

Research Article

The Importance of Developing E-Books Using The 4S-TMD Method to Improve Environmental Literacy

Intan Fitriyanti Sahra*, Sjaeful Sahra

Department of Chemistry Education, Indonesia University of Education, Dr. Setia Budhi Street, Number 229, Bandung 40154, Indonesia

ORCIDIntan Fitriyanti Sahra: <https://orcid.org/0009-0009-7865-7524>Sjaeful Anwar: <https://orcid.org/0000-0003-3708-5936>**Abstract.**

This preliminary study aimed to describe the importance of developing redox electronic books using the 4S-TMD method to increase environmental literacy. The 4S-TMD method consists of four stages: selection, structuring, characterization and didactic reduction. This study focused on the selection stage as a first step. Environmental literacy is the ability to understand and interpret ecological conditions. From the results of this understanding and interpretation, an individual can decide the appropriate action to maintain, restore and improve the condition of an environment. The components of environmental literacy that must be achieved include ecological knowledge, attitudes towards the environment, cognitive skills, and behavior towards the environment. This study used the Development Research (DR) method with the Design, Development and Evaluation type. This article discussed the importance of developing chemistry e-books in the selection stage. The results of the selection stage determined basic competencies, which are formulated as learning indicators and concept labels based on curriculum demands. The results of the selection stage were also related to the context of content related to everyday life and the development of basic concepts sourced from international textbooks, as well as pedagogic contexts related to achieving environmental literacy. The results of the selection stage were evaluated by expert lecturers in chemistry education who were declared valid. Based on the results and discussion of the research, it was concluded that the development of electronic books on redox material using the 4S TMD method was developed in several stages where the first stage, the selection stage, showed that development began with the selection of basic competencies, namely KD 3.9, by experiencing the development of indicators, namely eight indicators.

Keywords: redox, electronic books, 4S-TMD method, environmental literacyCorresponding Author: Intan Fitriyanti Sahra; email: intansahra27@upi.edu**Published:** 3 April 2024

Publishing services provided by Knowledge E

© Sahra, Sahra. This article is distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use and redistribution provided that the original author and source are credited.

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

OPEN ACCESS

1. INTRODUCTION

Environmental literacy can be developed through formal learning in schools. Planting environmental literacy in schools can be done if students know the aspects of environmental literacy. Aspects of environmental literacy that students must possess to master environmental literacy are aspects of knowledge, skills, attitudes and behavior [1].

Environmental literacy is currently part of the School Literacy Movement (GLS) which is also listed in Permendikbud No. 23 of 2015. GLS aims to develop reading and writing activities so that school members become literate [2]. Literacy in context consists of listening, speaking, reading, writing and critical thinking skills. Furthermore, GLS aims to build more specific literacy such as scientific literacy, mathematics, information language and environmental literacy.

The concept of environmental literacy is emphasized by the Environment Education and Training Partnership (EETAP) which states clearly that an environmentally literate person knows what he is going to do for the environment and he knows how to do it [3]. When a student has environmental literacy skills and an attitude of caring for the environment, the student will have the awareness to build a sense of love for the environment and maintain the existence of abundant natural resources in Indonesia. A person's environmental literacy status can be measured based on the criteria for environmental literacy components [3]. In learning, it is not only the knowledge aspect that is emphasized, but the ability to think, affect and behave with respect to the environment is also the main benchmark for the success of environmental education programs [4].

Based on the facts on the ground, environmental literacy has not been maximized. Students' environmental literacy is still stated to be low due to several factors, one of which is the intention to know and study environmental problems [5]. Teachers as educators must inform and realize that an understanding of the environment must be the basis of attitudes to be able to solve environmental problems. This is in line with the low environmental literacy that also occurs among students. The results of PISA 2006 put Indonesia in the 52nd rank (lowest 6th rank) for both environmental science and geoscience from the 57 countries that participated in the activity [6]. The 2016 PISA analysis conducted by the OECD shows that students' awareness of environmental issues is in line with their level of knowledge and environmental literacy skills. Students who are more familiar with complex environmental phenomena have environmental literacy skills intended to prepare humans to understand and solve environmental

issues, this is because only environmentally literate people can find solutions to these problems [3].

