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Cognitive Conflict-Based Learning Materials Integrated with Augmented Reality: Is It Practical in Learning Global Warming?

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ABSTRACT

The low understanding of concepts in physics learning is still a common problem, including in the topic of global warming. The use of technology such as augmented reality that has the potential to improve understanding of physics concepts is still rarely applied. One way to overcome this problem is to develop physics teaching materials based on cognitive conflict integrated with augmented reality in global warming learning. This study aims to test the level of practicality of global warming teaching materials products based on cognitive conflict. This study reports the development stages in the Plomp model, especially at the small group evaluation stage. The instrument used in this study was a practicality questionnaire analysed using a percentage technique. The four aspects tested in this study were aspects of ease of use, attractiveness, efficiency and benefits with an average for each aspect in sequence of 91.66; 94.91; 92.78; and 94.99 with very practical criteria. And the average value of the results of the practicality test of the teaching material product reached 93.58 which was very practical. Global warming teaching materials based on cognitive conflict integrated with augmented reality are practical for students in terms of ease of use, attractiveness, benefits and efficiency.

INTRODUCTION

The progress of knowledge and technology in the 21st century has had a significant impact of education, especially in the learning procedures. Learning in this era requires the integration of technology in learning activities. According to Mufit (2022), definition of learning is a correlation relationship between students, educators and their surroundings, so that there are stages of learning within the student to achieve a certain goal. In addition, learning is all efforts made by teachers so that the learning stages occurs in students (Marheni et al., 2025). Based on this definition, it can be concluded that learning is a process that involves interaction between students, teachers, and the environment to encourage learning.

Physics learning must basically involve students in the concept discovery stage that matches the characteristics of 21st century learning (Mufit et al., 2024). This process allows students to build a deeper and more meaningful understanding of physics concepts. Based on research by Mufit et al. (2023) learning that ignores initial conceptual understanding and not involving students in the discovery process has the potential to increase misconceptions because most students acquire misconceptions from previous education. Most students' misconceptions start from their own thoughts, followed by the influence of books, teachers and online sources (Isra & Mufit, 2023).

The urgency of this research is based on several factors that cause misconceptions in physics learning. Misconceptions in physics learning are caused by several main factors that need attention. These factors include students' low ability to understand the material, limited valid and credible learning resources such as reference books, modules, and bold libraries, so that many students use internet literature that is not guaranteed to be true. In addition, the learning methods applied by teachers are less able to arouse students' interest in learning, and task factors that are not discussed further in learning also contribute to the emergence of further misconceptions (Darwis & Hardiansyah, 2022).

Based on observations with 2 physics teachers at SMAN 1 Batang Anai, it was found that misconceptions still often occur in students. This is because learning is still cantered on the teacher. This means that learning still uses the lecture method and students tend to be passive. On the other hand, there is still no teaching material that is specifically designed to overcome students' misconceptions about global warming. This condition can be a problem in the potential to increase conceptual understanding of global warming. In line with the real conditions obtained in previous research by Hayati & Mufit (2023) in 2 high schools in Padang City, teachers have not identified understanding of students' concepts regarding of global warming material and the existing teaching materials are still one, namely science which includes physics, chemistry, and biology.

The way out of this problem is to develop cognitive conflict teaching materials that are integrated with augmented reality. Based on previous research findings, an important focus in developing effective and interesting learning media for students is cognitive conflict-based teaching materials integrated with augmented reality on global warming material (Hayati & Mufit, 2023). Other studies have also found that the use of augmented reality in cognitive conflict models can increase student engagement and their understanding of complex scientific concepts (Mufit & Dhanil, 2024). In addition, to develop cognitive conflict-based physics teaching materials aimed at reducing misconceptions, it can also present and provide opportunities for students to reinforce a concept repeatedly and activate students in learning to improve and grow their motivation (Faresta et al., 2020).

