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Development of Integrated Basic Physics Learning E-modules for Natural Disaster Mitigation to Improve Quality Learning

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Abstract: In an era of increasingly frequent natural disasters, integrating disaster mitigation into educational frameworks is crucial. This study addresses the need for innovative teaching materials that not only enhance basic physics understanding but also prepare students for challenges in disaster-prone regions. The research aims to develop a basic physics e-module integrated with disaster mitigation. The goal is to improve students' knowledge of physics and disaster preparedness, particularly in areas like Central Sulawesi. Using a Research and Development (R&D) approach with the ADDIE model, the study's findings show expert validators gave an average score above 4.00, lecturers rated the course 4.67, and there was an improvement in learning outcomes, with CI values ranging from 6.74 to 8.39 and an effect size (Cohen's d) of 4.17. The research concludes that e-modules can effectively enhance learning quality and disaster preparedness.

Keywords: Basic physical course; E-modul; Natural disaster mitigation

Introduction

Indonesia is a country with a high risk of natural disasters. Central Sulawesi is one of the provinces that often experiences natural disasters, especially the city of Palu. The worst natural disaster ever occurred on September 28 2018, namely an earthquake with a magnitude of 7.4 followed by a tsunami and liquefaction which resulted in 4,340 deaths and disappearances, 172 thousand people were displaced and more than 68 thousand houses were damaged (Damayanti et al., 2021). Low public knowledge and understanding of the physics and mitigation of natural disasters is one of the factors that worsens the impact of disasters. Therefore, community preparedness for disasters is very necessary to survive in disaster-prone areas (Yani & Wahyono, 2020; Sumarmi et al., 2021; Wahyono et al., 2022).

Physics education in universities has an important role in increasing students' knowledge and understanding of physics and natural disaster mitigation (Arif & Syaflita, 2018; Sasma & Fauzi, 2020; Fadilah, 2021). However, physics learning in universities currently still uses traditional methods that are less interesting and interactive (Mendari & Kewal, 2016). This causes students' low learning motivation and their lack of ability to solve physics problems related to natural disasters.

Integrated basic physics learning e-modules for natural disaster mitigation can be a solution to overcome these problems. E-modules that are packaged in an interesting and interactive way can increase students' learning motivation (Hasanah et al., 2017; Sulmeni & Walanda, 2020; Walanda et al., 2022), and help them understand physics concepts better easy (Suprayekti & Hirmana Kustandi, 2016; Puspitasari, 2019; Darma et al., 2019). Apart from that, e-modules can be equipped with simulations and animations that help students visualize natural phenomena and understand the process of natural disasters (Sumarmi et al., 2021). So it can train students to analyze physics problems in depth (Haspen

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& Syafriani, 2022), identify relevant variables, and apply appropriate physics concepts and principles to find creative and effective solutions (Afriyanti, 2021). It also encourages students to evaluate information and data critically, distinguish fact from opinion, and construct logical arguments in the context of physics. E-modules present various questions and assignments that challenge students to think outside the box, generate new ideas, and apply physics concepts in unfamiliar situations, helping students to communicate physics ideas effectively, both orally and in writing (Sunaryo, 2020; Sasma & Fauzi, 2020; Mukarrama, 2021). Thus making physics learning more interesting, motivating and improving student learning outcomes.

Method

This research uses a Research and Development (R&D) approach with the ADDIE model, which consists of five stages (Branch, 2009): Analysis, Design, Development, Implementation, and Evaluation. Research location at Tadulako University, Palu. The time for conducting the research is the odd semester 2024/2025. The research sample was students who were taking basic physics courses. The e-module created discusses the concept of elasticity and the concept of waves, which are integrated with natural disaster mitigation in the form of earthquakes, tsunamis, liquefaction and landslides. At the analysis stage, researchers carried out student needs analysis and curriculum analysis.

