

DEVELOPMENT OF TEACHING MATERIAL BASED ON PLOMP DEVELOPMENT MODEL TO SUPPORT MERDEKA CURRICULUM ON GLOBAL WARMING TOPIC

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Abstract: The COVID-19 pandemic has resulted in changes and impacts on education in Indonesia. One of the impacts is the emergence of learning loss, where students lose the competencies learned before and could be more optimal at completing learning. The government is updating the curriculum to overcome the existing problems. Based on the Ministry of Education, Research, and Technology decision, the curriculum applied now is the Merdeka Curriculum. With curriculum changes, additional teaching tools are needed as references that will be used in the learning process for teachers and students. Teaching materials are one teaching tool that teachers can use in the classroom. This study aims to produce Teaching Materials to Support The Merdeka Curriculum Learning on Global Warming Caused by Human Activities Material in Phase E. The research method used is Educational Design Research (EDR) using the Plomp development model, which consists of three stages: (1) Preliminary Research, (2) Development or Prototyping Phase, and (3) Assessment Phase. Data collection is carried out using a validity questionnaire sheet that will be given to five validators consisting of three lecturers and two teachers. Two teachers and nine high school phase E students will receive a practicality questionnaire sheet. Data from the research results show that the validity test conducted by five validators obtained a valid category score with a validity value of 0.89. The results of the practicality test on students obtained a score of 93% with a very practical category, and the value of the practicality test on the chemistry teacher was 92% with a very practical category. Teaching Materials to Support the Merdeka Curriculum Learning on Global Warming Caused by Human Activities Material are included in the valid and practical categories.

Keywords: *Teaching Material, Merdeka Curriculum, Global Warming, Plomp Model.*

INTRODUCTION

After the COVID-19 pandemic, various changes have occurred in every aspect of life, including education [1]. The changes that occur have an impact, and the problems of education in Indonesia [2]. One of the impacts of the pandemic is learning loss [3], where students lose previously learned competencies and are less than optimal in completing learning, resulting in reduced literacy and numeracy skills [4].

One of the things the government has done to reduce the impact of learning loss is to adjust the curriculum [5]. The curriculum is an important part of the education system and is the main support for learning [6]. The curriculum exists to facilitate the course of education [7]. Based on the Decree of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 56/M/2022 concerning Guidelines for Implementing the Curriculum in the Framework of Learning Recovery, it was decided to implement a Merdeka Curriculum in the learning process. The Merdeka Curriculum aims to improve the quality of education, which has elements of flexibility, freedom, and openness, and is involved in educating the nation's next generation in era 4.0 and society 5.0 [8].

The industrial revolution 4.0 has caused major changes in various fields of life, one of which is education because education is one of the keys to the

nation's progress that should have to adapt to the times [9]. In the current era of industrial revolution 4.0, education globally must respond to the challenges of the 21st century by making 21st-century skills a global goal of education [10]. The 21st century is a century that demands an increase in the quality of human resources to master the various skills needed to face global challenges [11]. Education in the era of Revolution 4.0 emphasizes four competencies in the education curriculum: creativity, communication, collaboration, and critical thinking [12].

Success in a Merdeka Curriculum can occur if teachers support it. Teachers need innovation in preparing for learning [10]. Teachers can support the Merdeka Curriculum by organizing and compiling learning resources that students will use to facilitate the learning process, such as preparing materials, textbooks, and learning content [8]. One of the teaching tools that support learning with the Merdeka Curriculum is teaching materials [13]. Teaching materials are all kinds of materials used by teachers in helping the implementation of the learning process, and teaching materials are important because they can make it easier for teachers to teach and help students understand learning materials [14].

Global warming material is one part of the material in phase E chemistry learning outcomes of high school students in the Merdeka Curriculum. Global warming material is studied to be understood,

proven, and discussed during learning [15]. In addition, global warming at school can educate the youth age group to be wiser in their behavior and decisions related to the worldwide warming phenomenon in the future [16]. Students can be motivated to learn chemistry by providing an overview of chemical phenomena that occur in everyday life [17].