Based on the target of educators and teaching staff in the 2013 curriculum which is realized in Law Number 14 of 2005, there are four competencies to be achieved, including pedagogic competence. Chingos (2012) adds that students learn mainly through interaction with teachers and teaching materials, learning interactions between students and teachers are framed by learning materials selected by the teacher and provided by the school. Interaction in learning includes interaction with people (teachers, peers) and teaching materials (textbooks, workbooks, instructional software, web-based content, homework, projects, quizzes and tests). The use of teaching materials has a direct influence on learning compared to the influence of the teaching methods used by the teacher and the teacher's behavior in choosing all teaching materials is more important.

The development of teaching materials needs to bring innovation. In schools the teaching materials used are printed teaching materials where these printed teaching materials have shortcomings, one of which is not being able to present movement, the presentation of the material is linear, and it is difficult to provide guidance to the readers [7]. Therefore, it is necessary to develop teaching materials from printed teaching materials to non-printed teaching materials that are more interactive. The results of developing more interactive teaching materials are expected to increase students' interest in taking lessons. Interactive teaching materials are teaching materials that combine several interactive learning media (audio, video, text, or graphics) to control a command or natural behavior of a presentation. Thus, there is a two-way relationship between teaching materials and their users. So, if the learning process is carried out using teaching materials like this, students can be encouraged to be active. One of the supporting factors to increase student interest and activity in learning is the presence of teaching materials with integrated technology. The use of technology in learning really helps the world of education, such as learning books that can be developed in electronic form with pdf format.

Using electronic books is done to make it easier for students to understand the subject matter in class. So that it can minimize the occurrence of lack of knowledge in teaching and learning activities and can achieve learning goals as well as examples in everyday life. Students are also expected to be able to practice environmental literacy skills on Redox material, because environmental literacy skills are considered one of the goals of education so that students do not lack knowledge of the material [8].

Based on this, it is necessary to have chemistry teaching material that is made by taking into account various aspects, namely electronic books containing phenomena in

everyday life. According to Anwar (2017), in the process of developing teaching materials, there are four stages that must be taken before the teaching materials are feasible to be delivered to students. The four stages of developing teaching materials are the process of selection, structuring, characterization, and didactic reduction. These four stages are referred to as 4S-TMD (Four Steps Teaching Material Development). 4S-TMD was chosen as the method of processing teaching materials because with 4S-TMD, it will produce teaching materials that are in accordance with cognitive development and are easier for students to understand and learn. In the fourth stage of 4S-TMD, namely Didactic Reduction, the difficulty level of teaching materials will be reduced both qualitatively and quantitatively so that it is easier for students to learn. In addition, the 4S-TMD method also integrates values that can be explored by students when interacting with teaching materials.

The teaching materials currently circulating have not fully accommodated environmental literacy into chemistry learning. So that researchers are interested in conducting research by developing electronic textbooks using the 4S-TMD method to improve environmental literacy.

2. RESEARCH METHOD

This study was designed using the Development Research (DR) research method with the type namely Design, Development and Evaluation which is abbreviated as DDE [9]. At the design stage, the activity begins with analyzing needs, which begins with a study of literature from the curriculum and journals related to previous research, especially in the development of electronic books on redox material. At the development stage, teaching materials are developed using the 4S-TMD method which includes the selection stage, the structuring stage, the characteristic stage and the didactic reduction stage [10]. In this article, we will focus on the selection stage as the first step of research. The selection stage begins with determining basic competencies based on curriculum demands that are developed into learning indicators, especially redox material and determining concept labels according to the indicators that have been developed. Furthermore, it describes the basic concepts sourced from international textbooks, as well as content contexts related to daily life and pedagogic contexts related to the achievement of environmental literacy.

RESULTS AND DISCUSSION

The eBook development process in this study uses the 4S-TMD method, where this method has four stages, namely the selection stage, the structuring stage, the

characterization stage and the didactic reduction stage. In the first stage, eBook development at this selection stage includes a review stage of content standards in the 2013 curriculum, selection of chemistry textbooks and taking values related to environmental literacy contained in chemical material that will be reviewed by experts according to the 4S-TMD method.

The results of the research at the selection stage, namely the development of eBooks, began with the development of the scope of redox material based on the 2013 curriculum requirements for chemistry subjects in high school, starting with the selection of basic competencies (KD). KD is the minimum ability that must be possessed by students. After analyzing and determining the KD, the next step is to carry out a concept mapping analysis of the selected KD. The KD selected in this study are:

1. Analyze the development of the concept of reduction-oxidation reactions and determine the oxidation numbers of atoms in molecules or ions
2. Designing, conducting and concluding and presenting the results of oxidation-reduction reactions experiments.