The design stage consists of: media selection, e-module format selection, expert validation sheets, and preparation of pre-tests and post-tests. At the development stage, the e-module that has been created is then validated by 3 experts (1 internal validator and 2 external validators). The research instrument used was a validation sheet using a 5 Likert scale. The data analysis technique in the expert validation step is as follows (Sugiyono, 2015):

$$V_a = \frac{\sum_{i=1}^{n} A_i}{n} \quad (1)$$

After the effectiveness score of the e-module was obtained and verified, the e-module was then tested using a small group of lecturers who taught basic physics courses to find out information about the suitability of the e-module for users. In this research, there were 3 lecturers who taught basic physics courses (2 lecturers from the MIPA faculty and 1 lecturer from the FKIP faculty), who were asked to respond to the e-module that had been created.

Then, to test whether there was a change in student learning outcomes after using the e-module, the e-module was tested on MIPA students (as an experimental class) and FKIP students (as a control). After that, students are given a pre-test and post-test.

Result and Discussion

Based on the research that has been carried out, the following results were obtained: At the analysis stage, data was obtained from several previous batch students, that in general lecturers taught using presentation slides, so they needed teaching materials that could increase students' learning motivation. It was then discovered that the basic physics course was a mandatory course and was programmed by several study programs at Tadulako University. Therefore, it is hoped that innovative e-module designs can provide a solution to this problem.

In the design section, the e-module was developed using the Canva and Heyzine platforms, which allows the creation of teaching materials that are visually attractive and easy to access.

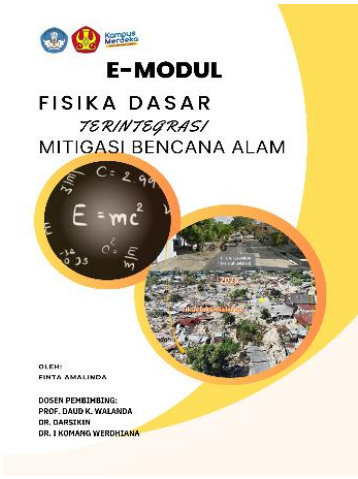


Figure 1. E-module cover design

In the development section, the results of the e-module validation were obtained from the three experts, namely as follows.

Table 1. Media expert validation results

Assessment Aspect	Average	Category
Appearance	4.60	valid
Use	4.27	valid
Technology	4.56	valid
Implementability	4.33	valid
Total average	4.44	valid

Table 2. Material expert validation results

Assessment Aspect	Average	Category
Presentation of Material	4.67	valid
Material Organization	4.83	valid
Language and readability	4.67	valid
Disaster mitigation integration	4.67	valid
Total average	4.71	valid

Table 3. Construction expert validation results

Assessment Aspect	Average	Category
Appearance	4.47	valid
Programming	4.33	valid
Learning	4.20	valid
Total average	4.33	valid

Validation results from experts show that the e-module meets the specified criteria, with an average validity score above 4.00 in all aspects assessed. This indicates that the e-module is not only interesting but also suitable for use in the learning process. Then the validated e-module was assessed by 3 lecturers who taught basic physics courses, and the results were obtained as follows:

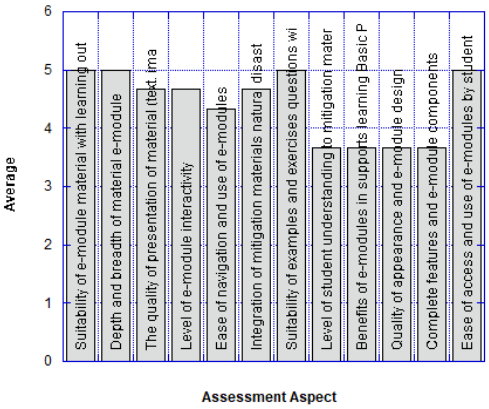
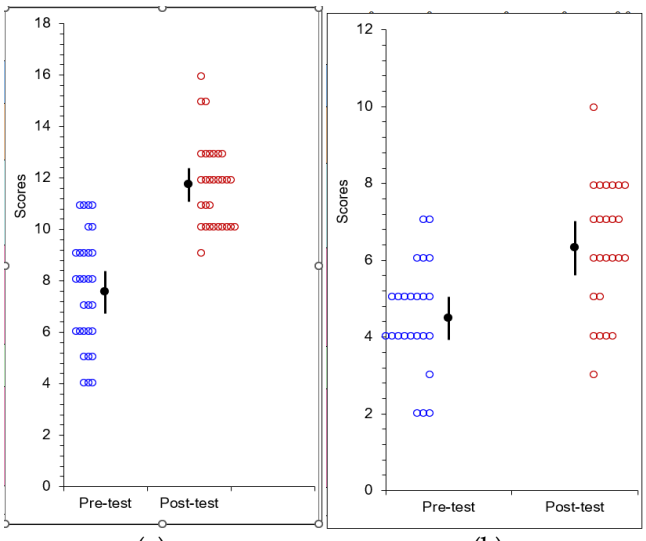


