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DEVELOPMENT OF CONTEXTUAL TEACHING AND LEARNING (CTL) BASED LEARNING MATERIALS TO FACILITATE STUDENTS IN IMPROVING CRITICAL THINKING ABILITY IN REDOX AND ELECTRO CHEMICAL TOPICS

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Abstract

Some high school students still experience difficulties in studying chemistry, one of which is redox and electrochemistry topics, which is very closely related to daily life. Besides that students 'understanding of the application of the material in daily life and students' critical thinking skills are low. This happens because students learn by rote caused by learning material that is contextual. Therefore it is necessary to develop learning materials based on Contextual Teaching and Learning to facilitate students in improving students' critical thinking skills on redox and electrochemistry topics. The development method used is basically the development model of the Four-D Model (4D Model by Thiagarajan) which consists of 4 stages, namely Define, Design, Develop, and Disseminate. Teaching material that has been developed in the form of teaching material products based on Contextual Teaching and Learning on redox and electrochemical materials to facilitate critical thinking skills of high school students. This teaching material consists of student books, teacher books, and learning videos. Based on the validation test and readability test on student books, teacher books, and learning video the results of the obtained scores were 86%, 89%, 82%, and 83%, respectively. This shows that the learning material resulting from the development is very suitable to be used in learning on the material at the high school level.

Keywords: *Learning materials, Critical Thinking, Contextual Teaching and Learning, Redox, Electrochemistry*

Abstrak

Sebagian siswa SMA masih mengalami kesulitan dalam mempelajari kimia, salah satunya adalah materi redoks dan elektrokimia, yang sangat erat dengan kehidupan sehari-hari. Disamping itu pemahaman siswa terhadap aplikasi materi tersebut dalam kehidupan sehari – hari serta kemampuan berpikir kritis siswa termasuk rendah. Hal tersebut terjadi karena siswa belajar secara hafalan yang disebabkan dari bahan belajar yang bersifat kontentual. Oleh karena itu perlu dikembangkan bahan belajar berbasis Contextual Teaching and Learning untuk memfasilitasi siswa dalam meningkatkan kemampuan berpikir kritis siswa pada materi redoks dan elektrokimia. Metode pengembangan yang digunakan pada dasarnya adalah model pengembangan Four-D Model (Model 4D oleh Thiagarajan) yang terdiri atas 4 tahap yaitu Define, Design, Develop, dan Disseminate. Bahan ajar yang telah dikembangkan berupa produk bahan ajar yang berbasis Contextual Teaching and Learning pada materi redoks dan elektrokimia untuk memfasilitasi kemampuan berpikir kritis siswa SMA. Bahan ajar ini terdiri atas buku siswa, buku guru, dan video pembelajaran. Berdasarkan uji validasi dan uji keterbacaan terhadap buku siswa, buku guru, dan video pembelajaran hasil pengembangan diperoleh hasil skor berturut – turut adalah 86%, 89%, 82%, dan 83%. Hal tersebut menunjukkan bahwa bahan belajar hasil pengembangan tergolong sangat layak digunakan dalam pembelajaran pada materi tersebut di tingkat SMA

Katakunci: *Bahan belajar, berpikir kritis, contextual teaching and learning, redoks, elektrokimia*

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INTRODUCTION

One of the efforts to develop and improve the quality of Human Resources (HR) is through education, because education is the most important aspect of life as a place to develop human potential (Nabila & Gani A., 2017). Government efforts to improve human resources in education continue, one of which is through changing the 2006 curriculum to the 2013 curriculum. The results of Noviana's (2017) study concluded that using the 2013 curriculum can make students more active and passionate about learning. Recommendations from the results of this study are that teachers are required to enrich their knowledge of innovative and effective learning models. This is to increase enthusiasm, independence, and the level of thinking of students in the learning process as expected in the 2013 curriculum. Effective and innovative learning models also need to be applied to chemistry subjects.

Chemistry is one of the subjects taken by Senior High School (SMA) students majoring in Natural Sciences (IPA). According to Effendy (2016: 1), chemistry studies the structure of substances, the properties of substances, and their changes, and studies the laws, theories and principles that describe the phenomenon of substance change. Meanwhile, according to Liliasari (1995) chemistry is a branch of science that studies the structure, arrangement, properties, and changes of matter and energy that accompany it (Liliasari, 1995). Human life is often associated with chemistry, such as food, medicine, clothing, electronic materials, and many more. Therefore, when studying chemistry, humans also learn to understand what is happening around them.