Global warming material is one of the materials considered difficult because of the abstract material because it studies the processes that occur in nature but cannot be observed directly the reactions that occur which impact global warming [18]. Abstract concepts contained in chemistry learning can be explained with submicroscopic-level illustrations [19]. Three types of chemical multi representations, namely: (a) macro and tangible: what can be seen, touched, and smelled; (b) sub-micro: atoms, molecules, ions, and structures; and (c) representational: symbols, formulas, equations, molarity, mathematical manipulations, and graphs [20].

Learning with three levels of chemical representation is also related to mental models, where mental models are defined as internal images that appear in the reasoning process. With the existence of multiple chemical representations, it is expected to facilitate the students' reasoning process [21]. For this reason, teaching materials are needed that contain chemical representations that can be an additional reference for student learning so that students better understand the concepts in education.

The problem is that teachers' teaching materials must fully support students in understanding learning. Another problem is that teaching materials require illustrative images to understand the material [19]. Based on previous research, a contextual-based physics learning module on global warming for high school students has been developed [22], and there has been a development of global warming module based on the SETS approach to improve physics learning outcomes of grade XI students [16]. Developing student worksheets on global warming material based on problem-based learning integrated with values to improve student learning outcomes is necessary [23]. Several teaching tools on global warming material have been developed, but the modules and Learner worksheet developed still apply to the 2013 curriculum.

There still needs to be research that develops teaching materials on global warming material that applies to the Merdeka Curriculum. In addition, the teaching materials developed are equipped with complete material content and pictures that can make it easier for students to understand the material. The teaching materials developed also contain chemical representations. Besides, because the teaching materials are designed to support Merdeka Curriculum learning, the teaching materials use systematics and components tailored to the Merdeka

Curriculum, including student activities that support the Pancasila student profile.

Therefore, researchers are interested in developing Teaching Materials to Support The Merdeka Curriculum Learning on Global Warming Caused by Human Activities Material in Phase E, valid and practical and can be used as a reference for teaching materials to maximize the learning process.

RESEARCH METHODS

This research uses the type of research educational design research (EDR) [24]. The development model used is the Plomp development model. The stages of research carried out with the Plomp development model are preliminary research, development or prototyping, and assessment phase [24]. The research was conducted with three chemistry lecturers of the Faculty of Mathematics and Natural Sciences, Padang State University, two chemistry teachers of State Senior High School 8 Padang, and phase E students of State Senior High School 8 Padang. The object of the research is teaching materials to support Merdeka Curriculum learning on the material of human activities that cause global warming in phase E Senior High School.

In the Preliminary research stage, (1) needs and context analysis, (2) literature review, and (3) developing a conceptual framework. The development or prototype stage establishes the design guidelines for the developed teaching materials. Through formative evaluation carried out at each prototyping stage, the stages carried out are (1) prototype I, designing teaching materials and compiling material content, then carrying out self-evaluation, (2) prototype II, which is the result of improvements from the prototype I which is then subjected to expert review and one-to-one evaluation. (3) prototype III, from the results of the improvement of prototype II, a small group test was carried out on nine students to obtain practicality data. Improvements made based on the results of prototype III resulted in prototype IV. The last stage is the assessment phase, where the test is carried out on a larger group. Still, this stage is not carried out because the research limit is limited to obtaining valid and practical results.

The data generated from the formative evaluation is then analyzed. The data obtained from the validation questionnaire will be analyzed using Aiken's V formula.:

$$V = \frac{\sum S}{n(c - 1)}$$
$$S = r - I_0$$

- S = The validator's assigned score minus the lowest score of the category used
r = Validator's preferred category score
I₀ = The lowest score in the suspension category
n = Number of validators
c = Number of validator-selected categories

Table 1. Aiken's V validation index level conversion [25].

