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Research Article

Developing a Hydrocarbon Electronic Book to Develop Students Critical Thinking Skills Through the 4S TMD Method

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Abstract.
This study aimed to develop an electronic book on hydrocarbon study materials using the Four-Steps Teaching Material Development (4S TMD) method to develop students' critical thinking skills. To achieve this goal, an electronic book was developed using the 4S TMD method, which will be tested using the Development Research (DR) research method which consists of three stages: design, development, and evaluation. At this stage the study was the first part of the development of teaching materials which consisted of four stages: selection, arrangement, characterization, and didactic reduction. The results of the research were focused on the selection stages. At the selection stage, the development of teaching materials begins with the development of learning indicators, the development of the concept of hydrocarbons based on curriculum demands, the development of basic concepts sourced from international textbooks, and finally, the development of skills that can be integrated with the concept of hydrocarbons. The results of the selection stage were evaluated by expert lecturers in the field of chemistry education.

Keywords: electronic book, hydrocarbon, 4S TMD, critical thinking skills

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1. INTRODUCTION

The development of science and technology causes educational institutions to focus on improving thinking skills to ensure they can compete globally in the 21st century [1]. Basic knowledge and skills are no longer enough, students must have 21st century skills, one of which is analytical skills (critical thinking, problem solving, decision making, research, and investigation) [2]. Critical thinking skills are part of higher order thinking skills. These skills include analyzing skills, inferring using inductive or deductive reasoning, assessing or discovering, and making decisions or solving problems [3]. The ability to think critically is the goal and choice of learning chemistry. So that when students study chemistry, critical thinking skills are expected to be used to deal with complex life [4].

Each person's critical thinking ability is different, some are classified as low and some are classified as high so that it affects a person's level of understanding and activeness in solving a problem, so that there is an influence between students' critical thinking abilities and students' understanding in mastering a concept. High school chemistry material contains many concepts that are quite difficult and complicated for students to understand, because they involve chemical reactions and calculations and involve abstract concepts so students need a deep understanding of concepts. One of the chemistry materials that requires in-depth conceptual understanding is hydrocarbon material because it is classified as material that is difficult for students to understand [5]. One way to improve students' thinking skills is to connect facts that occur in the environment with chemical concepts, find problems and solve problems according to the concepts and theories that have been studied. Thinking in chemistry, especially the problem of hydrocarbon compounds, is not only thinking about concepts and principles but also understanding applications in everyday life. This is in accordance with the development of skills that are integrated with the concept of hydrocarbons, using a dilemmas story approach. Dilemmas stories are an approach that prioritizes contextual learning that relates problems to everyday life through the use of stories containing dilemmas as learning media to involve students in the learning process [6]. Critical thinking is not only receiving information but also searching for facts and making decisions that information is in accordance with reasoning supported by evidence or information [7]. One of the goals of education is the development of critical thinking skills [8], this is in accordance with the objectives of the 2013 curriculum which requires students to have high-level thinking skills, one of which is that students are required to think critically in order to understand theories, concepts, and facts in the learning process. With the 2013 curriculum, students are expected to be able to face challenges and problems in the future [9]. Learning activities in the 2013 curriculum must take advantage of the role of information and communication technology to increase the efficiency and effectiveness of learning. Technological developments are indispensable in every area of our lives. Digital learning resources that can be accessed and used repeatedly through technology are essential for learning and teaching [10]. with the integration of technology into education, the development of digital publishing has been achieved and the diversity of digital teaching materials has increased [11].

Technology-assisted learning environments enriched with digital materials appeal to today's teachers and students who want to use the digital transition to improve education. Digital teaching materials combine text, images, animated cartoons and transfer data into digital formats [12]. Digital teaching materials can be accessed anytime,

digital teaching materials make the teaching environment more effective and fun. The use of interesting teaching materials in the learning process offers a positive impact for children [13]. There are several electronic teaching materials used today, one of which is electronic books. Electronic books are teaching materials in the form of electronic-based books packaged digitally and arranged systematically [14].

