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Development of an interactive digital physics module (IDPM) on the concept of global warming to improve students' Problem-Solving Skills (PSS)

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ABSTRACT

Problem Solving Skills are very important skills in life because they help students find creative and innovative solutions to various complex problems. In addition, global warming is one of the physics materials studied in the Independent Curriculum phase E. Through learning with the Interactive Digital Physics Module, students can learn scientific principles and concepts to solve problems. However, so far physics learning has been more focused on physics products, while aspects of the scientific process and attitude that should be trained are often neglected. The purpose of this study was to develop an interactive digital physics module on the concept of global warming to improve students' PSS. This research method uses the ADDIE model with a sample size of 37 in one of the schools in Banten Province, Indonesia. The results showed that the characteristics of the IDMP on the concept of global warming can improve students' PSS tests consisting of indicators Defining problems clearly increased by 0.71, Making action plans increased by 0.72, indicators Implementing plans effectively increased by 0.63 and indicators Assessing and reflecting on results increased by 0.65 categories. The N-gain results of the four indicators were 0.69, meaning that students' PSS increased in the moderate category.

Keywords : Digital Module; Global warming; Media; Physics; Problem Solving Skills .

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INTRODUCTION

Universities need to develop a perspective and train the mindset of the academic community in preparing their graduates to face the challenges of the industrial revolution 5.0. One of the challenges is problem solving skills which require learning outcomes in aspects of

attitudes and values, knowledge and skills according to Graduate Learning Outcomes (CPL) (Desmet, 2024; Mutohhari et al., 2021). CPL master's degree in physics education is the ability to apply areas of expertise and utilize science and technology (Deta et al., 2024; Grayson, 2020). Physics is the key to uncovering the Global Warming phenomenon. Concepts such as the greenhouse effect, radiation, and albedo help to understand the processes and impacts of this phenomenon. This knowledge is essential in formulating appropriate solutions and policies to overcome them. Innovative and interactive learning media is present as a solution to help students and the public understand physics concepts related to Global Warming (Ngodu et al., 2024). Simulations, animations are able to visualize complex processes and increase participation in learning.

Other facts show that based on the results of learning observations conducted by researchers in several secondary schools in Jakarta and Tangerang involving 30 students, it was found that 85% of students did not know the causes of global mobilization, 73% of students could not mention the effects of global warming correctly and 50% of students did not understand. Actions that must be taken to reduce global warming. This is supported by data regarding Problem Solving Skills (PSS) which has indicators such as realizing that there is a problem situation, building an understanding of the nature of the situation, identifying specific problems that must be solved, planning solutions, implementing solutions. Based on the test results, 19 students or 47.5% got a score of 0-54 in the very low category, 15 students or 37.5% got a score of 55-64 in the low category, 4 students or 10% got a score of 65-79 in the medium category. , and 2 students or 5% got a score of 80-89 in the high category (Fajrin et al., 2024).

When compared to printed modules, interactive digital modules make it easier for users to interact and be active, such as actively paying attention to images, sounds, animations, even videos and films (Pyo et al., 2021; Yang et al., 2021). Digital modules take the form of simulations and animations that can arouse enthusiasm and have high graphic value in their presentation (Feri & Zulherman Z, 2021). Interactive learning modules on basic physics and mathematics concepts are online learning modules that are useful in encouraging student learning and readiness (Rahmatsyah & Dwiningsih K, 2021). The Digital Module trains critical thinking skills, there are learning videos which have a significant impact on improving students' understanding of learning (Febliza et al., 2023). Digital modules on vector concepts (F. Wibowo et al., 2023)and a module called MyKimDG which was developed to improve conceptual understanding and development of 21st century skills in the field of chemistry (Osman & Lay, 2022)and digital modules in the field of engineering education(Nopriana et al., 2023)

However, many digital modules have been developed for science learning, such as digital modules with Blended learning (Laskaris et al., 2017); Chemistry Magazine's Digital Chemistry Module on Kvisoft Flipbook Maker states that this module can improve understanding (Linda et al., 2018); PSS to practice HOTS learning strategies (Retnawati et al., 2018); Social development (Kivunja, 2014); Sustainability of 21st-century skills (Szabo et al., 2020); Problem-solving skills through RICOSRE (Mahanal et al., 2022); School chemistry course (Yu et al., 2023); School learning environment (Karamustafaoğlu & Pektaş, 2023). Digital modules make learning material more interesting (Saphira et al., 2023). The Digital Module using professional pdf flip on temperature and heat material was declared to have

obtained very good scores in expert validation tests as well as student and teacher trials (Rahman et al., 2023). However, there have not been many research results that have developed digital modules to train problem solving skills and specifically the concept of global warming.