Aikens'V scale	Validity
$V \geq 0.80$	Valid
$V < 0.80$	Invalid

Data obtained from the utility questionnaire were analyzed using the following formula:

$$NP = \frac{R}{SM} \times 100$$

- NP = Searched Percentage or Expected Percentage
R = Raw scores achieved by students
SM = The ideal maximum score for relevant tests
100 = fixed numbers

Table 2. Category of practicality level [9].

Value	Assessed Aspect
86%-100%	Very practical
76%-85%	Practical
60%-75%	Practical enough
55%-59%	Less practical
$\leq 54\%$	Not practical

RESULTS AND DISCUSSION

This study aims to develop teaching materials to support Merdeka Curriculum learning on the material of human activities that cause global warming and phase E solutions and determine the level of validity and practicality of the teaching materials developed.

The results obtained from the development of teaching materials carried out based on educational design research (EDR) procedures and using the Plomp development model will be explained as follows:

Preliminary Research

1. Need and context analysis

The first stage of needs and context analysis was conducted by interviews with three chemistry teachers at three schools, namely State Senior High School 1 Padang, State Senior High School 8 Padang, and Senior High School Pembangunan Laboratorium, Padang State University, which implemented the Merdeka Curriculum in the first year. The results obtained are information related to changes experienced in implementing the Merdeka Curriculum, such as changes in learning outcomes, the existence of a Pancasila student profile, and the types of learning resources used in schools. The learning resources used at school are integrated science books issued by the Ministry of Education and Culture. The variety of teaching materials that implement the Merdeka Curriculum is still limited, so more references are needed to increase students' knowledge.

According to the Ministry of Education Standards, Curriculum, and Evaluation, Decree of the Minister of Education, Culture, Research and Technology of the Republic of Indonesia on Early Childhood Education, Basic Education and Educational Learning Outcomes No. 008/H/KR/2022. Chemistry for High School Students Phase E-learning outcomes includes: "Students can observe, investigate, and explain chemical concepts in everyday life; apply chemical concepts in environmental management including explaining the phenomenon of global warming; write chemical reactions and apply basic laws of chemistry; understand atomic structure and its application in nanotechnology." Global warming material is one of the materials that students must understand to achieve phase E-learning outcomes [15]. Global warming material is studied so that the material can be understood, proven, and discussed during learning. In addition, studying global warming at school can educate the youth age group to be wiser in their behavior and decisions related to the global warming phenomenon in the future [16]. Students can be motivated to learn chemistry by providing an overview of chemical phenomena that occur in everyday life [17].

2. Literature review

The second stage of the literature review was conducted to find solutions to several problems and sources of reference from the research. Implementing a Merdeka Curriculum in education can reduce learning loss [4]. The development of teaching materials on the impact of global warming based on the Schoology learning management system resulted in 75% material expert validation, 75% language, 83.33% implementation aspects, and 81.667% problem-based learning characteristics aspects. Therefore, the teaching materials developed are suitable for use as a reference for teaching materials on the impact of global warming [26]. Data calculation using Aiken's V can prove that the teaching materials developed have high validity [27]. Therefore, developing Teaching Materials to Support The Merdeka Curriculum Learning on Global Warming Caused by Human Activities Material is expected to help students understand the learning material.

3. Conceptual framework development

The conceptual framework results are formed in a scheme containing the problems found in the solutions provided. The scheme formed is obtained from the analysis of needs and context to the literature study that has been carried out. The results are the need for more Merdeka Curriculum chemistry learning resources for phase E, so it is necessary to develop Teaching Materials to Support The Merdeka Curriculum Learning on Global Warming Caused by Human Activities Material.