The material in chemistry consists of abstract and complex concepts with calculations (Nabila & Gani A., 2017). In chemistry there are 3 levels of representation. (1) the macroscopic level, where topics or concepts are expressed in terms of observable phenomena, substances, energies, or things; (2) the microscopic level (sometimes called submicroscopic), where the topic or concept is expressed in terms of the species level in the form of molecules, atoms, and ions; (3) the symbolic level, where topics or concepts are expressed in the form of formulas, equations, or a modeling (Nadi et al., 2016). If the teacher teaches students by developing the ability to correctly associate the three levels of representation (submicroscopic, macroscopic, and symbolic), it will make it easier for students to understand the material. The existence of misunderstanding of students at the three levels of representation resulted in students having difficulty connecting concepts with surrounding phenomena (Jansoonn et al., 2009). Redox and electrochemical materials are materials that are closely related to the surrounding phenomena (Ziana, 2019). Redox and electrochemical materials are materials that are considered difficult for students (Haryani et al., 2014).

Students often have difficulties when studying chemistry, because they have many terms that are rarely used by ordinary people. In addition, some of the concepts are abstract. Based on research conducted by Haryani et al (2014) it was found that one of the difficult topics is redox and electrochemistry. In this topic there are many abstract things, for example about the movement of electrons, the occurrence of electric currents, and the movement of ions in salt bridges so that to teach them students need sufficient provisions, such as the ability to think formally, the ability to use microscopic, macroscopic, and symbolic explanations (Fatmawati, 2013). If these concepts are only memorized, it is feared that they will result in boredom, and students will not be able to understand them completely. Moreover, the learning methods, learning models and learning resources used have not supported students to find their own concepts.

Research related to learning in chemistry has been carried out by several researchers, including research that tries to apply a CTL learning model (Susanti, 2011). The Contextual Teaching and Learning (CTL) learning model with the experimental method and the CTL learning model with the assignment method applied to redox and electrochemical materials concluded that the average results of students' cognitive scores increased from 59.3 to 75.8 and 80.0. These results indicate that the students' cognitive abilities have increased, but not maximally. A learning model is not effective if the student learning resources do not support the applied learning model. Therefore, the teaching materials used must be in accordance with the learning model.

One of the reasons students only learn by memorizing is because the books content used so far are only reading, which emphasizes the dimensions of content, for example, such as the Electronic School Book (BSE) Chemistry for SMA/MA. This means that the teaching material presented in the book is only a definition of a concept, a set of formulas and practice questions (Hasanah, 2006). Therefore, it is necessary to modify teaching materials, so that students are more motivated to learn and in accordance with the applied learning model.

Redox and electrochemistry are chemistry topics that are widely applied in everyday life, such as batteries in motorbikes and batteries. However, the students' mastery of the concepts of redox and electrochemical applications is still low. Aini's research (2011) regarding the identification of conceptual understanding of redox and electrochemical application materials in everyday life concluded that students experienced difficulties regarding redox and electrochemical applications. These difficulties include: (a) students cannot explain why Aluminium is not easily oxidized; (b) students cannot determine the time required for the gilding process; (c) students cannot determine the time required for an electrolysis process, and more. In addition, there was also a positive but weak linear relationship between students 'understanding of redox and electrochemical reactions with the students' ability to apply redox and electrochemistry in everyday life. This shows the need for a learning approach that emphasizes the relationship between concepts and applications in everyday life, which can be improved by learning the CTL model.

CTL is a learning method that can help students relate academic lessons to the real-life contexts they face. CTL enables students to connect the content of academic subjects with the context of their daily lives to find meaning (Johnson, 2007). CTL has 7 main components, namely: (1) constructivism; (2) inquiry; (3)

asking; (4) the learning community; (5) modelling; (6) reflection; and (7) authentic assessment. Meanwhile, in helping students develop their intellectual potential, CTL teaches steps that can be used in critical thinking and provides opportunities to use thinking skills at a higher level in the real world (Johnson, 2007).

According to Ennis (2011), critical thinking is reasonable and reflective thinking that focuses on deciding what to do. The goal of critical thinking is to achieve deep understanding. In addition, critical thinking allows students to study problems systematically, face many challenges in an organized way, formulate innovative questions, and design original solutions (Johnson, 2007).

Learning activities in CTL can improve students' critical thinking skills through questions and student activity steps to answer questions. Based on this background, it is necessary to develop teaching materials based on Contextual Teaching and Learning (CTL) to facilitate students and students.

METHODS

Development Model

The development of teaching materials with redox and electrochemical topics referred to the Four-D Model (4D Model) development model from Thiagarajan which consists of 4 stages, namely Define, Design, Develop, and Disseminate (Thiagarajan et al., 1974). However, this research was conducted only up to the Develop stage, this was due to time and cost limitations so that the results of product development were not disseminated.

At the stage of testing the feasibility of student books, teacher books, and learning videos, validation was carried out to experts consisting of Malang State University lecturers and high school chemistry teachers, and readability testing was carried out on 10 high school grade XII students.