Global warming is like a monster that secretly threatens the earth, its impacts are increasingly felt, such as extreme weather, natural disasters and water crises, which endanger the future of the planet (Tran, 2023). In the midst of this situation, digital learning media is absolutely necessary as an oasis to increase public awareness and understanding. Apart from that, problem solving skills are one of the essential abilities in this digital era. This ability allows individuals to deal with complex situations, analyze information, and find creative solutions. Digital learning media exists as an innovative solution to improve problem solving skills at various levels of education. Based on this, it is deemed urgent or important to develop Interactive Digital Media Physics Modules on the Concept of Global Warming to improve students' Problem Solving Skills. The problem formulation in this research is How to Develop an Interactive Digital Physics Module (IDMP) on the Concept of Global Warming to improve Students' Problem Solving Skills.

RESEARCH METHODS

This research method uses the ADDIE model with a sample size of 37 consisting of 10 men and 27 women for the problem solving skills of students in one of the schools in Banten Province, Indonesia. The explanation of the ADDIE model can be seen in Figure 1.

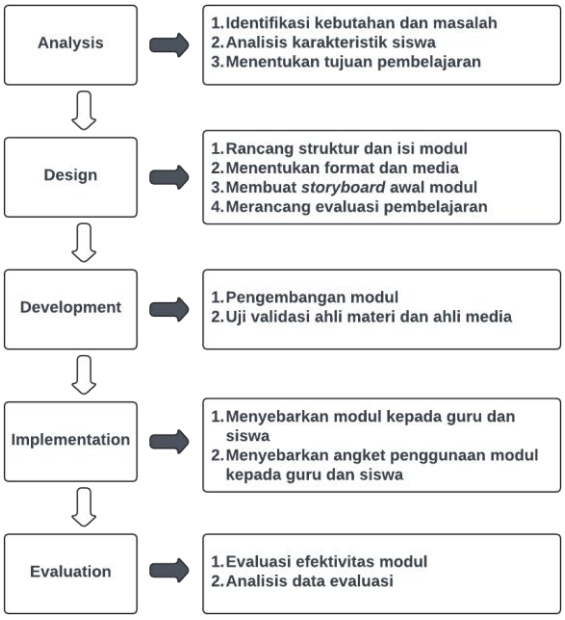

Figure 1 Chart of the ADDIE model

The data collection instruments used were teacher and student needs questionnaires, expert validation, and teacher and student test questionnaires. The data analysis techniques used in this research are expert validity test, question validity, question reliability and normalized gain test. The validity test data analysis used is by changing the qualitative assessment with the guidelines in Table 1 below.

Table 1 Rating scale criteria

No	Criteria	Score
1	Strongly agree	5
2	Agree	4
3	Doubtful	3
4	Don't agree	2
5	Strongly Disagree	1

The validity test results are calculated in the following way:

$$Persentase\ skor = \frac{\sum skor\ perolehan}{\sum skor\ maksimum} x\ 100\% \quad (1)$$

The percentage of scores obtained is then measured using a Likert scale interpretation for the value scale. The Likert scale interpretation guide can be seen in Table 2 below.

Table 2 Interpretation of likert scale

Percentage	Interpretation
0%-20%	Very Not Good
21%-40%	Not good
41%-60%	Enough
61%-80%	Good
81%-100%	Very good

The research is considered successful if the questionnaire data that has been processed obtains a score of between 61% to 100%, or the interpretation of "Good" and "Very Good".

If the interactive digital physics module (IDMP) on the global warming concept is said to be feasible, then the next stage is to carry out limited trials. Limited trials will be analyzed using the normalized gain test. The normalized gain test was carried out to provide a general picture of the increase in learning outcomes before and after learning. The amount of improvement before and after learning is calculated using the normalized gain formula *as* follows:

$$< g > = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score} \quad (2)$$

The normalized gain categories (g) are as follows:

Table 3 Interpretation of normalized gain

Normalized Gain Value	Interpretation
$-1{,}00 \leq 0{,}00$	There was a decline
g = 0.00	No increase occurred
$0{,}00 < g < 0{,}30$	Low
$0{,}30 \leq g \leq 0{,}70$	Currently
$0{,}70 \leq g \leq 1{,}00$	Tall

RESULTS AND DISCUSSION

1. Validation by Experts

This research produces an interactive digital physics module (IDMP) product on the concept of global warming. The interactive digital physics module (IDMP) on the concept of global warming was developed by analyzing the independent curriculum, physics learning achievements in Phase E, developing concepts, and evaluation to improve problem solving skills. The characteristics of the interactive digital physics module (IDMP) on the concept of global warming consist of the module title, physics learning outcomes, learning objectives, understanding problem based learning, the concept of global warming, assessment and self-reflection.