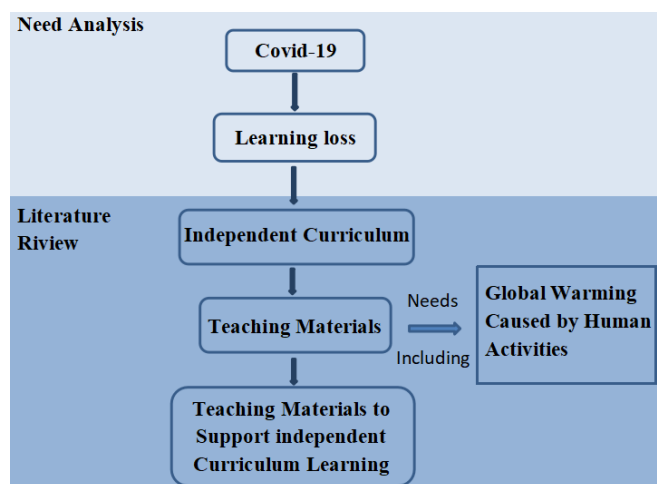


Figure 1. Conceptual Framework

Development or Prototyping Phase

The prototype phase is the stage of designing designs to produce products through teaching materials to support Merdeka Curriculum learning on the material of human activities that cause global warming phase E high school students. In the prototype phase, formative evaluation is used to improve and perfect the products developed at each prototype stage so that the final product produced will have fewer errors and be suitable for learning support.

1. Prototype I

The results obtained in the prototype I are the design of teaching materials, which are made systematically, the components of the teaching materials used are adjusted to the Merdeka Curriculum, and the material content is compiled based on the learning outcomes of the E phase. The components are adjusted to the Merdeka Curriculum, and the material content is compiled based on the learning outcomes of phase E chemistry. The components in the teaching materials are equipped with a cover, preface, table of contents, learning outcomes, learning objectives, concept map, instructions for using teaching materials, material content, Pancasila student profile, keywords, activities, sample questions and discussion, comprehension test, the final question of teaching materials, summary, reflection, bibliography, glossary, index. After completing the design and preparation of teaching materials, the first evaluation carried out is self-evaluation.

2. Prototype II

After implementing prototype I, it was continued to the self-evaluation stage. The researchers carried out the self-evaluation stage. The self-evaluation instrument used is a checklist questionnaire to check the completeness characteristics of the teaching materials prepared and correct any obvious errors in the teaching materials. Then improvements or revisions are made based on the self-evaluation.

Based on the self-evaluation results, the components in the teaching materials developed are complete, and there are no more obvious errors in the teaching materials, including typos or unclear images. So there is no need for revisions.

3. Prototype III

The revised results obtained from the self-evaluation are continued by conducting further formative evaluations in the form of expert assessments and one-to-one evaluations to obtain the validity results of the developed teaching materials.

a) Expert review

The assessment conducted by experts aims to assess several aspects of teaching materials, including content, presentation, language, and graphic components. Expert validation was carried out by three chemistry lecturers from the Faculty of Mathematics and Natural Sciences, Padang State University, and two chemistry teachers from State Senior High School 8 Padang. The data was obtained using an instrument in the form of a checklist questionnaire.

The validation results with five validators, namely, validators 1 and 2, stated that teaching materials were suitable for use with some revisions. In contrast, validators 2, 3, and 4 stated that teaching materials were suitable for use without revision. Some of the criticisms and suggestions given by validators that can be used as guidelines in making revisions to teaching materials are that there are still some words that are considered difficult for students, explain the description of the image in the material explanation text, improve the concept map and the source in the image must be clear, and improve the coverage of the teaching materials.

b) One-to-one evaluation

In the one-to-one evaluation, one-to-one interviews were conducted with three students of phase E of State Senior High School 8 Padang with different ability levels: high, medium, and low. They aimed to determine the student's response to the

teaching materials developed. The instrument was used to collect data through interview sheets. The results of the personal evaluation indicated that the appearance of the presented cover page was attractive, the design and colors of the material were satisfactory to the students, and the students could understand the presentation method and the components of the material. It can be concluded that there are About teaching materials. It is easy to use the teaching materials.

