradi,James, Jespersen, Neildan Hyslop, Alison. 2015. Chemistry Seventh Edition. New York: John Wiley & Sons.
2. Chang, Raymond dan Overby, Jason. 2005. General Chemistry: The Essential Concepts, Sixth Edition. New York: The McGraw-Hill.
3. Davis, Raymond E., Metcalfe, H. Clark., Williams, John E., dan Castka, Joseph E. 2002. Textbook modern chemistry. USA: Holt, Rinehart dan Winston.
4. Gallagher, Rose, Marielden Ingram, Paul. 2009. Chemistry IGCSE Revision Guide. New York: Oxford University Press.
5. Norris, Roger., Ryan, Lawriedan Acaster, David. 2011. Cambridge International AS and A Level Chemistry Coursebook. UK: Cambridge University Press.
6. Glencoe. 2002. Chemistry concepts and application. USA: The McGraw-Hill.

The next step is the development of values or skills that could be developed through redox reaction materials such as religious values, social care, tolerance, creative, environmental care and discipline. Table 2 show a sample of value linkage with concept

| Concept description | Related value | Value linkage with concept |
|---------------------|---------------|---------------------------|
| Picture of burning garbage | Environmental care | Household garbage piled up, if not burned or recycled, will certainly decay and cause major disasters. Because bacteria thrive and cause various diseases. In general, household waste is plastic, paper, leaves, and food scraps. If the waste is burned, then smoke and other harmful gases are formed. For example the burning of waste plastic produces CO₂ gas is very dangerous because it can raise the temperature of the earth. Therefore we must be more wise in using plastic |

Table 2 show the value of environmental care in the redox concept based on the binding and release of oxygen. This teaching material is made oriented to SETS. Where SETS is a way of view that everything facing humans in this life contains aspects of science, environment, technology and society that affect the reciprocal [11][12].

3.2 Structuring Step

Structuring step is generated concept map as part of teaching materials that provide guidance on the relationship between the existing concepts on redox material; macro-structure which gives guidance on the systematic writing instructional materials; And multiple representations which are the development of teaching materials that connected between macroscopic, submicroscopic, and symbolic level representations. This step can facilitate students in connecting one concept with another concept, so that students' knowledge was more structured. [1] the students knowledge are structured in cognitive structure will facilitate students in considering new information received. [13] In addition to showing the relationship between concepts in teaching material, concept maps used as a first step to define planning (in the form of an outline) into writing.

Some of the benefits of structured teaching material are provide conformity between the needs of certain levels of learners with the content of teaching material, be able to describe the structure of science and helping students in describing cognitive structures in their brains [1]. In macro structures, there was mensions of progression and elaboration dimensions. The progression dimension is a vertical dimension in the form of a downward plot showing macro precision, while the elaboration dimension is the horizontal dimension of flow to the right as a way of reaching the clarity or explanation criteria of a subject matter. There are 4 core macro dimension, that is the phlogiston theory, redox reactions, oxidizing and reducing agents and the autoredox. Figure 1 show the part of the macro structure.
Figure 1. Redox macro structure

The characteristics of chemistry was based on the theory of the particulate nature of an object at the submicroscopic, macroscopic, and symbolic levels. [14] The chemical representations has three levels. The macroscopic level is a real and visible. The submicroscopic level is used for explanations in molecular form or symbolic explanations. The latter is a symbolic level consisting of different types of image representations and symbols. The success of chemistry learning involves the construction of mental associations between the macroscopic, submicroscopic and symbolic levels of the representation of chemical phenomena by using different representations [15]. Therefore it is necessary to integrate the three chemical representations to facilitate students in understanding a material.

Table 3. Redox multiple representation

| Concept | Macroscopic | Submicroscopic | Symbolic |
|---------|-------------|----------------|----------|
| Redox based on the release and binding of electrons | Fireworks is one example of a redox reaction. One of the substances contained in it is magnesium which gives a bright white color to the fireworks. Magnesium (Mg) reacts with oxygen (O2) to produce MgO. In this reaction Mg releases an electron which means Mg is oxidized and Oxygen binds an electron indicating it is undergoing a reduction. | 2Mg(s) + O₂(g) → 2MgO(s) (Oksigen bond the electron) | 2Mg + O₂ → 2MgO (Magnesium released the electron) |
|          |             |                | OxidaMgO (MgO) is the ionic that arranged from Mg²⁺ dan O²⁻ ions. 2 Mg → 2Mg²⁺ + 4e⁻ O₂ + 4e⁻ → 2O²⁻ |
Then the compilation of the matter was made in the draft of teaching material. The evaluation of the draft of the teaching material is done by an expert lecturer in the field of chemical education to assess the feasibility of teaching material. Views of teaching material obtained can be seen in Figure 2.

4. Conclusion
The subject matter that developed on teaching materials was a development of KD 3.9 with 9 indicators. These indicators include the concept of the phlogiston theory, redox based on the binding and release of oxygen, redox based on the release and binding of electrons, redox based on changes in oxidation numbers, oxidation state and its application in daily life. At the structuring step was developed concept map as a part of teaching materials that provide the relationship between redox concepts; Macro structure that guide systematic on the writing of teaching material; And multiple representations which are the development of teaching materials that connect between macroscopic, submicroscopic, and symbolic level representations. The result of the two steps in this first part of the study produced a draft of teaching material.

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