Cognitive conflict is a misunderstanding that arises in a person's mind through viewing an event in finding the right concept (Mufit & Fitri, 2022). A learning model that can activate students' cognition by challenging their initial understanding is a cognitive conflict-based learning model. The cognitive conflict-based learning model is also an innovative approach whose main goal is to foster conceptual understanding and remediate misconceptions in students (Zuwita & Mufit, 2023). In line with the research of Pramono & Mufit (2022) the cognitive conflict-based learning model has an impact on the interpretation of students' concepts, so that these misconceptions can be avoided. According to Mufit & Fauzan (2019) there are 4 stages or syntax of the cognitive conflict-based learning model, namely: (1) activation of preconceptions and misconceptions, (2) presentation of cognitive conflicts, (3) discovery of concepts and similarities, and (4) reflection.

Augmented reality technology has been used in various disciplines because its potential to increase learning motivation and conceptual understanding has been widely reported in

various studies (Buchner et al., 2022). Based on the explanation of scientist Ali et al. (2021), learning media that uses augmented reality is a solution by presenting interactive and real-time three-dimensional visualizations, this allows students to experience a deeper learning experience with efforts to directly increase students' imagination. Augmented reality has three advantages which are why this technology is chosen by many developers: 1) able to broaden the user's view of an object and provide "user experience" for the 3D object displayed 2) gives users the possibility to interact cannot be done in the real world 3) can be used with various tools (devices) according to needs and availability (Dedynggego et al., 2015).

This research is important to be conducted for the development of cognitive conflict-based teaching materials integrated with augmented reality for global warming learning. The teaching materials used in this study were previously developed by Hayati & Mufit (2023) which are valid by six validators and very practical in one-to-one evaluation, but their practicality in small group evaluation is not yet known. The results of previous research on the validity of teaching material products include material substance, learning design, visual communication displays, and software utilization, and cognitive conflict model assessment, respectively, obtained validity values of 0.90; 0.87; 0.94; 0.89; and 0.92 with an overall average of 0.90 with a valid category. Result of the practicality of the teaching material product have an average practicality value of 91.28% with a very practical category. The characteristics of the practicality of this teaching material product are practical in terms of ease of use, attractiveness, efficiency, and benefits in the learning process. In this way, the teaching material products that have been produced are valid and very practical in one-to-one evaluation.

In order to obtain a quality product, the teaching materials in this study must be tested for their practicality using small group evaluation. According to Nieveen (1999) there are three main criteria that must be met to assess the quality of a product, namely validity, practicality, and effectiveness. The Language Development and Fostering Agency (2016) defines practicality as something that is easy and fun to use. Therefore, a practicality test is very necessary to assess the degree of a product based on ease, attractiveness, benefits, and time efficiency for its users, namely students. This study aims to examine the practicality of global warming teaching materials based on cognitive conflict integrated with augmented reality with research questions "teaching materials based on cognitive conflict integrated with augmented reality: are they practical in global warming learning?"

METHODS

This research method uses a development model (Plomp, 2013). Plomp stated that development research is essential for designing and creating interventions as well as advancing knowledge as a solution to complex problems. This development research was conducted to overcome problems in physics learning, especially the problem of lack of students' conceptual understanding. The teaching material products of this research will be tested directly to obtain practical teaching materials that have the ability to improve students' conceptual understanding. The Plomp model consists of 3 stages, namely the preliminary research stage, the development stage and the last is the assessment stage. This research is only at the stage of developing teaching material products in small group evaluations (practicality tests) of teaching material products. While the previous stages have been carried out by previous researchers. So, the focus of this research is only the practicality test. The use of the Plomp model leads to several considerations, including being more flexible and flexible to be adjusted to the needs of researchers and research characteristics (Mufit et al., 2020; Rosalina Rawa et al., 2016).

The research sample was 9 students of Grade X phase E of SMAN 1 Batang Anai. The object of the research was a conflict-based teaching material product integrated with augmented reality. The selection of samples was based on certain considerations, especially the varying academic abilities of students. This ensures that the open-ended product is practical for students of all ability levels, including low, medium, and high achievers.