From the results of validation and one-to-one evaluation, revisions were made to the coursebook as follows:



Figure 2. Cover of teaching materials

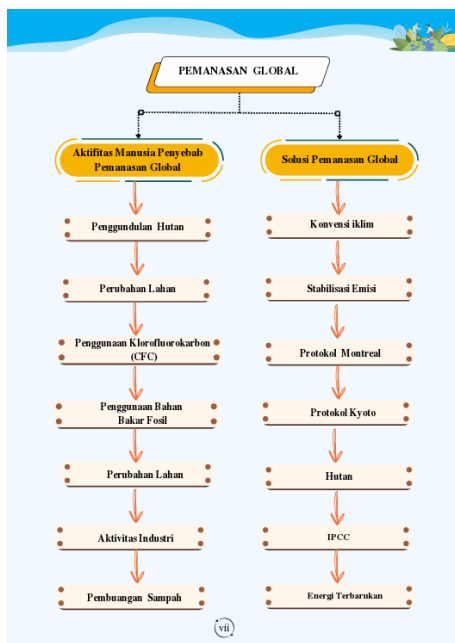


Figure 3. Concept maps

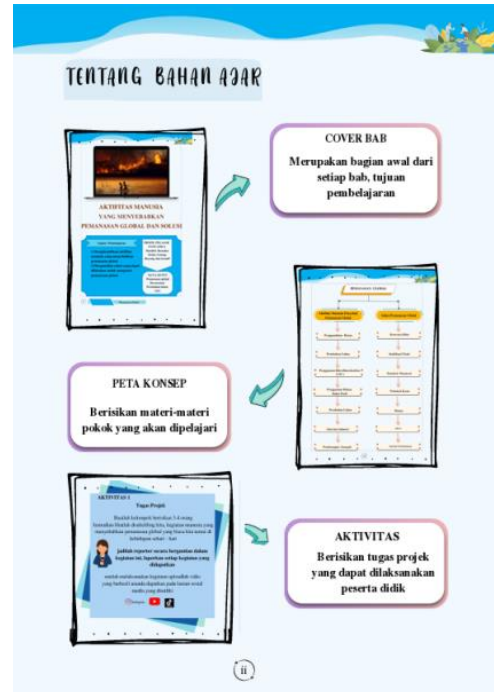


Figure 4. Instructions for using teaching materials

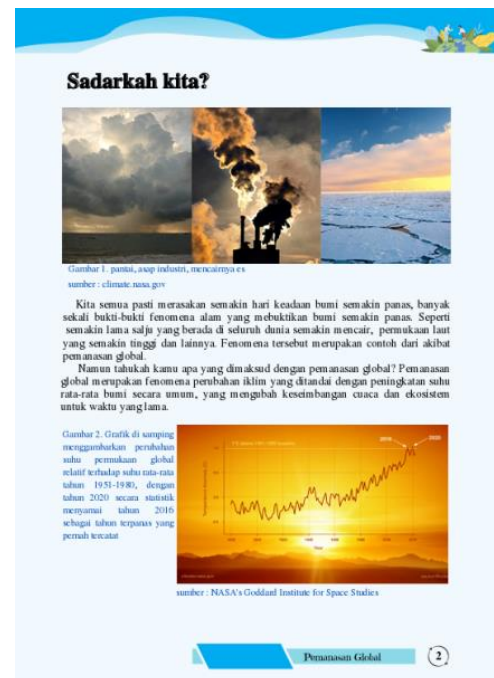


Figure 5. Materials model

The results of the obtained data were analyzed using Aiken's V formula, which can be categorized as valid if the data processing results are 0.8 for five validators [25]. Based on the data processing results obtained, the assessment of the teaching materials developed with an average of 0.89 can be categorized as valid.

