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The Development Teaching Materials of Chemical Representation on Redox Reaction Topic by Using Knowledge Building Environment to Develop Science Process Skills

Yuli Andrianto

Department of Chemistry Education, SPs of*Indonesia University of Education*
Jl. Dr. Setiabudi No. 229, Bandung 40154, Jawa Barat, Indonesia, *email: andrianto_yuli@yahoo.co.id

Abstract

This research aims to develop teaching material on redox reaction topic for high school students through Four Steps Teaching Material Development (4STMD) and test the level of comprehension, expose characteristics, describe knowledge building environment, and test feasibility. This research is based on the unavailability of high school chemistry materials presented an integrated redox reaction topic and based on knowledge building environment. This research uses development research method. The development of teaching materials consists of the design step, development step with 4STMD, and evaluation step by testing its comprehension and feasibility. The development stepwith 4STMD of this resource consist the step of selection, structuring, characterization, and didactic reduction. Selection step is an assessment of Kompetensi Inti (KI) and Kompetensi Dasar (KD) then determine the appropriate theme, make an indicator of achievement and developed aspects of the values contained in the concepts of matter. Structuring step is the steps of making a concept map, macro structure, and multiple representations. This multiple representation is an attempt at presenting data which includes macroscopic, submicroscopic and symbolic representations. Next, at the characterization step, characterization of the concepts conducted on 91 students of class X IPA. Data from the results of the characterization step become the basic for didactic reduction of concept which is difficult for students to understand. The characteristics of teaching materials include presentation format of teaching materials, proximity of teaching materials with daily life of students with knowledge building environment, developing science process skills with teaching materials, and suitability of teaching materials with BSNP standards. Based on the test, the teaching materials have met the aspect of high category comprehension. Knowledge building environment on teaching materials is developed by linking the contexts in redox reactions with phenomena in daily life. The results of this research is a draft of teaching materials which will be in the test of its content feasibility aspect, feasibility of presentation, language feasibility, and feasibility of graduation. So it can be used as teaching materials to develop science process skills.

Keywords: teaching materials, redox reactions, knowledge building environment¸ science process skills

Introduction

According to the theory of contructivism, learning is the process of building understanding through meaningful interaction with the world, thus incorporating

the active involvement of students with learning materials and learning environments (Antle, et al., 2011). One of the learning functions is self-evident that is to store the scheme automatically in long-term memory (Sweller, 1994). Allwrigh categorizes the learning process as an interaction between the three elements, that is: teachers, students and teaching materials (Hutchinson & Torres, 1994). The interaction result of the three elements is a learning opportunity. One of the important components in learning is teaching materials as a learning resource for students. In the learning process, students need instructional materials as declarative knowledge, procedural knowledge, and intellectual skills that are the framework or guidance in helping them to organize what they learn in and out of the classroom during learning, while doing activities or exercises, self-study, and prepare for exams (Yanti, et al., 2008). Teaching materials allow students to learn better, faster, clearer, easier and more.

Good teaching materials can be an excellent tool in developing science process skills. Science process skills are very important to develop in education as they are a basic competency to develop students' scientific attitude and problem-solving skills so as to shape creative, critical, open, innovative, and competitive student personalities in the competitive world of the global community. It is fitting for teachers to develop students' science process skills as supporters in developing the concept of science, especially chemistry, which in turn will provide the best learning outcomes. Chemistry is a part of science that is built by three levels of representation, that is: macroscopic, sub-microscopic and symbolic levels. To develop students' understanding of chemistry, learning must guide them using different representations and linking these three levels of representation (Wu, 2003).