After the curriculum analysis was done, the next step was the development of indicators. It at to measure the achievement of KD and as a guide in the development of teaching materials. The development of indicators obtained are listed in Table 1.

TABLE 1: Development of indicators and labels for oxidation-reduction reactions.

Basic Competence (KD)	Learning Indicators (IP)	Concept Label (LK)
3.9 Analyze the development of the concept of oxidation- reduction reactions and determine the oxidation number of atoms in molecules or ions.	Explaining the Phlogiston Theory Explaining the concept of redox reactions based on the incorporation and release of oxygen Explaining the Concept of Reaction Redox based on Letting Go and Accept Electron Explaining the Concept of Reaction Redox based on Decrease and increase Oxidation Number Explaining Oxidation Numbers Determine the oxidation number of an atom in a molecule or ion Determine the oxidizing agent and reducing agent in a redox reaction Explain auto redox reactions	Phlogiston Theory Oxidation based on oxygen acceptance and Reduction based on oxygen release Oxidation based on the loss of electrons and Reduction based on electron acceptance Oxidation based on increasing oxidation number and reduction based on decreasing oxidation number Oxidation Number Oxidizing and reducing agents auto redox reaction

Table 1 shows that there are 8 indicators that developed in redox subject matter. The results of this step of selection are the subject matter of the redox concept of the theory of phlogiston, redox reactions based on the incorporation and release

of oxygen, Reaction Redox based on Letting Go and Accept Electron, and Reaction Redox based on Decrease and increase Oxidation Number, oxidation numbers and auto redox reactions. The next step was to identify the concept label in accordance with the indicators developed.

After the labeling of the concept is determined, it is continued by looking for an explanation of the concept from an international standard textbook. In this study source materials in the form of basic chemistry books and international textbooks. Books used as reference are:

1. Brady, J., Jespersen., Neil and Hyslop, Alison. 2015. Chemistry Seventh Edition. John Wiley & Pte.Ltd
2. Chang, Raymond. General Chemistry The Essential Concepts 6th, 2011
3. Davis, Raymond E., Metcalfe H. Clark., Williams, John E., and Castka, Joseph E., 2002. Textbook modern chemistry, USA: Holt, Rinehart and Winston.
4. Gallagher, RoseMarie and Ingram, Paul. 2009. Chemistry IGCSE Revision Guide New York: Oxford University Press
5. Gallagher, RoseMarie and Ingram, Paul. 2007. Chemistry IGCSE Revision Guide New York: Oxford University Press
6. Norris, Roger., Ryan, Lawrie and Acaster, David. 2011. Cambridge International AS and A level Chemistry Coursebook UK: Cambridge University Press
7. Neil D. Jespersen and James E. Brady. 2012. Chemistry The Molecular Nature of Matter 6th. H. 220.

The next step is the development of environmental literacy values that can be developed through redox reactions seen from several components such as environmental knowledge, attitudes towards the environment, cognitive skills, behavior towards the environment. Table 2 shows an example of the relationship between values and the pedagogic context.

Table 2 shows the value of caring for the environment in the redox concept based on bonds and release of oxygen, gain and gain of electrons. These teaching materials are oriented towards Chemistry to Society to improve environmental literacy. Where environmental literacy is the ability of each individual to understand and interpret environmental conditions, from the results of this understanding and interpretation each individual can decide on appropriate actions to maintain, restore and improve the condition of an environment [11].

TABLE 2: The relationship of values with the pedagogical context.

Material Description	Pedagogic Context	Description of the development of pedagogic context
In oxidation, electrons are lost, In reduction, electrons are gained and Oxidation is the loss of electrons, Reduction is the gain of electrons.	Cognitive Skills	Pay attention to the surrounding environment, of course we know motorized vehicles, in motorized vehicles there are objects that are useful as a source of electric current. So that the motor vehicle can be turned on. But do we know what it is? The object is a battery (accumulator). If we pay attention to the working process, the battery generates electricity and electrocution involves a redox reaction. Why is that? A battery contains an electrolyte solution of sulfuric acid (H ₂ SO ₄). The battery is composed of a negative pole and a positive pole. The negative pole is made of lead metal (Pb), while the positive pole is made of lead (IV) oxide (PbO ₂). At the negative pole (anode) an oxidation reaction occurs, while at the positive pole (cathode) an oxidation reaction occurs.
Oxidation is a reaction that accepts oxygen, reduction is a reaction that releases oxygen. When a substance binds oxygen, the substance is oxidized, then oxidation has occurred. When a substance loses oxygen, the substance is reduced, then reduction has occurred.	Attitude to the environment	Pay attention to the environment around you. We often encounter objects that are damaged due to rust/corrosion, especially in ferrous metals. One of them is the iron on the rusty iron chair. This phenomenon is one of the redox reaction phenomena. Do you know what causes these things to rust? Most metals are easily oxidized by oxygen from the air. Corrosion will occur in the presence of water and oxygen. In the event of iron rusting, Fe metal reacts with oxygen to form iron rust (Fe ₂ O ₃). This means that in this reaction Fe metal binds oxygen to form Fe ₂ O ₃ . Rusting of iron is an example of an oxidation reaction. Based on this, the oxidation reaction is a reaction to the binding of oxygen by a substance. As for the reduction reaction occurs in the isolation of iron ore into ferrous metal. In this event the iron ore releases oxygen. This means that iron ore loses oxygen. Referring to this fact, a reduction reaction is a reaction to release oxygen by a substance.

