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Article

Development of CADITEKS (Carbon Dioxide Test Kit for Sustainability) as Interactive Green Technology Learning Media

Jamus Alma'ruf[1]*, Krisna Fitrianto Khoirul Alim[2], Ilham Yusuf Arifin[3], Rahmi Faradisya Ekapti[4]

[1,2,3,4]Intitut Agama Islam Negeri Ponorogo, Indonesia

Corresponding Address: jamusal87@gmail.com

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ABSTRACT

By 2023, air pollution is one of the world's problems. Even Indonesia is one of the top contributors to air pollution in the world. Air pollution in Indonesia is caused by CO_2 gas emissions from coal and motor vehicles. Awareness of the dangers of air pollution has been taught to school students. However, the lack of innovative and fun learning media is one of the problems faced. Therefore, this study aims to develop learning media "*CADITEKS*: Carbon Dioxide Test Kit for Life Sustainability" on the material of environmentally friendly technology. This research is a development research with a modified 4D model which is converted into 3D, namely defining, designing, and developing. Defining includes formulating learning problems that are used as a reference for designing learning media. The design of learning media is adjusted to the basic competencies and learning objectives, where the *CADITEKS* components include CO_2 detectors, combustion chambers, CO_2 level indicators, and user manuals and work safety. At the development stage, product quality testing was carried out by validating one material expert and two media experts who obtained an average score of 88.46%, which indicates that *CADITEKS* is very valid or can be used without revision.

INTRODUCTION

Every country around the world has different problems. However, in general, increasing air pollution is one of the problems that needs to be prioritized to be resolved. Based on an excerpt from CNN Indonesia, in 2023 Indonesia became the largest contributor to air pollution in the world. Air pollution in Indonesia, especially in Jakarta and other major cities, is a serious problem that affects the quality of life of the population. According to the Air Quality Life Index (AQLI), Indonesians are expected to lose 2.5 years of their life expectancy due to current air pollution. Increased technological activities in the modern era are one of the causes of increased air pollution with industrial factories, power plants, and transportation gas emissions

as the sources (Abidin et al., 2019). Awareness of the dangers of air pollution has been taught to students in schools.

In improving students' understanding of the dangers of air pollution, innovative and interactive learning media are needed. Innovative learning media is a tool designed with teacher creativity to deliver material with the intention that students easily understand the core material (Puspitaloka et al., 2022). he uses of interactive learning media can increase student learning motivation. However, in its application, the use of interactive learning media is still relatively lacking in certain materials. Environmentally friendly technology is one of the junior high school science learning materials in grade IX. In the material of environmentally friendly technology, the use of interactive learning media is still relatively lacking. The lack of learning media has an impact on the quality of students in understanding the content of the material (Putrawangsa & Hasanah, 2018). Teachers play an important role in developing innovative and interactive learning media.

According to Ariandini & Ramly's research (2023), the use of interactive learning media provides positive results in the form of an increase in the posttest scores of students at SMP Negeri 5 Makassar. Rahmadani's research (2022), on the use of interactive multimedia in learning junior high school students also found an increase in the average cognitive ability on respiratory system material. These two studies prove that the use of interactive learning media can improve student understanding. The problem of the lack of interactive learning media on environmentally friendly technology material is the background for making learning media innovations under the name *CADITEKS* (Carbon dioxide test kit for life sustainability).

CADITEKS, an innovation in the form of carbon dioxide (CO_2) detectors, is emerging as an important part of green technology-focused learning media. It not only contributes to the understanding of the impact of carbon dioxide on the environment, but also provides a practical means to visualize the concept. *CADITEKS* is designed to provide an immersive and interactive learning experience. Using sophisticated sensors, it is able to detect the level of CO_2 in an environment. As such, students can directly observe how human activity or energy use can affect CO_2 levels in their environment.

This learning medium not only utilizes technology, but also provides a better understanding of global environmental issues. *CADITEKS* allows students to see the direct impact of their behavior on the surrounding environment. By integrating this tool into the curriculum, teachers can guide students in understanding the relationship between carbon dioxide production and climate change. In addition, the use of *CADITEKS* creates awareness of our responsibility to the environment and encourages more sustainable behavior.