However, as currently known, most chemistry studies only teach symbolic levels only and give little emphasis on the macroscopic and sub-microscopic levels and the lack of learning that tries to make connections between these three levels with long-held knowledge in students' thinking. Chemistry as one of the science subjects has an important role in building the students' environmental knowledge, let alone the phenomena that occur in many natural phenomena which are

chemical phenomena. So chemistry should indirectly lead to the development of environmental knowledge, by utilizing the surrounding environment in the process of chemistry learning, so students can get concrete experience so it is expected more easily in understanding the concept of chemistry, one of them is the topic of redox reaction which concept is very close to life daily. So the development of knowledge building environment is the task of various parties including the school which includes the smallest element is the teacher. Teachers are expected to be able to direct their students on the development of environmental knowledge when in presenting lessons, meaning that chemistry teachers in particular must be able to convey natural phenomena that occur in the environment associated with the concept of chemistry being studied.

The aims of this research are (1) development teaching materials of chemical representation on redox reaction topic by using knowledge building environment to develop science process skills. (2) Develop chemical representation by using knowledge building environment to develop science process skills. (3) Analyze the feasibility of teaching materials on redox reaction topic by using knowledge building environment to develop science process skills. (4) Analyze the comprehension of teaching materials on redox reaction topic by using knowledge building environment to develop science process skills.

Material and Method

This research is designed using development research method development research method are used to produce a specific product and test the effectiveness of the product (Sugiyono, 2008). This research follows model of Borg & Gall (1989) that is limited to the 9th stage, tailored to the needs of the researcher. The product design of the teaching materials was developed using the Four Steps Teaching Material Development (4STMD) procedure which included the selection, structure, characterization and didactic reduction (Sjaeful Anwar & Arifin, 2015).

The selection process is a literature study to collect information related to document studies, curriculum, resource and other resources in developing high school chemistry materials. Activities include: 1) Analysis of curriculum 2013 at

the high school level on the subjects of chemistry, related to Kompetensi Inti and Kompetensi Dasar; 2) Analysis of descriptions to reduce KompetensiDasar into learning objectives that will be developed in making teaching materials; 3) Analyze the values that can be inserted and in accordance with the scope of topic study the teaching materials; 4) Collecting resources and compiling subject material obtained from textbooks and other sources adapted to Kompetensi Dasar into a draft collection of selection materials; and 5) Validation by experts to ensure the validity and accuracy of the teaching materials content before being developed in the next stage.

In the process of structuring, the draft collection of materials of the structural selection is didactically in accordance with the characteristics of the teaching material structure. The procedure of the stage of structuring includes (1) making concept maps of concepts on the draft collection of selection materials; (2) create macro structures by sorting the concept material in the draft collection of selection materials; And (3) summarize multiple representations in the form of macroscopic, sub-microscopic and symbolic representations of the draft collection of selection materials. (4) expert validation (concept maps, macro structures and multiple representations) to see the truth of composing the subject matter structure