3. CONCLUSION

Based on the results and discussion of the research, it was concluded that the method of developing electronic material redox books using 4S-TMD was developed in several stages where in the first stage, namely the selection stage, it showed that development started from selecting basic competencies, namely KD 3.9 by experiencing indicator development, namely 8 indicators. These indicators include Phlogiston theory, redox

based on the gain and combination of oxygen, redox based on the gain and acceptance of electrons, redox based on decreasing and increasing oxidation numbers, oxidation numbers, oxidizing agents, reducing agents and auto redoxes. The results of the selection stage show that the development of electronic books is in accordance with the curriculum. The results of the selection stage are also related to the content context related to everyday life and the development of basic concepts sourced from international textbooks, as well as the results of the selection stage also show the pedagogic context related to the marketing of values related to environmental literacy, namely environmental knowledge, attitudes towards the environment, cognitive skills and behavior towards the environment. In this way, it is hoped that students will not only be able to master redox material but also be able to master the values contained in redox material related to phenomena in everyday life. The next step in this research will be continued at the stages of structuring, characterization and didactic reduction.

ACKNOWLEDGMENTS

The author would like to Thank you to all those who have helped in the preparation of this research article. And last but not least, I wanna thank me, for believing in me, for doing all this hard work, for having no days off, for never quitting, for just being me at all times.

References

- [1] Erdoğan M, Kostova Z, Marcinkowski T. Components of environmental literacy in elementary science education curriculum in Bulgaria and Turkey. *Eurasia J Math Sci Technol Educ.* 2009;5(1):15–26.
- [2] Kemendikbud. *Buku saku gerakan literasi sekolah.* 2015
- [3] NAAEE. *Developing a framework for assessing environmental literacy.* Washington DC: The National Science Foundation; 2011.
- [4] Saribas D. Investigating the relationship between pre-service teachers' scientific literacy, environmental literacy and life-long learning tendency. *Science Education International.* 2015;26(1):80–100.
- [5] Pratama AY, Marpaung RR, Yolida B. Pengaruh literasi lingkungan terhadap environmental responsibility siswa kelas XI SMA Negeri 2 Bandar Lampung. *Jurnal Bioterdidik: Wahana Ekspresi Ilmiah.* 2020;8(1):56–65.
- [6] OECD. *Green at Fifteen.* 2009.

- [7] Heryani Y, Rustina R. Implementasi bahan ajar berbasis masalah pada perkuliahan kapita selekta matematika pendidikan dasar. *Jurnal Siliwangi: Seri Pendidikan*. 2018;4(2):72–3.
- [8] Adu-Gyamfi K, Ampiah JG. Chemistry students' difficulties in learning oxidation-reduction reactions. *Chemistry. Bulgarian Journal of Chemical Education*. 2019;28(2):180–200.
- [9] Richey RC, Klein JD. Developmental research methods: creating knowledge from instructional design and development practice. *J Comput High Educ*. 2005;16(2):23–38.
- [10] Anwar S. *Pengolahan Bahan Ajar (4 Steps Teaching Material Development)*. Bandung: Unpublished Manuscript; 2017.
- [11] Prasetyo P. Pembelajaran matapelajaran biologi materi lingkungan di Sekolah Menengah Atas dan daya dukungnya terhadap literasi lingkungan siswa. *Florea: Jurnal Biologi dan Pembelajarannya*. 2017;4(2):55. <https://doi.org/10.25273/florea.v4i2.1857>.