The research instrument used was a practicality test questionnaire. This questionnaire assesses practicality from the aspects of ease of use, attractiveness, efficiency, and benefits. The practicality of the teaching material product was analysed based on the responses of students of SMAN 1 Batang Anai. To determine certain practicality criteria, the teaching material product was tested on three groups with high, medium, and low academic abilities.

The percentage criteria for the practicality of the final product range from 0-100, which contains five criteria. The percentage value showing 0-20 is included in the "not practical" criteria, 21-40 is included in the "less practical" criteria, then 41-60 is included in the "quite practical" criteria, 61-80 is included in the "practical" criteria, and finally 81-100 falls in the "very practical" criteria (Riduwan, 2019).

RESULTS AND DISCUSSION

Results

The results data presented below are data on the practicality of learning materials based on cognitive conflict integrated with augmented reality obtained from calculating the percentage of each aspect tested. The aspects tested in this practicality test are divided into four aspects, namely aspects of ease of use, attractiveness, efficiency, and benefits. Data were generated by giving a practicality questionnaire to 9 students who were divided into three small groups (small group evaluation). Each group consists of three students who have different skills, namely high, medium and low.

The first aspect, ease of use of learning materials consisting of nine indicators. Eight of the nine indicators are in the very practical criteria. The values of the nine indicators are presented in Table l.

Table 1. Results of Ease-of-Use Aspect

Indicator	Value (%)	Criteria
a. Instructions for teaching materials are easy to understand	97.22	Very practical
b. The sequence of materials in the teaching materials is easy to understand	94.44	Very practical
c. The materials presented are easy to understand	94.44	Very practical
d. The preconception and misconception activation stage are easy to implement	88.89	Very practical
e. The cognitive conflict presentation stage is easy to implement	86.11	Very practical
f. The concept and equation discovery stage are easy to implement	94.44	Very practical
g. Reflection, has been implemented	91.67	Very practical

h. Learning activities using Augmented Reality integrated teaching materials are easy to implement	97.22	Very practical
i. 3D images in the Augmented Reality application are easy to understand	80.56	Practical
Average	91.66	Very practical

From Table 1, it can be seen that the range of values produced for each ease-of-use indicator is in the practical and very practical criteria. The assessment of the practicality of teaching materials with practical criteria is in indicator i with a value of 80.56 and indicators with very practical criteria are in indicators a, b, c, d, e, f, g and h which have a range of 86.11 to 97.22. When viewed from the average aspect of ease of use of the teaching materials produced, it is 91.66 with a very practical criterion. So that the aspect of ease of use of cognitive conflict-based teaching materials integrated with augmented reality about global warming is in the very practical criteria.

The second aspect is the attractiveness of teaching materials consisting of six indicators. The six indicators in this aspect are in the very practical criteria. The values of the six indicators are presented in Table 2.

Table 2. Results of the Attractiveness Aspect

Indicator	Value (%)	Criteria
a. interesting teaching material cover	100	Very practical
b. interesting teaching material content display	100	Very practical
c. interesting font type on teaching material	83.33	Very practical
d. interesting image illustration	100	Very practical
e. interesting Augmented Reality application display	94.44	Very practical
f. interesting 3D images on Augmented Reality	91.67	Very practical
Average	94.91	Very practical

From Table 2, it can be seen that the range of values produced for all indicators of attractiveness starts from 83.33 to 100. So, all indicators of attractiveness are in the very practical criteria. The average aspect of the attractiveness of the teaching materials produced is 94.91 with the very practical criteria. So that the criteria for the attractiveness aspect of teaching materials based on cognitive conflict integrated with augmented reality on global warming material are in the very practical criteria.

The third aspect, the efficiency of teaching materials consisting of five indicators. The five indicators in this aspect are in the very practical criteria The values of the five indicators are presented in Table 3.