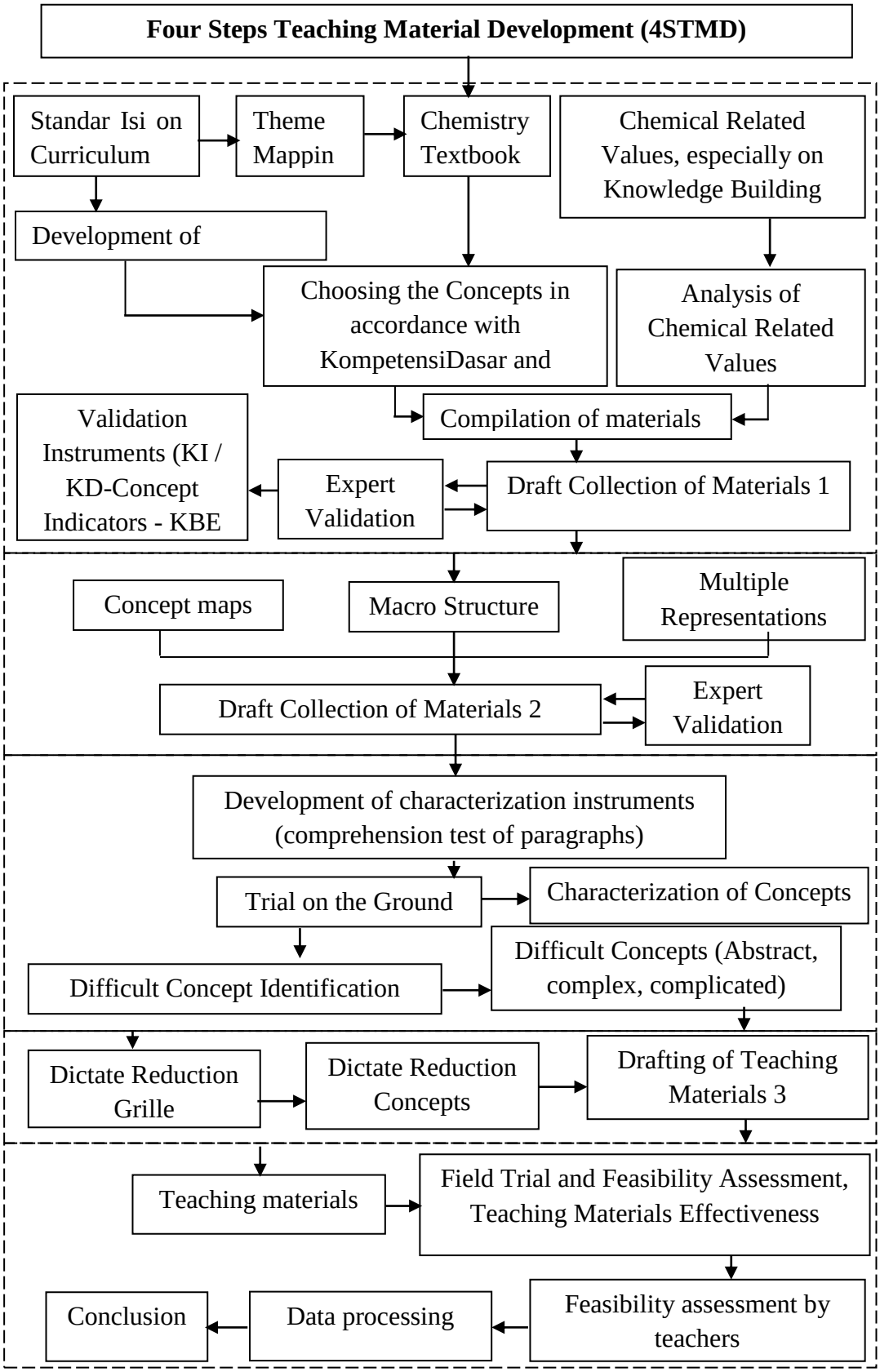

Fig. 1. Four Step Teaching Material Development Scheme

At the characterization stage, teaching materials that were didactically structured were then tested to the students to identify difficult concepts using the writing of the main idea developed by Sjaeful Anwar (2014). The main idea-writing instrument is used with the consideration that to be able to understand a text requires a thorough understanding of each of the text-forming paragraphs. In otherwords through the writing of the main idea of the text on teaching materials, students will perform the stages of thinking and find ideas that are written from a text.

The difficult concepts on the teaching materials are further reduced didactically at the last stage of the 4STMD method or didactic reduction stage. The reduction process can be done by creating a didactic reduction grille and then doing didactic reduction using symbols, sketches, samples or analogies. The teaching materials produced at the re-reduction stage were tested on the students to compare the difficulty criteria of the concept before and after didactic reduction. The end result of the teaching materials development process of Four Step Materials Teaching Development is a teaching material that has easy concept criteria.

Tests on teaching materials are done in two stages, that is testing the comprehension and feasibility of teaching materials. Understanding of teaching materials in question is the comprehension of the concept of teaching materials that are tested through a comprehension test, to see the quality of students' understanding of the concept on teaching materials. In addition, the assessment of the feasibility of teaching materials by experts and teachers from the aspect of content, presentation of material teaching, language and graphics.