Product Trial

The product trial aimed to determine the appropriateness of the teaching materials that have been developed in learning activities, the suitability of the teaching material components developed with the Contextual Teaching and Learning (CTL) model, and indicators of critical thinking. The subject of the trial was carried out in small groups of 10 students of SMA PGRI 1 Sidoarjo.

The data obtained were (1) qualitative data in the form of suggestions, criticism, and responses which were used as a reference for improving the teaching materials that had been developed; and (2) quantitative data in the form of validation results, used as a basis for testing the feasibility of teaching materials. The assessment data was obtained through a questionnaire using a Likert scale.

Validation result data processing was done by using percentage analysis technique which was stated by the following formula.

$$P = \frac{X}{X_1} \times 100\%$$

P = Percentage of value obtained
X = Total score of respondents' answers in one item
X1 = The maximum number of scores in one item

The results of the calculation of each item percentage were analysed and determined through the development of classification criteria in the Table 1.

Table 1. Criteria for Percentage of Eligibility for Teaching Materials

Percentage (%)	Criteria
0-20	Not feasible
21-40	Less feasible
41-60	Decent feasible
61-80	Feasible
81-100	Very feasible

Source : (Riduwan, 2010)

RESULTS AND DISCUSSION

Description of the developed CTL-based teaching materials

The developed products were CTL-based teaching materials on redox and electrochemical topics consisting of student books, teacher books, and learning videos. The developed product was equipped with user instructions for student books, teacher books, and learning videos. In the student book, the content description follows the components of the CTL learning model. In addition, the tasks and activities in the book developed to support students in improving students' critical thinking skills.

The teacher's book is equipped with learning tools in the form of lesson plans, assessment guidelines, question grids, evaluation questions, and scoring guidelines. The development product in the form of learning videos helps students visualize the microscopic level of a series of voltaic cells, electrolysis cells, electrolysis cell applications, and corrosion. In addition, the instructional videos also help students discover the macroscopic and microscopic relationships of redox and electrochemical materials.

Results of Validation of Developed Products

Data validation results consist of two types of data, quantitative and qualitative. Quantitative data was obtained from the results of the assessment of teaching materials that had been developed through a questionnaire using the Likert scale. The data on the results of the student book feasibility test were presented in Table 2.

Table 2. Feasibility Test Results for Student Books, Teacher Books, and Learning Videos

No	Feasibility test	Percentage	Criteria
1	Student book	86	Very feasible
2	Teacher book	89	Very feasible
3	Learning video	82	Very feasible
	Mean	86	Very feasible

The results of the validation of the feasibility test for student books, teacher books, and learning videos developed reached 86%. According to Riduwan (2010) this was categorized as very feasible or can be used without revision. Based on the results of the analysis of the validation test of learning materials, CTL-based learning materials had met the eligibility standards for printed study materials set by the National Education Standards Agency (BSNP). In accordance with the assessment standards set by BSNP (2014), the feasibility of printed study materials could be assessed based on aspects of the content or material content, presentation, and language. Achievement of the eligibility category could also be caused by the process of preparing learning materials according to the guidelines set by the Ministry of National Education.

Feasibility aspects of the presentation of teaching materials, namely presentation techniques, presentation of learning, and completeness of presentation. The material in CTL-based teaching materials is presented coherently from general concepts regarding the concept of redox, the basic concepts of electrochemistry, as well as the application of the concepts of redox and electrochemistry. Besides that, the learning materials are presented with various illustrations in the form of pictures that support the learning material. According to Cook (2008), illustrations in study materials can help students absorb knowledge and understand concepts. In addition, the presentation of the material is also equipped with learning videos that can visualize redox and electrochemical materials more realistically. This is supported by the results of researchers Mitra et al (2010) which state that videos can help increase their understanding of the subject matter taught by the teacher.

Aspects of language feasibility, consisted of conformity to the level of development, straightforward, communicative, and conformity to Indonesian language rules. CTL-based teaching materials were prepared using Indonesian language that was straightforward, communicative and considers the rules of *Ejaan Yang Disempurnakan* (EYD) grammars. This was in accordance with the requirements for teaching materials put forward by the Ministry of National Education (2008), the components of teaching materials included legibility, clarity of information, and conformity to the rules of good and correct Indonesian.

Student Readability Test Results

The following are the readability test results by class XII high school students which are presented in Table 3.