Table 3. Results of the Efficiency Aspect

Indicator	Value (%)	Criteria
a. Teaching materials make learning time more efficient	88.89	Very practical
b. Teaching materials make costs more efficient to own and use	94.44	Very practical
c. Teaching materials can be used anywhere	100	Very practical
d. Virtual labs are more efficient to use on teaching materials because they already use barcode scanning	88.89	Very practical
e. Augmented Reality is more efficient to use on teaching materials because there are already markers that are scanned	91.67	Very practical
Average	92.78	Very practical

From Table 3, it can be seen that the range of values produced for all efficiency indicators starts from 88.89 to 100. So, all efficiency indicators are on very practical criteria. The average efficiency aspect of the teaching materials produced is 92.78 with the very practical criteria. So that the criteria for the efficiency aspect of teaching materials based on cognitive conflict integrated with augmented reality on global warming material are very practical.

The last or fourth aspect, the benefits of teaching materials consisting of five indicators. The five indicators in this aspect are in the very practical criteria. The values of the five indicators are presented in Table 4.

Table 4. Results of the Benefits Aspect

Indicator	Value (%)	Criteria
a. Teaching materials can be used for independent learning	97.22	Very practical
b. Teaching materials have the potential to facilitate understanding of concepts	88.89	Very practical
c. Teaching materials have the potential to improve understanding of concepts	97.22	Very practical
d. Teaching materials can train cooperation in learning	97.22	Very practical
e. Augmented Reality has the potential to improve students' understanding of concepts	94.44	Very practical
Average	94.99	Very practical

From Table 4, it can be seen that the range of values produced for all benefit indicators starts from 88.89 to 97.22. So that all benefit indicators are in the very practical criteria. The

average benefit aspect of the teaching materials produced is 94.99 with the very practical criteria. So, the benefit aspect of teaching materials based on cognitive conflict integrated with augmented reality on global warming in very practical criteria.

Discussion

According to the results of the research conducted, a practicality test of the teaching material product conducted in three small groups (small group evaluation) consisting of three students in each group. The aspects tested in the research on the practicality of teaching material products consist of four aspects, namely ease of use, attractiveness, efficiency and benefits. Average for each aspect in sequence of 91.66; 94.91; 92.78; and 94.99 with the criteria of very practical. And the average percentage of all aspects of overall practicality is 93.58 with the criteria of very practical.

The first aspect is ease of use which consists of nine indicators. The resulting values for the overall ease of use indicators range from 80.56 to 97.22. All ease-of-use indicators are in the practical and very practical criteria. One indicator with a practical criterion with a value of 80.56, eight indicators with a very practical criterion with a value range of 86.11 to 97.22. One indicator with a practical criterion because the augmented reality application can only be accessed via an Android cell phone, so students who use iOS-based cell phones cannot install this application on their cell phones. When viewed as a whole, the average value of the ease-of-use indicator for this teaching material is 91.66 with a very practical criterion. This is in accordance with Nieveen's opinion (1999) that the practicality aspect of a teaching material product can be measured based on its ease of use. So, eight of the nine indicators in this section have a very practical standard, because the instructions and material on the concept of global warming easy to understand by students and use. In the teaching materials there are also instructions for using augmented reality applications which give students an easier way to use them. The teaching materials are equipped with learning achievements, learning objectives, and the flow of learning objectives from the global warming material so as to provide students with an overview of the material they will study.