The object of this research is teaching materials in the form of student modules for chemistry subjects at high school the topic of redox reactions. Meanwhile, the respondents in the research are the students of class X IPA who learn by applying the Curriculum 2013. Implementation of identification test of difficult concept and comprehension of teaching materials is done in one SMA in Karawang. The data obtained from this research and development consists of quantitative and

qualitative data. Qualitative data are: 1) Expert validation result on collection of selection material; 2) Expert validation results on the collection of material structuring; 3) Assessment of the feasibility of teaching materials. Quantitative data are: 1) Identification difficult concept; and 2) Understanding of teaching materials.

To see the feasibility of developed teaching materials, then the feasibility study of teaching materials. The feasibility of teaching materials will be assessed based on the assessment criteria of BSNP. Questionnaire feasibility of teaching materials consists of aspects of the content feasibility, language, presentation, and graduationteaching materials. Percentage of the level of eligibility of the teaching materials can be calculated using the equation as follows:

$$P = \frac{f}{n} \, x \, 100\%$$

Information:

f = number of scores obtained

n = maximum number of scores

p = percentage number

The criteria of the level of eligibility of the teaching materials are as follows:

20% <P ≤ 36% = not feasible

36% <P ≤ 52% = less feasible

52% <P ≤ 68% = quite feasible

68% <P ≤ 84% = feasible

84% <P ≤ 100% = very feasible

(Sudijono, 2008)

To determine the level of legibility/comprehension (TK) used the formula as follow

$$TK = \frac{\text{scores obtained}}{\text{maximum score}} \, x \, 100 \, \%$$ (Suhadi, 1996)

Information:

f = score obtained = number of correct answers from respondents

n = maximum score = all test answers are correct.

According to Rankin and Culhane in Suryadi (2007). The scoring of the legibility of the lessons is done as follows:

0% <P <40% = low (elusive)

40% ≤ P ≤ 60% = medium (already qualified for understanding)

60% <P ≤ 100% = high (easy to understand)

Result and Discussion

The teaching materials developed through the Four Step Teaching Materials Development (4STMD) method are a student module entitled "Redox reaction in daily life" that integrates the phenomena of daily life with the concept of redox reactions. The results of the analysis curriculum 2013 selected one main basic competence that isKompetensiDasar (KD) 3.9 and 4.9. KD 3.9 is about analyzing the development of the concept of redox reactions as well as determining the oxidation number of atoms in molecules or ions. KD 4.9 is designing, performing, and summarizing and presenting the results of experiments of redox reactions.The source book used in Table 1.

Table 1. Reference books

No	Author	Publication Year	Book title
1	Raymond Chang	2011	Chang General Chemistry The Essential Concepts 6th
2	John S. Phillips, Victor S. Strozak, & Cheryl Wistrom	2002	Chemistry Concepts and Applications
3	Daniel L., Reger Scott R., & Goode David W. Ball	2010	CHEMISTRY: Principles and Practice 3th
4	Mc Murry Fay	2012	Chemistry 4th

In addition to the above reference books, to supplement the information obtained from most Internet sources in the form of images illustrating text reading.

The character of knowledge building environment inserted in this instructional material is attentiveness, careness, curiosity, critical, moderation,

respect, environment (Respect for environment), respect for health, and wisdom. This character is raised so that students can build their knowledge through the phenomena that exist around the environment.

The results of the validation of the draft of selection materials concluded that: a) the development of learning objectives has been "suitable" with basic competencies, with some improvement on the operational verb use of learning objectives; B) conceptual texts developed "suitable" with learning objectives; and c) values inserted in "suitable" teaching materials with conceptual text of instructional materials. The second stage of 4STMD is the process of structuring that produces a draft collection of material in the form of concept maps, macro structures, and multiple representations. The entire validator considers that the draft collection of material of structuring has been in accordance with the concepts on the teaching materials.