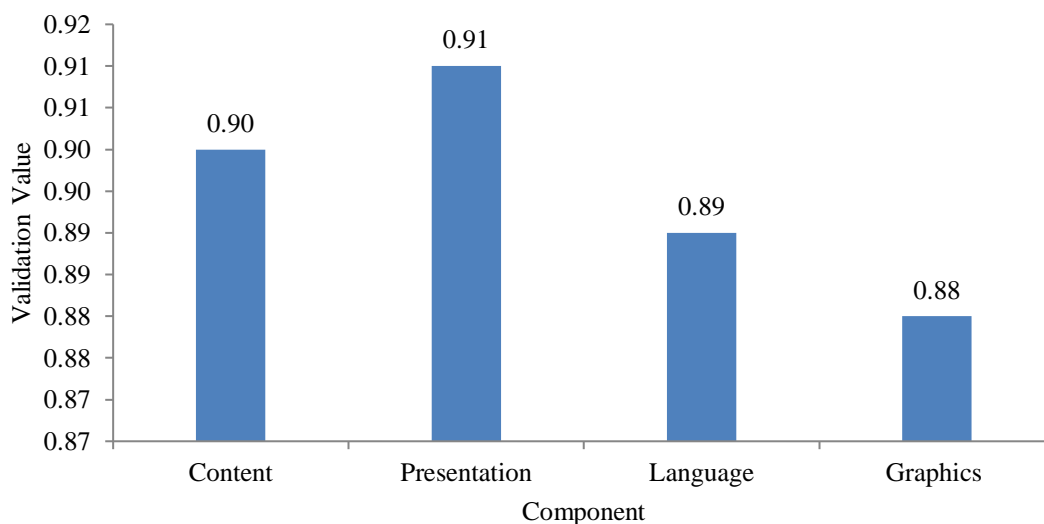


Figure 6. Diagram Showing the Results of Validity Analysis

Figure 7 shows the results of the teaching material validation analysis. Based on Figure 7, the validity value of each component states that the product developed is valid from the components of content, presentation, language, and graphics. By examining the teaching materials, this means that the materials are designed to follow what is taught in the Merdeka Curriculum, that the content of the materials is appropriate to achieve the Phase E Chemistry Outcomes, that the student activities and questions offered are It is meant to help students deepen their understanding and improve and achieve learning outcomes.

4. Prototype IV

Prototype IV is conducted by testing the material that is valid for Prototype III in small groups. A small group test will be conducted to determine the practical value of the material. The small-group exam was conducted by nine phase E students with different abilities, high, medium, and low, who were selected based on the recommendation of the chemistry teacher

leading the class. Nine students carried out learning using the teaching materials developed. Students can assess the teaching materials developed while carrying out learning simulations and working on practice questions contained in the teaching materials.

After learning with the teaching materials developed, students were given a practicality questionnaire, and students were asked to fill out the questionnaire and provide criticism and suggestions for the teaching materials developed. Besides being given to students, the questionnaire was also given to two teachers who taught in phase E at State Senior High School 8 Padang. In addition to being given to students, the questionnaire on the practicality of teaching materials was also given to two chemistry teachers of State Senior High School 8 Padang,

Based on the data processing results on the practicality of students and teachers, the results are shown in Figure 8.