Puspitasari (2022) believe that easy-to-understand learning is important for student success. In the teaching materials, there is material in the form of supporting information that is easy to understand because it discusses everyday events from the concept of global warming. The first syntax stage, activation of preconceptions and misconceptions is easy to implement because it is guided by basic statements of global warming material that will be analysed by students for true/false/don't know about the statement, so that teachers can directly find out the initial conceptual understanding that students have whether it includes understand concept / misconception / do not understand concept. The second syntax stage of presenting cognitive conflicts is easy to implement because it is guided by questions in the form of phenomena of global warming material so that students answer these phenomena based on the hypotheses, they have in the hypothesis column contained in the teaching materials. The third syntax stage, discovery of concepts and equations is easy to implement because students will work in their groups to find concepts with videos and simulations contained in the teaching materials. The fourth syntax stage, reflection is also easy to implement because students will present their group work so that they can express and share ideas about the concepts found, then students work on evaluation questions independently to review the understanding they have obtained in the previous stage. Mufit (2018) presents cognitive conflict for students that needs to be done to obtain the correct concept. On the other hand, there is also augmented reality that is easy for students to use so that a concept can be found.

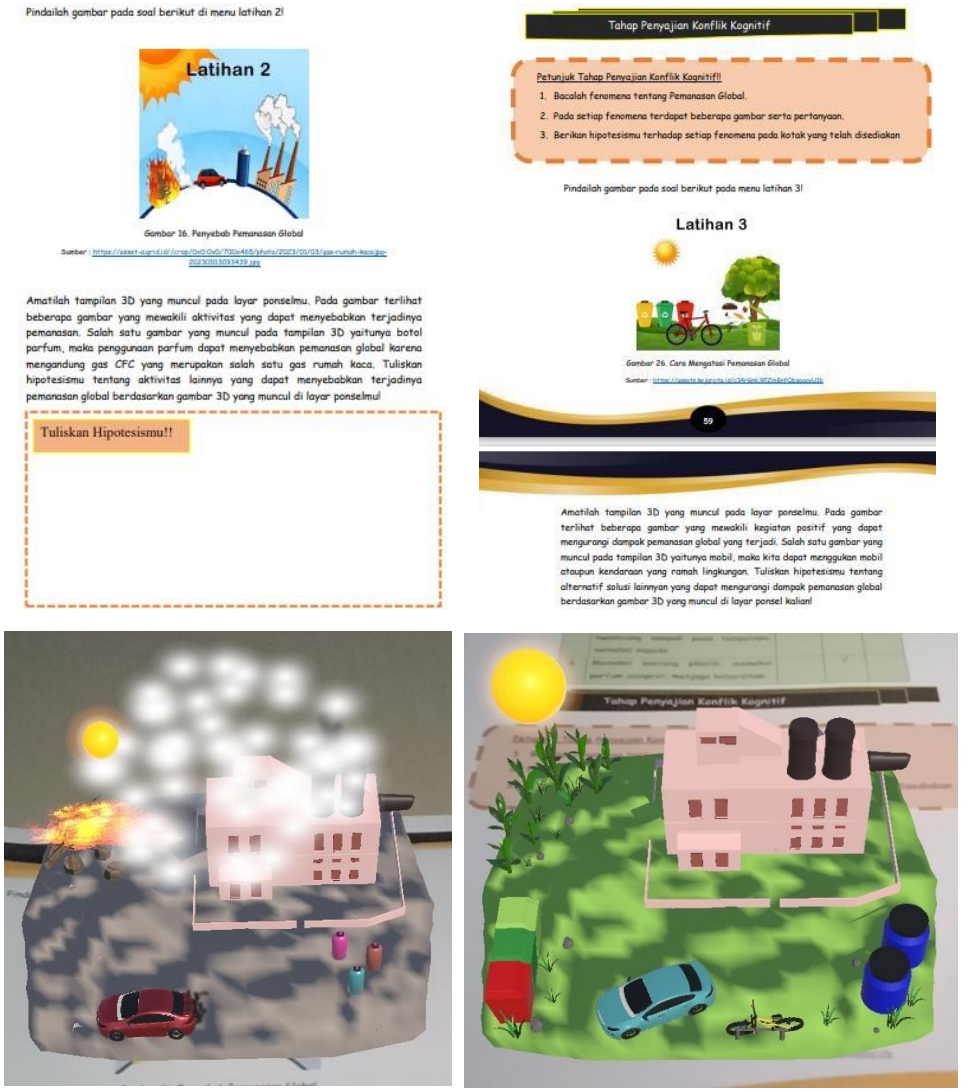

Figure 1. Augmented Reality material display and Augmented Reality 3D display

Figure 1 above is an Augmented Reality material display and Augmented Reality 3D display in the syntax or second stage of the cognitive conflict-based learning model, namely the presentation of cognitive conflicts integrated with augmented reality which aims to trigger cognitive conflicts and then students are given instructions to estimate phenomena by providing hypotheses from the given physics concepts. The 3D display that appears will trigger what problems or events occur so that they can cause conflicts between students' initial concepts. The cognitive conflicts presented here are the causes of global warming (in exercise 2) and how to overcome global warming (in exercise 3). The procedure for doing this is by opening the application according to the exercise menu that is opened and pointing the cell phone towards the image, then the phenomenon will appear on the cell phone screen and can be analysed. Research by Rohmaniyah (2021) explains that students enjoy doing learning activities and analysing through augmented reality.

The second aspect, attractiveness consisting of six indicators. The range of values produced by the six indicators is 83.33 to 100. All attractiveness indicators show very practical criteria with an average of 94.91. This is supported by the attractive cover design of the teaching material because there are events related to global warming on the cover, then the appearance of the teaching materials is very attractive because it is neatly arranged so it is interesting to read, as well as the type of font and the appearance of the illustration images on the teaching material that are already proportional. Then the appearance and 3D images on