In developing teaching materials there are several methods that can be used, one of which is the 4S TMD development method. The method of developing teaching materials 4S TMD (Step Teaching Material Development) has four stages in the processing of teaching materials, namely the stages of selection, structuring, characterization and didactic reduction. At the selection stage, material selection is carried out in accordance with the curriculum that refers to core competencies and is limited by competency standards and basic competencies that must be achieved. The selected material is then compiled in the form of teaching materials. The teaching materials will be structured according to the field of scientific structure. Each material that has been structured will have a distinctive characterization. Teaching materials will be characterized in categories of easy and difficult to read. Determination of this characterization is called the characterization stage. Teaching materials that are difficult will be given treatment to make them easy and the stages of processing treatment are called teaching materials that are difficult to be made easy with didactic reduction stages [15]. This study aims to develop active ingredients in the material using the 4S TMD model to develop students' critical thinking skills.

2. RESEARCH METHOD

The research design used was development research with the stages of the procedure, namely design, development, and evaluation [16]. The Design step begins with conducting a literature review of chemical concepts that students often have difficulty learning. Based on the results of the literature review, it was found that one of these concepts is hydrocarbons. Based on the analysis, it is known that one of the causes of students' difficulties in learning chemistry is the teaching materials used. Based on the analysis, it is known that one of the causes of students' difficulties in learning chemistry is the teaching materials used. The development stage of teaching materials is carried out using the 4S TMD method. The 4S TMD method consists of four development steps, namely selection, structuration, characterization, and didactic reduction [14]. This article is an important part of the development of teaching materials which consists of a selection step. The selection stage is the initial stage in the development of the 4S TMD

method. This selection stage begins with developing indicators of hydrocarbon material, determining concept labels according to the indicators that have been developed then explaining standardized hydrocarbon concepts from standardized textbooks, and developing aspects of critical thinking that can be integrated into hydrocarbon teaching materials. The concepts that have been selected are reviewed by expert lecturers and then data analysis is carried out by looking at the compatibility of basic competencies (KD) with indicators, the suitability of indicators with concept labels, and the suitability of critical thinking skills with hydrocarbon concepts.

3. RESULT AND DISCUSSION

The development of an electronic book using the 4S TMD method consists of four stages, selection, structuring, characterization, and didactic reduction. In this article, we will discuss the selection stage, the selection stage consists of three parts. The first part is the development of indicators that are in accordance with the implementation of the curriculum. The indicators of basic competence determine, then determine the concept of the indicators that have been formulated. The development of indicators and concept labels is shown in Table 1.

Table 1 shows that there are 10 indicators developed and 10 concept labels determined from the basic 3.1 competition on hydrocarbon materials. Then the developed indicators are evaluated by expert lecturers. Evaluation is carried out to see the suitability of indicators with basic competencies. Based on the evaluation results of the expert lecturers, the indicators that have been developed are considered capable of achieving basic competencies (14). Determination of concept labels is carried out to determine the hydrocarbon core concept.

The second part of the selection step is the development of basic concepts sourced from international textbooks, the books used as references are listed in Table 2. Concept explanations are taken from standard textbooks that have been recognized by scientists to guarantee the scientific truth of each concept. In this study, the source material in the form of international textbooks. Choosing teaching materials that have been collected from various sources, it is necessary to consider aspects of the truth of these teaching materials from a scientific point of view, so that they can be used as a basis for developing the correct concept according to scientists [15].

The third part of the selection stage is the development of skills that can be integrated with the concept of ideas. The skills used are critical thinking skills. The pedagogic context is obtained from the aspect of critical thinking skills. The relationship of the

Table 1: Development of hydrocarbon concept indicators and labels.

