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Implementation E-Module on Anthropogenic Climate Change To Enhance Creative Thinking Skills

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Abstract: This study aims to develop an e-module on anthropogenic climate change to enhance students' creative thinking skills. This research is a Research and Development (R&D), using the ADDIE development model. The research was conducted at MAN Tolitoli, taking 28 students each from the experimental class and the control class as comparators in this study. The results of the Cohen's effect size analysis yielded 0.48, categorised as medium, and there was also a significant increase in creative thinking skills in the experimental class, which improved from the category of fairly skilled to skilled and even very skilled in each session. Additionally, there was an improvement in the posttest results of the students in the experimental class.

Keywords: Anthropogenic climate change; Creative thinking skill; E-module

Introduction

The era of Society 5.0 demands that the education sector adapt to the acceleration of knowledge and technology that can change in an instant (Jiyanto et al., 2024). 21st-century learning is the type of education that must be prepared for 21st-century learners, enabling them to keep pace with the changing times. 21st-century learning requires education that refers to life contexts regarding a problem or event (Astuti, 2024). 21st-century skills that must be honed in the learning process (Rochmah, 2023) then we called with the term 6C (critical thinking, creativity, collaboration, communication, character, and citizenship (Akcanca, 2020). Critical thinking and creativity are two of these skill that may be cultivated through problem solving (Perez & Andrade, 2023).

Creativity isn't only about describing imagination or the future, but also the ability to innovate an existing fact and to make a difference in an ongoing process (Johansson, 2020). According to Guilford, creative thinking skill is the fundamental skill that needs to be internalized to train students' flexibility, fluency, originality, and elaboration (Mulyati et al., 2021).

Based on data from the Trends in International Mathematics and Science Study (TIMSS) in 2011 and the Program for International Student Assessment (PISA) in 2012, the creative thinking skills of students in Indonesia remain low (Suharno et al., 2022). As one of the branches of natural science, physics can be applied to the module with the Problem-Based Learning Model, which will have a good impact. Because it requires the students to skillfully apply the concept and principles of science, also focusing on the analysis aspect, which is included in HOTS, especially critical thinking about phenomena and creative thinking in solving problems. It will be good to apply in Indonesia, which prioritizes providing 21st-century skills (Bao & Koenig, 2019).

So the researcher is interested in developing an e-module to enhance students' creative thinking skills. By

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using Google Sites as a platform, combining PBL as a learning model, and incorporating contextual digital materials and content that can adapt to the surrounding environment of the learners, the learning becomes more meaningful. Anthropogenic climate change was chosen as the subject in the development of this e-module because environmental issues have increasingly become a major concern in recent years (Bogert et al., 2024). Ecological damage due to carbon emissions from various industrial activities and daily activities has caused an increase in Earth's temperature, which is then known as global warming (Zikra et al., 2025). Contents on anthropogenic climate change can be integrated into the chapter on global warming (symptoms and solutions) in Chapter VII of the 10th-grade Science subject, specifically in the Physics sub-subject (Puspaningsih et al., 2021).

Method

This research was conducted at MAN Tolitoli with a population of 10th-grade students and a sample of 28 students in the experimental class and 28 students in the control class. The type of this research is Research and Development (R&D) using the ADDIE development model and has five (5) phases called analysis, Design, Development, Implementation, and evaluation (Anwar et al., 2024). This model is widely chosen in educational research because it is considered more valid since the evaluation stages can be conducted at each phase, but it requires more time (Waruwu, 2024).

Figure 1. Model ADDIE

The first phase, called the analysis phase, its conducted on four components, namely needs analysis, material analysis, learner analysis, and learning objectives analysis. This aims to determine how the e-module on anthropogenic climate change should be designed. This analysis was conducted through direct observation, interviews with several subject teachers and students, as well as a literature study related to the currently used curriculum. At this phase, a pre-test is conducted, the results of which will be used as initial data to assess the creativity of the experimental and control classes. The criteria of creative thinking skills are interpreted in Table 1 (Derniati et al., 2022).