the augmented reality application are also attractive when used so that they are not monotonous when learning. This is in line and accordance with Zuwita & Mufit (2023) the appearance of attractive teaching materials will motivate students' interest in learning and also Hanum et al. (2019) practicality refers to the attractiveness of teaching materials used in learning.

The third aspect, efficiency consisting of five indicators. The value of this efficiency indicator is from 88.89 to 100. All indicators of the efficiency of these teaching materials are very practical in terms of efficient learning time, costs of using teaching materials, access to teaching materials can be anywhere, virtual labs supported by barcodes, and augmented reality already has markers that can be scanned so that teaching materials are very efficient for students to use in learning. This is also the same as the research of Mufit et al**.** (2025) with augmented reality providing efficient support in learning without time and place limitations. In Fadhilah's research (2020) it was found that cognitive conflict-based teaching materials using the virtual lab that they developed were also in the very practical criteria in the efficiency component.

The last or fourth aspect, benefits which also consist of five indicators. The results of the five indicators in the benefits component show a range from 88.89 to 97.22. All indicators in this component are categorized as very practical with an average practicality value of the benefits component of this teaching material of 94.99 with a very practical criterion. The benefit indicators in this teaching material are categorized as very practical because this teaching material makes it easier for students to learn independently, has the potential to facilitate understanding and improve conceptual understanding, training cooperation in learning and augmented reality also has the ability to construct conceptual understanding. Mufit & Fauzan (2019) explained that the best way to build students' conceptual understanding is taught by using a cognitive conflict-based learning model, and by involving students in actively discovering concepts and equations. The discovery of concepts and equations carried out directly by students will stick in students' minds and memories longer. Students conduct realistic greenhouse effect experiments and the images displayed from the augmented reality global warming application can be directly observed and will be easier to understand. Incorporating the use of technology into teaching materials can be a fun activity for students. Considering the many benefits of this teaching material, the researcher recommends that further researchers test its effectiveness.

CONCLUSION

The conclusion of this study is that the average overall practicality of cognitive conflict-based learning materials integrated with augmented reality in global warming learning is 93.58, which means it is very practical. This study tested four aspects, namely ease of use, attractiveness, efficiency and benefits with an average of each aspect in sequence of 91.66; 94.91; 92.78; and 94.99 with the criteria of very practical. Although there are weaknesses in terms of using augmented reality applications that can only be accessed with Android phones. Furthermore, other researchers can test the effectiveness of global warming cognitive conflict-based teaching materials integrated with augmented reality on students' conceptual understanding.

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