Draft results of the process of characterization in the form of teaching materials entitled "Redox reactions in daily life". This Teaching Material consists of 53 paragraphs consisting of conceptual texts. Characterized concept text is labeled a small number on the left of the text; Then at the end of the sub-chapter the student is asked to write down the main idea and its judgment on the understanding of the text in the feedback section. Recapitulation of concept analysis is difficult by using the main idea of conceptual text of teaching materials can be seen in Table 2 and Table 3.

From Tables 2 and 3, Material concepts with the category "difficult" were then subjected to didactic reduction treatment and re-examined to identify the criteria for the concept. The results of the identification of the concept has been reduced, the concept into concepts with easy concept criteria. Assessment of students' understanding of teaching materials "Redox reactions in daily life" using concept comprehension test questions. This test is based on the learning objectives used in the development of teaching materials.

Table 2. Percentage of ease in understanding conceptual texts

Main Idea of the To-	Percentage of Ease (%)	Infor-mation	Concept Text Criteria	Main Idea of the To-	Percentage of Ease (%)	Infor-mation	Concept Text Criteria
1	87,88	-	Easy	**28**	42,86	Reduction	Difficult
2	72,73	-	Easy	**29**	78,57	-	Easy
3	93,94	-	Easy	**30**	14,29	Reduction	Difficult
4	93,94	-	Easy	**31**	100,00	-	Easy
5	78,79	-	Easy	**32**	100,00	-	Easy
6	81,82	-	Easy	**33**	85,71	-	Easy
7	75,76	-	Easy	**34**	39,29	Reduction	Difficult
8	84,85	-	Easy	**35**	80,00	-	Easy
9	87,88	-	Easy	**36**	13,33	Reduction	Difficult
10	78,79	-	Easy	**37**	20,00	Reduction	Difficult
11	33,33	Reduction	Difficult	**38**	76,67	-	Easy
12	90,91	-	Easy	**39**	100,00	-	Easy
13	48,48	Reduction	Difficult	**40**	96,67	-	Easy
14	36,36	Reduction	Difficult	**41**	73,33	-	Easy
15	72,73	-	Easy	**42**	100,00	-	Easy
16	87,88	-	Easy	**43**	96,67	-	Easy
17	75,76	-	Easy	**44**	83,33	-	Easy
18	75,00	-	Easy	**45**	63,33	Reduction	Difficult
19	71,43	-	Easy	**46**	43,33	Reduction	Difficult
20	100,00	-	Easy	**47**	83,33	-	Easy
21	78,57	-	Easy	**48**	70,00	-	Easy
22	100,00	-	Easy	**49**	10,00	Reduction	Difficult
23	78,57	-	Easy	**50**	80,00	-	Easy
24	71,43	-	Easy	**51**	20,00	Reduction	Difficult
25	75,00	-	Easy	**52**	96,67	-	Easy
26	10,71	Reduction	Difficult	**53**	90,00	-	Easy
27	71,43	-	Easy				