Table 3. Students Readability Test Results

No	Aspects assessed	Percentage of feasibility	Criteria
1	Cover	72	Feasible
2	Ease of understanding the table of contents	90	Very Feasible
3	Ease of understanding the list of images	86	Very Feasible
4	Ease of understanding the list of tables	88	Very Feasible
5	Ease of understanding the learning objectives	82	Very Feasible
6	Ease of understanding the concept map	72	Feasible
7	Easy to understand instructions for using the book	82	Very Feasible
8	Ease of understanding the introduction	84	Very Feasible
9	Ease of understanding the experimental activity instructions	82	Very Feasible
10	Ease, attractiveness, and clarity of images	85	Very Feasible
11	Ease and clarity of tables	88	Very Feasible
12	Ease and clarity of questions in the book	81	Very Feasible
13	The suitability of the questions with the learning objectives	86	Very Feasible
14	Ease of understanding tasks	82	Very Feasible
15	Ease, clarity, and attractiveness of animated videos	78	Feasible
16	Ease of understanding the summary	89	Very Feasible
17	Generating student interest in learning	87	Very Feasible
	Mean	83	Very Feasible

Based on the results of the readability test by students, there were 3 aspects that get proper criteria, including the cover display, the ease of understanding the concept map, and the ease, clarity, and attractiveness of the animated video. For the cover criteria, it got feasible criteria, because it was not attractive and not related to the content of teaching materials. For the ease of understanding the concept map criteria, got feasible criteria because the display of the concept map was complex, so students found it difficult when reading. Meanwhile, the criteria for convenience, clarity, and attractiveness of the animated video got feasible criteria because the video presented was not real so that students had difficulty understanding the animated video.

According to Jatnika (2007), the level of readability is influenced by two factors: 1. Language concerning word choice, sentence structure, paragraph structure and; 2. Other grammatical elements, as well as visual factors relating to letter or typography. In general, the sentence structure used in teaching materials was in accordance with Indonesian language rules and the abilities of high school students. CTL learning materials were arranged using standard fonts that are commonly used, namely Times New Roman with a size of 12-14 pt. This was in accordance with the physical standards of writing textbooks proposed by Syamsi (2013). Typography of learning content should not use decorative and excessive fonts.

Based on the data from the validation results of the learning materials, this teaching material had differences among other teaching materials that were available. The comparison of teaching materials commonly used by students with teaching materials developed is presented in Table 4.

From Table 4, it could be seen that the advantages of developed teaching materials were: (1) Teaching materials required students to build their own concepts; (2) The task given required students to solve problems that exist around students; (3) equipped with instructional videos that helped students connect the 3 levels of representation (macroscopic, microscopic, and symbolic); and (4) Several activities and assignments were able to improve students' critical thinking skills. In addition, some of the deficiencies that existed in teaching materials: (1) there needed to be some justification for the concept of redox material; and (2) instructional videos at the microscopic level still needed to be clarified; (3) both activities and tasks that support students in improving critical thinking skills was needed to be increased.

Table 4. Comparison of Common Teaching Materials with Developed Teaching Materials

No	Common Teaching Materials	Developed Teaching Materials
1	The concept was described descriptively based on the results of the validation by the Chemistry teacher.	The concept was described in the form of questions, thus requiring students to build their own concepts.
2	Contextual in the introduction and explanation of material regarding the application of redox and electrochemistry based on the results of validation by the Chemistry teacher.	Contextual in the introduction, material explanations regarding the application of redox and electrochemistry, assignments require students to solve problems that exist around students, such as assignments to make ways to prevent corrosion, and assemble batteries using surrounding materials.
3	Did not explain the relationship between the 3 levels of macroscopic, microscopic, and symbolic representations based on the validation results by the lecturers at the Universitas Negeri Malang	Described the relationship between 3 levels of macroscopic, microscopic, and symbolic representations. Explanation of macroscopic and microscopic relationships is assisted by instructional videos. Example: In activity 2 the video is in the form of a voltaic cell experiment, while in activity 3 the video is in the form of a microscopic voltaic cell animation that explains phenomena at the macroscopic level, then in the next section it is written in cell notation, so students can connect macroscopic, microscopic, and symbolic
4	Not yet accompanied by learning media that support the process of understanding the concept of teaching materials based on the results of validation by lecturers at the Universitas Negeri Malang	There was a learning media that accompanies to support the process of understanding the concept in teaching materials in the form of videos which are useful for helping students connect the 3 levels of representation.
5	Not yet supporting students in improve critical thinking skills based on the results of validation by the lecturers of the Universitas Negeri Malang	Several activities and tasks supported students in improving their critical thinking skills, because they met the indicators of critical thinking.

CONCLUSION

The results of the development of Contextual teaching and learning based teaching materials on redox and electrochemical materials were printed teaching materials consisting of student books, teacher books, and learning videos. The results of the validation of student books, teacher books, instructional videos, and legibility tests were as follows: 86%, 89%, 82%, and 83%, respectively. This showed that the teaching material was very suitable for use in learning with improvements based on the validator's suggestions. This CTL-based chemistry learning material was considered good and could be used in the chemistry learning process. The developed CTL-based teaching materials can be used as a source of student learning in learning, especially redox and electrochemical materials, where students are expected to do all the tasks and activities in the book, so that the knowledge obtained is intact. This developed teaching material should be tested for readability on a wider scale and can be published so that it can be used by a wider range of users.

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