Figure 2 Display of the title of the interactive digital physics module

Figure 3 Display of physics learning achievements

Figure 4 Display of learning objectives and understanding problem based learning

Figure 5 View of the global warming concept

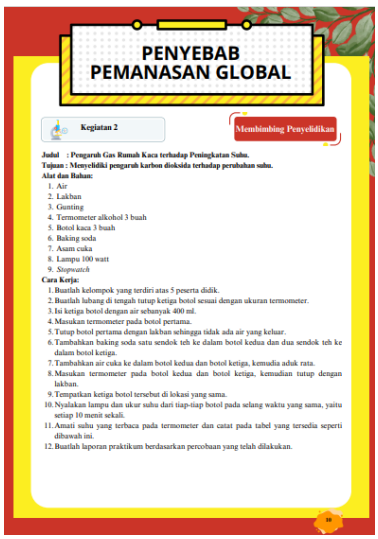

Figure 6 Practical view of the concept of causes of global warming

Figure 7 Display of summative assessment

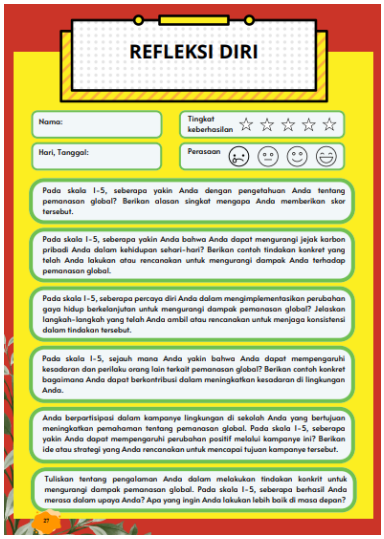

Figure 8 Student self-reflection display

The interactive digital physics module (IDMP) on the global warming concept was validated by media experts and material experts by 3 expert validators. In the media validation test, the instrument given contains 12 questions from 3 aspects of media suitability, namely the use of modules and attractiveness, images and letters, as well as design composition and layout. The validation results by media experts can be seen in Table 4 below.

Table 4 Media expert validation results

No.	Media Feasibility Aspects	Percentage	Interpretation
1.	Module Usage and Attraction	85%	Very good
2.	Images and Letters	80%	Good
3.	Design Composition and Layout	90%	Very good
	Average of All Aspects	85%	Very good

Meanwhile, in the validation test the instrument material provided contained 23

questions from 4 aspects of material suitability, namely content suitability, presentation suitability of problem based learning based modules on the global warming sub-material, independent learning, and language suitability. The validation results by material experts can be seen in Table 5 below.

Table 5 Validation results by material experts

No.	Media Feasibility Aspects	Percentage	Interpretation
1.	Eligibility of content	86%	Very good
2.	Feasibility of presenting problem based learning based modules on the global warming sub-material	81%	Good
3.	Learn to be independent	87%	Very good
4.	Language eligibility	85%	Very good
Average of All Aspects		85%	Very good

The results in Table 4 and Table 5 show that overall the average results from the 3 validators, media experts and material experts, obtained a percentage value of 85% with very good interpretation for both. If the validation results get a percentage value of 61% - 100%, research and development is considered successful (Sugiyono, 2013). So, it can be concluded that the interactive digital physics module (IDMP) on the concept of global warming is suitable for use as a learning medium (Basri & Akhmad, 2022).

After validation by experts, the next stage was a limited trial carried out by 37 class X students and 3 Physics subject teachers. A limited trial was carried out to find out students' opinions and evaluations regarding the interactive digital physics module (IDMP) on the concept of global warming whether it needed improvement or not. Limited student trials were carried out using Google Form, where the questionnaire contained 19 questions from 4 aspects, namely appropriateness of content, presentation, independent learning, and linguistics. Meanwhile, for the limited trial the teacher asked 22 questions from 4 aspects, namely appropriateness of content, presentation, independent learning and language. The results of responses from students and teachers are as follows.

Table 6 Results of student responses to the interactive digital physics module

No.	Media Feasibility Aspects	Percentage	Interpretation
1.	Eligibility of content	85%	Very good
2.	Presentation	87%	Very good
3.	Learn to be independent	90%	Very good
4.	Language eligibility	87%	Very good
Average of All Aspects		87.3%	Very good

Table 7 Results of student responses to the interactive digital physics module

No.	Media Feasibility Aspects	Percentage	Interpretation

1.	Eligibility of content	90%	Very good
2.	Presentation	88%	Very good
3.	Learn to be independent	92%	Very good
4.	Language eligibility	90%	Very good
	Average of All Aspects	90%	Very good

The results in Table 6 and Table 7 show that students' responses after using the interactive digital physics module (IDMP) on the concept of global warming, on average, all aspects received a percentage score of 87.3% with a very good interpretation. Meanwhile, the teacher's response after using the interactive digital physics module (IDMP) on the concept of global warming was that on average all aspects received a percentage score of 90% with very good interpretation. So, it can be concluded that the interactive digital physics module (IDMP) on the concept of global warming is suitable for use as physics learning material in schools (Pahlawan, 2021).