Table 1. Criteria of Creative Thinking Skill

Percentage	Criteria
81% - 100%	Very Skilled
61% -80%	Skilled
41% - 60%	Quite Skilled
21% - 40%	Less Skilled
0% - 20%	Very Poorly Skilled

The second phase is design. At this stage, the initial design of the e-module on anthropogenic climate change is prepared based on the analysis results from the previous stage. It begins with drafting the learning plan, module, teaching materials, and several supporting instruments such as questionnaires to test the validity, practicality, and effectiveness of the e-module. Then the module design is entered into the Google Site layout, resulting in the e-module product I.

The third phase is development. At this stage, the e-module on anthropogenic climate change product I is validated by experts for necessary revisions if it does not align with the content and media included. The development phase also involves the validation of supporting instruments, such as practicality questionnaires for students and teachers, and tests with rubrics for assessing creative and critical thinking skills. After validation and revision, product II is produced, ready to be implemented in the next stage. The validity data of the anthropogenic climate change E-module is obtained from validation data by experts using a validation sheet instrument that can be analyzed using the formula:

$$V_{ah} = \frac{T_{se}}{T_{sh}} \, x \, 100\% \quad (1)$$

To interpret the measurement results, the validation criteria presented in the Table are used (Jannah et al., 2022).

Table 2. Valid Criteria

Presentation	Validation Level	Criteria
85.01% -100%	Very valid	Can be used without revision
70.01% - 85.00%	Valid	Can be used with slight revisions
50.01% -70.00%	Less Valid	It is advised not to use it because it needs major revisions.
0% - 50.00%	Invalid	Cannot be used

The analysis of the practicality of the module product is based on the results of teachers' and students' response questionnaires. The data on the implementation of learning is analyzed for practicality using the formula (Sarip et al., 2022):

$$\text{Percentation} = \frac{\text{Score obtained}}{\text{Score maximum}} \text{ x } 100\% \quad (2)$$

To interpret the results can be interpreted in the practicality criteria presented in the Table.

Table 3. Practical Criteria

Percentage	Criteria
80% - 100%	Very Practical
60% - 79%	Practical
40% - 59%	Less Practical
20% - 35%	Not Practical
0% - 19%	Very not practical

The fourth phase is Implementation. At this stage, a trial of the anthropogenic climate change e-module was conducted in the experimental class consisting of 28 students, and a control class as a comparison learning without using the anthropogenic climate change e-module was also conducted over four face-to-face sessions. After conducting the learning process, a post-test was administered to assess the improvement in students' creative and critical thinking skills, which will be compared using Cohen's effect size to determine the magnitude of the effect between the experimental class and the control class. The formula for Cohen's effect size is used (Wisic & Makiyah, 2021).

$$d = \frac{Ma - Mb}{SD} \quad (3)$$

To interpret the effect size value results, the interpretation is used according to Table 4.

Table 4. Interpretation of Effect size Cohen's

Value Effect Size	Interpretation
0.2	small
0.5	medium
0.8	Large

The fifth phase of the ADDIE learning model is evaluation. At this point, evaluation can be carried out at each stage to modify the created e-module product to satisfy the learning goal.

Result and Discussion

The results of this study aim to develop the e-module of anthropogenic climate change to enhance creative thinking skills. There are four indicators of creative thinking: fluency. Flexibility, originally, and elaborate (Muqodas, 2015).

The presentation of results and discussion will be presented based on stage ADDIE development model. Analyze, Based on the results of observations and interviews with students and several physics teachers, it can be concluded that the majority of students do not yet possess creative thinking skills, especially in generating numerous and diverse ideas and in elaborating on ideas. Specifically about the content of anthropogenic climate change integrated with the global warming material in the Physics sub-subject of Natural Sciences. This is evidenced by the results of the students' pretest, which can be seen in the graph in Figure 2.