Basic Competencies	Indicator	Concept Label
Analyze the structure and properties of compounds based on understanding the peculiarities of the carbon atom and the classification of its compounds	Describe the peculiarities of carbon atoms in carbon compounds Identify elements C and H in hydrocarbon compounds Analyze the shape of the carbon chain Analyze the types of bonds in the carbon chain Describing hazardous compounds based on saturation Naming alkanes, alkenes, and alkynes according to IUPAC rules Identify the physical properties of alkanes, alkenes, and alkynes Identify the chemical properties of alkanes, alkenes, and alkynes Determine the isomers of alkanes, alkenes, and alkynes Identify the chemical reactions of alkanes, alkenes, and alkynes	The peculiarities of the carbon atom Identification of elements C and H in hydrocarbon compounds Aliphatic hydrocarbons and aromatic hydrocarbons Alkanes, alkenes, and alkynes Saturated hydrocarbon compounds and unsaturated hydrocarbon compounds Nomenclature of alkanes, alkenes, and alkynes Physical properties of alkanes, alkenes, and alkynes Chemical properties of alkanes, alkenes, and alkynes Structural isomers and geometric isomers Addition, substitution, oxidation and elimination reactions

Table 2: List of books used in teaching materials.

Author	Year	Book title
Atkins, P., Jones L., Laverman L.	2013	Chemicals Principles: The Quest for Insight
Phillips, J. S., Strozak, V., S., and Wistrom, C.	2002	Chemistry: Concept and Applications
Brady, James, Jespersen, Neil and Hyslop, Alison	2012	Chemistry: The Molecular Nature of Matter
Myers R.	2003	The Basics of Chemistry
Zumdahl, S., S. and Zumdahl, S., A.	2010	Chemistry, Eighth Edition

pedagogic context to the concepts listed in Table 3. Table 3 shows the pedagogic context in the concept of alkane compounds on hydrocarbon materials. The pedagogic context in this article is an aspect of critical thinking skills associated with the dilemmas stories approach. This teaching material was developed using the dilemmas stories approach. The dilemma stories presented in this article are environmental problems due to alkane compounds. Dilemmas stories is an approach that prioritizes contextual learning that relates problems to everyday life. One of the goals of this approach is to develop students' critical thinking and problem solving skills [6].

4. CONCLUSION

The development of electronic books to develop critical thinking skills has been carried out using the 4S TMD method, especially at the selection stage. The selection results

TABLE 3: The relationship between the pedagogic context and the concept of hydrocarbons.

Concept	Pedagogic context	The relationship of the concept to the pedagogic context
Alkanes are hydrocarbon compounds that have single bonds in their carbon chains. All carbon atoms in alkanes use sp3 hybrid orbitals for bonding because the carbon atom is bonded to four other atoms. Alkanes are named after the -ane suffix and the general formula is $C_nH_2n_{+2}$.		Dilemma Story Adi is the son of a famous cattle farmer in his area. Every day my father went to the cowshed to feed and clean the cage from cow dung. Adi always helps father to take care of their cattle. Adi feels happy in raising cows because he aspires to major in college when he is in college. However, Adi is worried about the cow dung that accumulates every day which causes environmental pollution. The by-product in the form of waste on a large scale will cause complex problems. In addition to unpleasant odors, the presence of the environment also disturbs the view and can become a disease. So far, Adi's father uses waste and urine only as fertilizer by bringing it directly to the garden. Once upon a time, plants that were fed with fertilizer from fecal waste and urine withered and stunted their development. After being checked by agricultural officers, it turned out that the waste used was still hot and had to go through a composting process first.
Critical thinking component	Draw a conclusion	Based on the discourse above, what conclusions can be drawn and what reasoning is used to draw these conclusions?
	Assumptions	How should you deal with this?
	Deduction	What are the causes of the above problems, and draw a conclusion!
	Interpreting	Based on the discourse above, look for evidence of the truth of the problem that occurred!

show that the teaching materials developed are in accordance with the curriculum requirements, are truly scientific, and aspects of critical thinking skills are in accordance with the evaluation of the material. as consideration for conducting research with the same research theme on different subjects.

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