Figure 2. Lecturer's responses to the e-module

Assessment by course lecturers showed a positive response to the e-module. This indicates that the e-module can be integrated into basic physics teaching effectively. Then, to measure changes in student learning, a pre-test and post-test were given, and the following results were obtained:

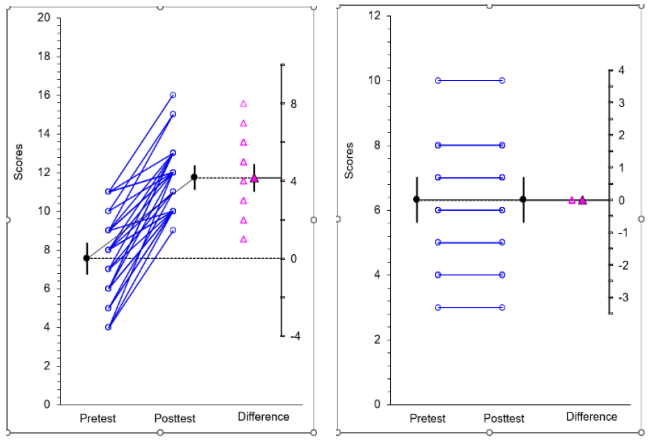


(a) (b)

Figure 3. Distribution of pre-test and post-test scores in (a) experimental class, (b) control class

In terms of measuring the increase in student learning outcomes, in Figure 3 it can be seen that in the experimental class (a) the pre-test score ranged from 4-9 then increased to 9-16 in the post-test (maximum score was 20). It was also found that: the confidence interval (CI) value, at the 95% confidence level, the difference in average scores (Mean of MOE1 and MOE2) between the pre-test and post-test was in the range of 6.74 to 8.39. This CI range is quite wide, indicating that there is quite large variability in the data, so that the estimated mean difference still has quite high uncertainty. And the calculated effect size (Cohen's d) is 4.17. This shows that the intervention provided through e-modules has a huge impact on student learning achievement.

Meanwhile, in the control class (b), the pre-test score ranged from 2-7, then increased to 3-10 (maximum score was 20). This class also experienced an increase in scores, but not too high. This is because this class is not given e-modules. It was also found that: the confidence interval (CI) value, at the 95% confidence level, the difference in average scores (Mean of MOE1 and MOE2) between the pre-test and post-test was in the range of 3.92 to 5.04. This CI range is quite narrow, indicating that the estimated mean difference has relatively small uncertainty. And the calculated effect size (Cohen's d) is 1.84 which shows a large effect between the pre-test and post-test. This means that there is a difference in the average pre-test and post-test scores in the control class even though the e-module was not given.



(a) (b)

Figure 4. Class pair data (a) experiment class, (b) control class

If you look at the pair class data, Figure 4 shows that the experimental class shows that not all participants experienced the same increase in scores, the variation in score increases shows that e-modules can have a significant positive impact on the learning process. for the control class, there was no significant increase in scores from pre-test to post-test.

Conclusion

Based on the research conducted, it can be concluded that the development of e-modules for basic physics courses has shown positive results. Preliminary analysis shows that the commonly used teaching method, namely presentation slides, needs to be improved with more interactive and interesting teaching materials to improve student learning outcomes. Overall, this research shows that the use of integrated basic physics e-modules for natural disaster mitigation can be an innovative solution to improve the quality of basic physics learning, as well as provide a better learning experience for students. Further research is needed to explore the application of e-modules in various courses and other educational contexts.

Author Contributions

F.A; conceptualization and writing original draft, E.D; data curation, D.K.W; supervision, funding acquisition, D; supervision, I.K.W; supervision

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Conflicts of Interest

The authors declare no conflict of interest

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