2. Problem Solving Skills

The field trial aims to see improvements in problem solving skills before and after using the interactive digital physics module (IDMP) product on the concept of global warming . The field trial was carried out by 37 students consisting of 10 men and 27 women at a school in Banten Province. The field trial was carried out by giving a pretest and posttest containing 8 questions consisting of 4 indicators, namely clearly defining the problem , developing a plan of action , effectively implementing the plan , and valuing and reflecting on the outcome . The learning results from the field trials can be seen in Table 8.

Table 8 Data on student learning results

Pretest Average Score	Posttest Average Score	N-Gain	Category
31	79	0.69	Currently

Student learning results show that the average pretest score before using the interactive digital physics module (IDMP) on the concept of global warming is 31 and the posttest score after using the interactive digital physics module (IDMP) on the concept of global warming is 79. This means that there is an increase in the results student learning. This can be seen from the N-Gain results which got a value of 0.69 with a moderate interpretation. The N-Gain results for each sub-indicator of problem solving skills can be seen in the following graph.

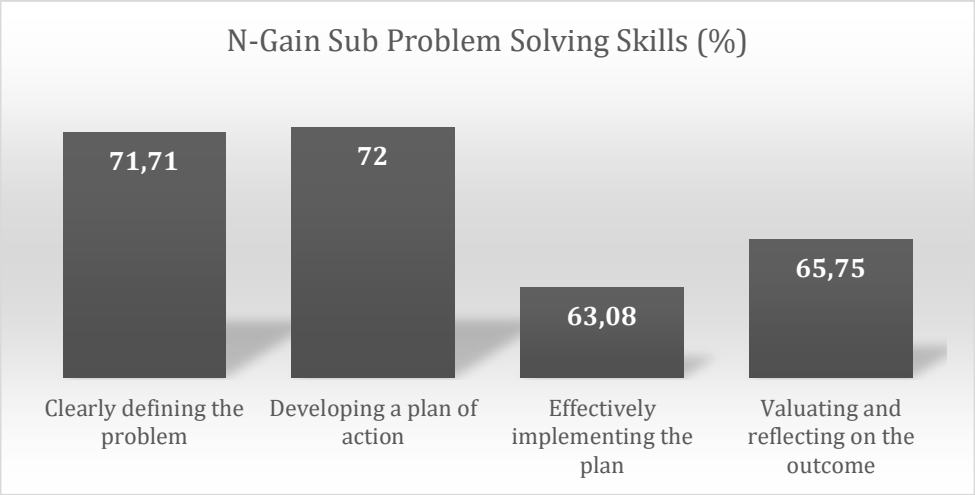

Figure 9 Results of N-Gain sub indicator of problem solving skills

The graph above is the N-Gain result for each sub-indicator of problem solving skills. The clearly defining the problem indicator gets a percentage value of 71.71% or 0.71 with high interpretation, the developing a plan of action indicator gets a percentage value of 72% or 0.72 with high interpretation, the effectively implementing the plan indicator gets a percentage value of 63.08% or 0.63 with interpretation moderate, and valuing and reflecting on the outcome got a percentage value of 65.75% or 0.65 with a moderate interpretation. This means that each sub-indicator increases students' problem solving skills. This is in accordance with previous research which states that the use of interactive digital modules in learning can improve problem solving skills and student learning outcomes (Rahma Gita et al., 2022; Zhafirah & Erna, 2021). Apart from that, the use of modules in learning also has many benefits, such as the use of interesting modules can increase students' learning motivation (Suryani et al., 2020), the use of digital modules equipped with simulations or videos is easier to understand and can attract students in learning (Islahiyah et al., 2021), digital modules are more efficient and cost effective (F. C. Wibowo et al., 2023), easy to access (Nurcahyani et al., 2024), and the use of interactive digital modules makes it easier for students to learn independently (Utami et al., 2018).

CONCLUSION

The development of an interactive digital physics module (IDMP) on the concept of global warming to improve students' problem solving skills is suitable for use in physics learning with material expert and media expert validation test results of 85% in the very good category. Apart from that, the interactive digital physics module (IDMP) on the global warming concept which was tested in the field to see the increase in problem solving skills showed an increase in each indicator, such as the clearly defining the problem indicator increased by 0.71, developing a plan of action increased by 0.72, the indicator of effectively implementing the plan increased by 0.63 and the indicator of valuing and reflecting on the outcome increased by 0.65. The average N-gain result from these four indicators is 0.69. This means that students have a moderate level of improvement in problem solving skills .

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