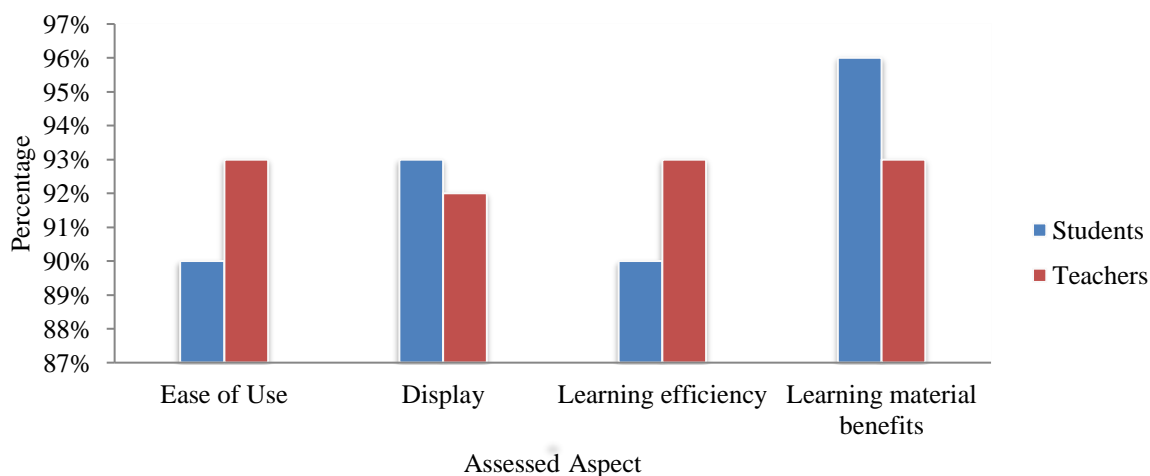


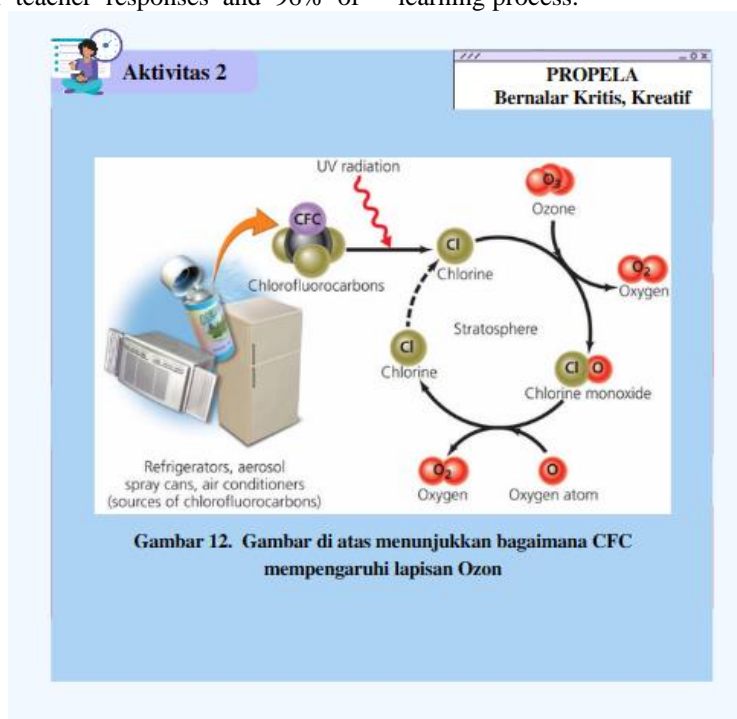
Figure 7. Diagram Showing the Results of Practicality Analysis

The data on the practicality of teaching materials in ease of use obtained a value of 90% from the teacher's response and 93% from the students' responses. It shows that teaching materials are easy for students to use in learning.

For advertising, 93% of responses came from teachers and 92% from students. It indicates that teachers and students like the overall look and feel of the material. In the aspect of learning efficiency, a value of 90% was obtained from teacher responses and 93% from the results of student responses, and this proves that the teaching materials developed are efficient in terms of learning time. The benefits obtained in 93% of teacher responses and 96% of

student responses show that developed teaching materials can help students during learning.

According to the results of the practice questionnaire, the average was 92% for teachers and 93% for students. Based on the comprehensive results of the practicality of the teaching materials, the teaching materials in Phase E, which supports the Merdeka Curriculum for learning about global warming caused by human activities, are very practical in terms of ease of use, time efficiency, efficiency, and advantage. Analysis results of utility data show that the designed prototype IV is of high quality and indeed valid and practical to use in the learning process.