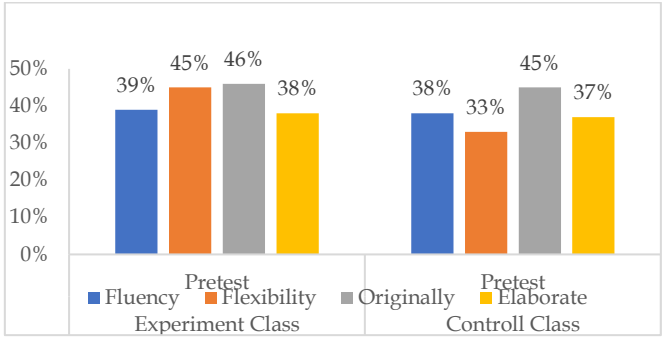

Figure 2. Pretest comparison of creative thinking skills

Based on Figure 2, which displays the percentage of pretest scores for the creative thinking skills indicators of students in the experimental class. The Fluency indicator in the experimental class is 39% and in the control class is 38%, Flexibility is 45% in the experimental class and 33% in the control class, Originality is 46% in the experimental class and 45% in the control class, and Elaborate is 38% in the experimental class and 37% in the control class. Thus, it can be concluded that the creative thinking skills of the sample in the experimental and control classes fall into the category of quite skilled. Based on the data, it can also be concluded that students need an e-module on anthropogenic climate change to enhance their creative thinking skills.

Design; In this design phase, the process begins with developing a learning plan, creating learning modules, and supporting instruments such as teacher and student practicality questionnaires, effectiveness tests for students' creative thinking skills, and validity tests for the anthropogenic climate change e-module. After completing the module preparation, the next step is to design the layout on Google Sites according to the content and appropriate media, resulting in Product I, which is ready to be validated and developed in the next stage before being implemented with the students.

Development; Product I the e-module anthropogenic climate change that has been designed

and the supporting instruments that have been prepared in the previous stage, were then validated by experts to ensure that the e-module to be designed meets the needs analyzed in the design stage and that the instruments used can measure the validity, practicality, and effectiveness of the e-module. The validator suggests changes to the systematics of the e-module product I, as the initial design is considered inefficient because too many buttons that need to be pressed before accessing the various sections of the e-module. It is also recommended to replace some of the content and media in the module so that it is more contextual and closer to the students' environment. Then the revision was carried out and produced product II as shown in Figure 3.

(a) (b)

Figure 3. Design E-module anthropogenic climate change before (Product I) and after (Product II) development. (a) Product I e-module anthropogenic climate change; (b) Product II e-module anthropogenic climate change

In addition to making changes to the e-module design, the validation of students' creative thinking skills tests was also carried out and revisions were recommended as shown in Table 5.

The e-module on anthropogenic climate change is validated with two aspects, namely content validation and media validation, to ensure that the e-module truly considers the relationship between the learning objectives of the material and the content/media used, and must genuinely be able to enhance creative thinking skills. The results of the expert validation reached the very valid category with a percentage of 96% for media expert validation and 93% for material expert validation.

Table 5. Development of Creative Thinking Skill Assessment

Skill Indicators	Learning Objective	Product I	Product 2
Creative Thinking Skill (Elaborate)	The students can elaborate on the stage of green greenhouse effect	Explain the causes of the greenhouse effect!	Describe the causes of the greenhouse effect

Implementation, after the anthropogenic climate change e-module and all its supporting instruments have been revised and developed as necessary, all research tools are ready to be implemented and tested on the students. The goal is to observe the improvement in students' skills during the learning process over four meetings, and a posttest will also be conducted for the students, which will then be analysed using Cohen's effect size to determine the magnitude of the effect and the interpretation of the use of the e-module on the improvement of students' creative thinking skills.

The improvement in students' creative thinking skills at each meeting can be seen in Figure 4.