Table 3. Percentage of students answered correctly the main idea

Main Idea of the To-	Percentage of Ease (%)	Infor-mation	Concept Text Criteria	Main Idea of the To-	Percentage of Ease (%)	Infor-mation	Concept Text Criteria
1	78,79	-	Easy	**28**	35,71	Reduction	Difficult
2	75,76	-	Easy	**29**	78,57	-	Easy
3	96,97	-	Easy	**30**	14,29	Reduction	Difficult
4	90,91	-	Easy	**31**	89,29	-	Easy
5	72,73	-	Easy	**32**	92,86	-	Easy
6	90,91	-	Easy	**33**	71,43	-	Easy
7	81,82	-	Easy	**34**	28,57	Reduction	Difficult
8	72,73	-	Easy	**35**	83,33	-	Easy
9	90,91	-	Easy	**36**	20,00	Reduction	Difficult
10	84,85	-	Easy	**37**	23,33	Reduction	Difficult
11	27,27	Reduction	Difficult	**38**	70,00	-	Easy
12	90,91	-	Easy	**39**	96,67	-	Easy
13	45,45	Reduction	Difficult	**40**	86,67	-	Easy
14	30,30	Reduction	Difficult	**41**	76,67	-	Easy
15	78,79	-	Easy	**42**	100,00	-	Easy
16	75,76	-	Easy	**43**	93,33	-	Easy
17	72,73	-	Easy	**44**	76,67	-	Easy
18	71,43	-	Easy	**45**	43,33	Reduction	Difficult
19	78,57	-	Easy	**46**	36,67	Reduction	Difficult
20	92,86	-	Easy	**47**	90,00	-	Easy
21	71,43	-	Easy	**48**	76,67	-	Easy
22	92,86	-	Easy	**49**	16,67	Reduction	Difficult
23	71,43	-	Easy	**50**	86,67	-	Easy
24	78,57	-	Easy	**51**	26,67	Reduction	Difficult
25	71,43	-	Easy	**52**	93,33	-	Easy
26	17,86	Reduction	Difficult	**53**	86,67	-	Easy
27	75,00	-	Easy				

The qualification criteria for conceptual understanding is obtained by using the ideal average value calculation with the following qualifications.

0% <P <40% = low (elusive)

40% ≤ P ≤ 60% = medium (already qualified for understanding)

60% <P ≤ 100% = high (easy to understand)

(Suryadi, 2007)

Based on the above qualifications, students' conceptual understanding of teaching materials has a high understanding qualification in understanding the concept in teaching materials. This can be seen in Figure 2 and Table 4. Further testing of feasibility will be done to five high school chemistry teachers. Its feasibility assessment includes aspects of content, language, and graduation. So it can be used as teaching materials to develop science processskills.

Table 4. Qualifications score Test of Understanding Concept

No	Qualifications	Percentage (%)
1	Low	20.75
2	Medium	3.78
3	High	75.47

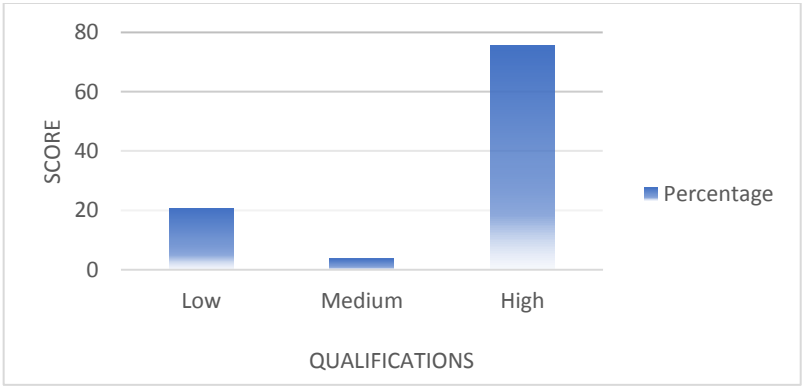

Figure 2. Qualification score Test of Understanding Concept

Conclusion

Based on the results of the research, it can be concluded that the teaching materials in the form of modules with the title "Redox in daily life" are processed by Four Step Teaching Materials Development (4STMD) method for high school students. In the process of making this learning materials are done four stages: selection, structuring, characterization, and didactic reduction process.

Assessments by judgement experts include assessing the suitability of developing learning objectives from Kompetensi Dasar, the suitability of the material draft text to the learning objectives, andthe suitability of characters inserted in the teaching materials, shows that all aspects have been compiled based on the curriculum and are scientifically correct, and have been devised in a didactic

manner.Besides, this resource contains concepts with easy criteria, which means students can understand the concepts easily.This is in accordance with the results of the calibration of students' understanding of teaching materials belonging to high (easy to understand). Next will be tested feasibility of content, language, and graduationaspects. So it can be used as teaching materials to develop science process skills.

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