Through the utilization of *CADITEKS* in learning media, students are not only taught theoretical concepts but also given the opportunity to observe and respond directly to real situations. This provides a new dimension to learning, creating a more holistic and relevant experience. Thus, *CADITEKS* becomes an integral part of efforts to create a generation that is more environmentally conscious and able to take positive action to protect the earth. Based on this explanation, the purpose of this research is to create learning media that makes it easier for students to understand material about environmentally friendly technology for sustainable survival.

METHODS

The research method used in this *CADITEKS* (Carbon dioxide test kit for life sustainability) learning media innovation adopts the 4D approach which is then refined into a 3D model, namely: Defining, Designing, and Development. The Defining stage aims to carefully detail the needs and objectives of the research (S.Sirate & Ramadhana, 2017). Researchers conducted a thorough analysis of the concept of environmentally friendly learning media and determined the specifications required by *CADITEKS*. This process involved an in-

depth understanding of the scope of the material, students' needs, and desired learning objectives.

After defining, the research proceeded to the design stage. This stage includes the preparation of the initial design of *CADITEKS*, both in terms of physical and software. This stage aims to determine the characteristics and needs of students as a reference in determining the concept of learning media to be developed (Herowati & Azizah, 2022). After recognizing and knowing the characteristics of students, concept analysis is then carried out. This design is produced by considering ergonomic, functionality, and security aspects, as well as ensuring the user interface can be accessed easily. At this stage, the active involvement of media experts and material experts was conducted to ensure that *CADITEKS* can be effectively integrated in the learning context.

The development stage is the main focus after the defining and designing stages (Ferdiansyah et al., 2023). At the development stage, the *CADITEKS* prototype was developed and tested through a series of iterations. At this stage, researchers evaluated the validity of the product by using the opinions of one material expert and two learning media experts from science lecturers through a validation test instrument which includes several assessment components including suitability, completeness, convenience, clarity, communicative and interactive, and security with a total instrument of 21 question items so as to produce innovative and interactive learning tools. Thus, the 3D approach in the *CADITEKS* research method has a positive impact holistically and integrated in the development of environmentally friendly technology-based learning media.

Meanwhile, the calculation of the validation test results was carried out using the formula (Fuada, 2015).

Formula for Processing Data from Material Experts

$$Expert\ Validity = \frac{Total\ empirical\ score\ (trial\ result)}{Total\ maximum\ expected\ score} \times 100\%$$

Criteria of Validity

Table 1. Criteria of Validity (Fuada, 2015).

No	Validity Criteria	Validity Level
1.	81,26 % - 100,00%	Highly Valid, or can be used without revision
2.	62,51 % - 81,25 %	Valid, or can be used but needs minor revisions
3.	43,76 – 62,50 %	Not valid, recommended not to be used because it needs major revisions
4.	25,00 % - 43,75 %	Very Invalid, or should not be used

RESULTS AND DISCUSSION

The developement of CADITEKS underwent a research phase to achieve the envisioned goals. This research followed a predefined approach, specifically employing the 3D development model encompassing definition, design, and implementation stages.

Defining Phase

At this stage, we define and analyze several things related to learning needs. The results of the steps in this stage are as follows:

1. Initial Analysis and Final Analysis

   At the initial analysis stage, the author found a statement in the grade 9 student book, the statement explained that biofuels are environmentally friendly fuels. The biofuels mentioned in the student book are ethanol and bio diesel. However, the student book did not explain the carbon dioxide emissions released from these biofuels. So the author developed a learning innovation in the form of a tool that can measure carbon dioxide emission levels, namely *CADITEKS* (Carbon Dioxide Test Kit for Sustainibility).
2. Learning Problem Analysis

   Learners are often faced with several learning problems, especially in science learning at the junior high school level. One of the common problems faced by learners is

the abstraction of science concepts that are sometimes difficult to understand. The concept of environmentally friendly technology is complex and difficult for learners to understand its practical implications in everyday life. In addition, the lack of practical experience in measuring and understanding impacts can also be a problem (Yunarti, 2021). Learners may struggle to connect scientific theories with practical applications in reducing carbon dioxide emissions or maintaining sustainability.