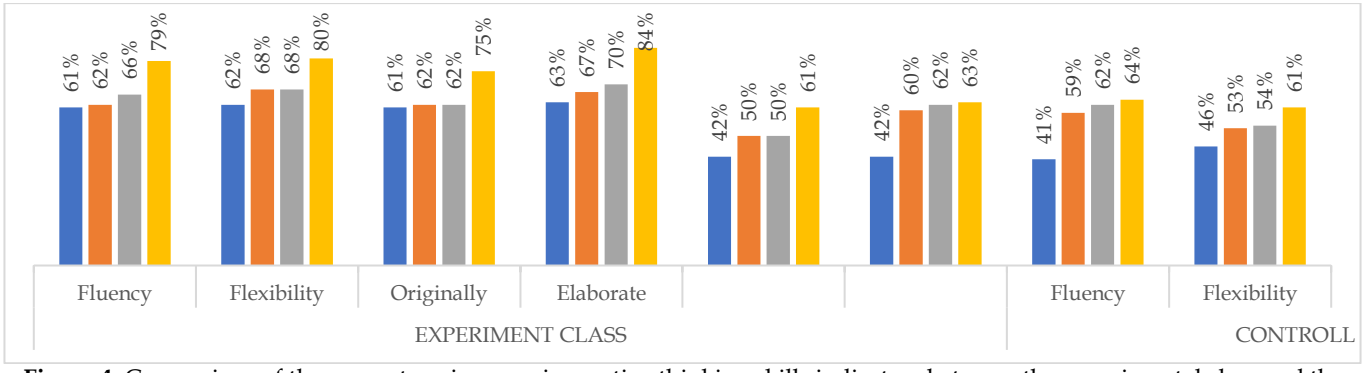

Figure 4. Comparison of the percentage increase in creative thinking skills indicators between the experimental class and the control class

Based on the graph in Figure 4, it can be seen that a significant improvement in students' creative thinking skills is found in the experimental class that uses the anthropogenic climate change e-module, resulting in the skill criteria increasing to proficient and highly proficient.

Besides that, there is also a stark difference in the posttest results between the experimental class and the control class, as shown in Figure 5.

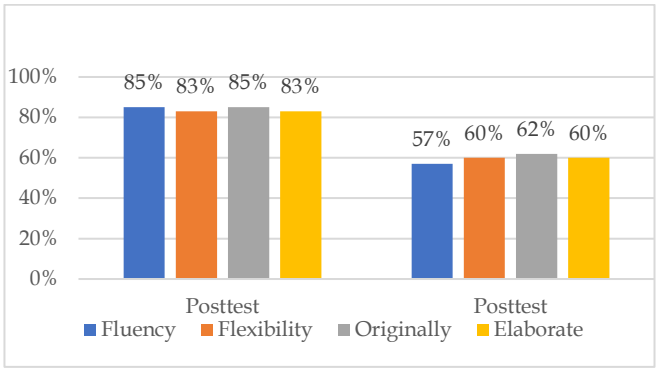

Figure 5. Comparison of the percentage posttest creative thinking skills indicators between the experimental class and the control class

The effect size of using the e-module on anthropogenic climate change to enhance students' creative thinking skills is 0.48, which falls under the moderate effect category. The effect size test data can be seen in Table 6.

Table 6. Effect Size Test

Description	Experiment Class	Control Class
Mean	79.00	82.74
Standard Deviation	14.57	3.49
SD Pooled		112.21
Cohen's d		0.48
Effect Size Category		Moderate

Evaluation; The evaluation results serve as a feedback mechanism. If there is a discrepancy between the development outcomes and the established goals in the evaluation, the evaluation results allow for revisions (Teibang, 2025). Furthermore, the evaluation becomes the basis for continuous improvement; thus, the e-module on anthropogenic climate change aims to enhance students' creative and critical thinking skills.

During the development process, continuous evaluations are conducted to achieve an e-module that meets the expected goal of enhancing students' creative thinking skills. The evaluations carried out during the research process include replacing several questions that do not align with the learning outcomes established in the analysis stage, ensuring that the use of gadgets during learning is accompanied by more active supervision from teachers, and adding project assignments that are deemed to enhance students' creative thinking skills.

Conclusion

The implementation of the anthropogenic climate change e-module has a significant impact on students' creative thinking skills, as seen from the effect size test results, which also fall into the moderate category. Students' creativity also increased during the use of the learning nature e-module, moving from the fairly skilled category to the skilled category. This indicates a change in students' thinking abilities in a more positive direction. This indicates that the anthropogenic climate change e-module can be used to enhance students' creative thinking skills.

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Author Contributions

All the authors in this article contributed to this research, with M as the conceptualization and the research executor, D as the methodology advisor of the research, S.S as the guide in writing and drafting, and U.W and S.R as validators who helped develop the e-module into a ready-to-use and beneficial product in the field of research.

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Conflicts of Interest

In this study all authors do not have a conflict of interest, because this research is an independent research in which all funds spent during the research process use the researcher's personal funds. There are no other interests in this research, but researchers only want to contribute to advancing education by informing the findings in this research. So that it can provide more benefits to the reader.

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