Gambar 12. Gambar di atas menunjukkan bagaimana CFC mempengaruhi lapisan Ozon

Figure 8. Activity in the teaching materials to support Merdeka Curriculum Learning

In this activity, students are asked to discuss how Chlorofluorocarbon (CFC) compounds break down ozone compounds. The ozone layer is a layer of the earth in the stratosphere, which has an important role in life, such as keeping humans from getting skin cancer and ultraviolet-B radiation rays [28]. Chlorofluorocarbon (CFCs) compounds are organic compounds composed of carbon, fluorine, and chlorine. CFCs have non-flammable and non-toxic properties. CFCs are so stable that they can be used in various equipment [29]. CFCs have been widely used in applications such as spray, aerosol, refrigerants, or foaming agents for insulation materials [30].

Chlorofluorocarbons (CFCs) significantly contribute to ozone layer depletion [31]. When exposed to ultraviolet light, CFCs compounds separate and form chlorine free radicals. These highly reactive free radicals cause damage to the ozone layer. Free radicals react with ozone to form molecular

oxygen (O₂) and chlorine monoxide (ClO). ClO then reacts with another ozone molecule. It produces two oxygen (O₂) molecules and returns chlorine to its free radical state. It can continue with more ozone molecules meaning one free radical can destroy large amounts of ozone.

Chemical representation in teaching materials is intended so that students can more easily understand the meaning of learning materials. As in Figure 9, using representations in activities will make it easier for students to discuss and improve their critical thinking, supporting the Pancasila student profile. In addition, this stage aims to find out how students respond to the teaching materials developed. Based on the results of this stage, the many displays of representations in teaching materials can Make it easier for students to answer questions and eliminate obstacles for students to use materials.

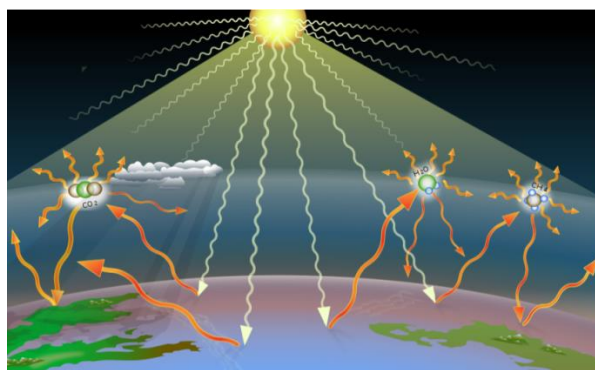


Figure 9. Greenhouse Effect as one of the questions in the teaching materials

Figure 10 shows the pictures of the critical question model that students must answer. The results of student interviews show that global warming occurs when most of the sun's light passes through the atmosphere and reaches the earth's surface. When the earth's surface is heated, the earth's surface emits some energy back into space as infrared radiation. But when many greenhouse gases are trapped in the atmosphere, the atmosphere's temperature increases. The heated atmosphere then emits infrared radiation back to the earth's surface. In this section, students are relied upon to answer questions based on the pictures provided accurately. Using pictures in the questions is expected to confine students to finding the correct and accurate answers.

This stage aims to find out how students respond to the learning developed. Based on the results at this stage, it is found that the appearance of the images given in the teaching materials is unmistakable and can facilitate students in understanding the material in the teaching materials. The questions and instructions given are also straightforward, so there are no obstacles for students in using teaching materials in learning.

CONCLUSION

In conclusion, teaching Materials to Support the Merdeka Curriculum Learning on Global Warming Caused by Human Activities Material in Phase E can be categorized as valid with an average validity value of 0.89 (3) based on the small group trial assessment results. The average practicality results from students are 93% and teachers are 92% which are declared very practical.

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