In this context, the development of *CADITEKS* learning innovation is very relevant. It can address several learning issues by providing a practical learning approach. By using *CADITEKS*, learners can measure CO_2 emissions directly, allowing learners to see the level of CO_2 emissions emitted by some of the samples tested. This learning innovation can stimulate learners' better understanding of green technology and help learners to connect scientific concepts with practical applications in maintaining sustainability. In addition, *CADITEKS* also enables a more interactive approach to learning, which can overcome the problems of boredom and lack of learner engagement that learners often experience in conventional science learning. Thus, the *CADITEKS* learning innovation is an innovative and suitable solution to overcome some of the learning problems often faced by learners in understanding green technology in science learning.

3. *CADITEKS* Concept Analysis

   CADITEKS or Carbon Dioxide Test Kit for Sustainibility is a learning innovation in the form of a tool to measure CO_2 emission levels from tested samples. Concept analysis is needed to determine the layout and arrangement of the tool. The use of used goods as materials for the CO_2 detector framework will provide students with an understanding that used goods can be utilized into an innovative tool or media. In addition to analyzing the concept of media layout, the selection of samples to be tested must also be considered, so that student safety is maintained.

4. Assignment Analysis

   This analysis is conducted to determine the form of assignments that will be presented in the *CADITEKS* learning innovation to strengthen and determine the level of student understanding of learning materials. The form of assignment in *CADITEKS* learning innovation is in the form of analysis sheet. The assignment is carried out after students conduct experiments that are accompanied and supervised by educators. After the students do the experiment, they can write down the results of their experiment in the observation table. From the observation table, learners can analyze the observations they get.

5. Specification of Learning Objectives

   Based on the concept analysis and assignments that have been carried out, 5 points of specific learning objectives specifications are obtained from the material that is the basis for the preparation of this LKPD, namely students are able to accurately measure and understand CO_2 emissions through LKPD learning media; students are able to identify sources of CO_2 emissions through LKPD learning media; students are able to analyze CO_2 emission levels through LKPD experiments; students are able to raise awareness of the importance of reducing CO_2 emissions through LKPD experiments; students are able to develop critical thinking skills in tackling CO_2 emissions through LKPD experiments.

Design Phase

In this design stage, the design and preparation of work steps to produce *CADITEKS* is carried out. The design includes what components are in *CADITEKS*. These components include carbon dioxide indicator sensors, combustion chambers, tool covers, how to use tools, work safety procedures, PPM Indicators, and observation tables.

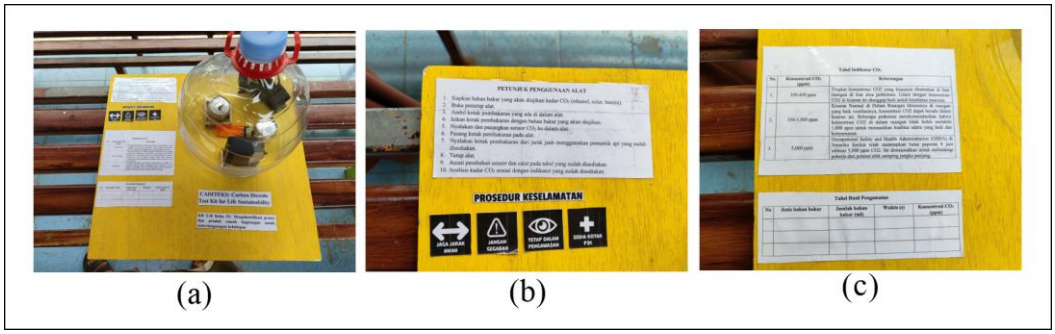

Figure 1. *CADITEKS* Design Components: (a) *CADITEKS* components, (b) how to use & safety procedures, (c) PPM indicators & observation results table

Development Phase

The development stage is the stage where *CADITEKS* began to be made and tested. At this stage, *CADITEKS* uses materials from used items such as used wooden boards, used gallons, and used cans. The arrangement of the sample holder and CO_2 detector is always considered for the safety of students and the efficient use of tools. On the wooden board there is space to attach several components such as instructions for using the tool, safety procedures, CO_2 level indicator tables, observation tables, tool names, and basic competencies that are the reference material. After *CADITEKS* is completed, a trial will be carried out to ensure that the CO_2 detector can function properly and is ready to be validated by several media experts and material experts.

At the development stage, the validation test of CADITEKS (Carbon Dioxide Test Kit for Sustainibillity) was carried out by 2 media experts and 1 material experts who are IAIN Ponorogo science lecturers. The validation test included an assessment of several components, including ease, suitability, completeness, clarity, communicative and interactive, and safety for students.

Furthermore, from the results of the validation analysis of media experts and material experts, the results of the calculation of the validation test of media experts and material experts can be seen in Table 2.

Table 2. Validation Test Results of Material Experts and Media Experts

Validator	Score Obtained	Maximum Score	Final Score $(\frac{Score\ Obtained}{Maximum\ Score} \times 100\%)$	Category
Material Expert	36	40	90%	Highly Valid
Media Expert 1	52	65	80%	Valid
Media Expert 2	62	65	95,38%	Highly Valid
Average			88,46%	Highly Valid

Based on Table 2, the validation results of the media experts and material experts obtained an average final result of 88.46%, which indicates that the *CADITEKS* learning innovation is in a highly valid category.

CADITEKS for Interactive Learning Media

CADITEKS is designed as an interactive learning media. Interactive learning is simply defined as a learning method that involves students actively in the learning process (Mitrawalida, 2018). Learners in using *CADITEKS* will be directly involved and discuss with friends and also teachers in understanding the concept of environmentally friendly and environmentally unfriendly technology. So that this kaditeks can be used as an interactive learning media. According to Munawaroh et al. (2022), learning media can be said to be interactive if a tool used as an intermediary to convey knowledge from educators to students, when its use will cause interaction between students and the media or tools, which are interrelated and influence each other in the hope of improving student learning outcomes.

In using *CADITEKS*, students will test each fuel that has been provided whether it is classified as environmentally friendly or not. Students burn the fuel and see how much CO_2 is produced from each fuel. Then students analyze the experimental data with their friends and present the results of their experiments in front of the class. In using cadets, students are more actively involved during learning so that it makes it easier for teachers to learn environmentally friendly technology. The role of media in the learning process is to facilitate the interaction process between educators and students in helping to learn optimally (Mustikawati, 2019).

Validity of *CADITEKS*

The results of the validation test to two media experts and one material expert obtained an average score of 88.46% where media expert 1 scored 80%, media expert 2 scored 95.38%, and material expert 90%. Based on the validation test results, Caditeks can be used validly without revision because the average validation test results are in the interval 81.26%-X-100%. Although without revision, input from media and material experts such as adding color to the CO2 level indicator table so that students better understand the dangers of each level of CO2 levels in fuel. This input is taken into consideration for us to develop this Caditeks to be more interactive and easily understood by students.

CONCLUSION

Based on the results of the discussion, it can be concluded that the development of *CADITEKS* is carried out with a 3D development model consisting of defining, designing, and developing. In the defining stage, problem definition is carried out and the problem found is the lack of interactive learning media innovation in learning the concept of environmentally friendly and environmentally unfriendly technology products. So that this *CADITEKS* can be used as an interactive media to teach the concept of environmentally friendly technology products. In the design stage, the selection of tool components and the layout of each tool component used is carried out. At the development stage, product quality testing was carried out by validating one material expert and two media experts who obtained an average score of 88.46%, which indicates that *CADITEKS* is very valid or can be used without revision.

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