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Development of interactive e-module based on video and augmented reality for earthquake technology course

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Abstract: The application of augmented reality and video in instructional media is highly suitable for courses in the field of civil engineering, one of which is the Earthquake Technology course. This research employs the Research and Development (R&D) method using the ADDIE model in developing the e-module. The result of this research is a dedicated e-module specifically designed for the Earthquake Technology course. The e-module has been assessed by media experts, subject matter experts, and students as part of the evaluation process. The average scores from the two media experts are 93.33 and 91.33 for graphic feasibility, and 96.67 and 93.33 for language feasibility. As for the two subject matter experts, the average scores for content feasibility are 87.06 and 87.06, for presentation feasibility are 87.50 and 90.00, and for contextual feasibility are 90.00 and 90.00. Meanwhile, the average score from the students during the limited classroom trial is 89.06. The results of this research indicate that the development of the Earthquake Technology e-module using the ADDIE method has resulted in an e-module of "very good" category in terms of media and "good" category in terms of content. The assessment results from students also indicate that the Earthquake Technology e-module falls into the "good" category. So, it can be concluded that the Earthquake Technology e-module based on video and augmented reality can be totally applied in the learning process of Earthquake Technology course at The Civil Engineering Education Program, Universitas Negeri Semarang.

Keywords: Augmented Reality; E-module; Video; Earthquake Technology

1. Introduction

The progress of education in the present era is closely aligned with the Industry 4.0 and Society 5.0 eras. The Industry 4.0 and Society 5.0 eras are characterized by rapid advancements in information and communication technology (ICT), marked by the development of the Internet of Things (IoT) in various fields. These advancements enhance connectivity, drive the development of digital systems, artificial intelligence, and integration between physical and virtual spaces (Nastiti & Ni'mal 'Abdu, 2020).

The optimal utilization of information and communication technology (ICT) advancements is crucial in achieving the learning objectives in higher education, which include successful learning outcomes for students with a high level of understanding of the subject matter (Nurlita et al., 2023). Indeed, one of the efforts to achieve these objectives is by developing interactive e-modules. E-modules are learning media that leverage the advancements in information and communication

technology to enhance efficiency and effectiveness in the learning process. By utilizing e-modules, it is expected that students can have diverse learning experiences that comprehensively enhance cognitive, affective, and psychomotor aspects (Fitriana & Rinaldi, 2021). One concept of e-modules that can be developed is an e-module that combines video and augmented reality.

Augmented reality (AR) is one of the latest technologies that can enhance interactivity and innovation in e-modules. AR combines the real world with 3D virtual objects in real-time and interactive manner through specialized devices (Maulana et al., 2019; Subhashini et al., 2020). The utilization of augmented reality technology can provide real-time visualization to students without the need to leave the classroom (Firdanu et al., 2020; Raharjo & Dinata, 2021; Setiawan & Dani, 2021). Combining augmented reality with video can further enhance the illustration of the material being taught to students. The utilization of augmented reality and video in instructional media is particularly suitable for civil engineering courses. This is because many topics in civil engineering require detailed illustrations to ensure that the material conveyed during lectures is fully understood by students (Kim & Irizarry, 2021; Sumarna et al., 2019; Wei et al., 2021).

The use of augmented reality (AR) in educational media has a significant positive impact on the classroom learning process. This can be observed through increased student interest, engagement, and comprehension of the presented material. Additionally, the use of AR facilitates its implementation within the context of learning (Diao & Shih, 2019; Mubai et al., 2020; Sholeh et al., 2021). In addition to providing positive impacts on student interest, engagement, and comprehension, the implementation of augmented reality (AR) in educational media can also enhance students' critical and creative thinking abilities (Buchner et al., 2022). With AR, students can engage in challenging and interactive learning experiences that encourage them to approach problems and events around them in a more critical and creative manner (Estheriani & Muhid, 2020; Indrawan et al., 2021).

One of the courses in civil engineering at the Civil Engineering Education Program, Universitas Negeri Semarang, that can implement video and augmented reality-based e-modules is the Earthquake Technology course. The integration of videos and augmented reality can provide real-life illustrations to students regarding the topics covered in the Earthquake Technology course, aiming to enhance their understanding of these subjects in a detailed and comprehensive manner. The objective of this research is to develop a video and augmented reality-based E-module for the Earthquake Technology course, as well as to assess the response of media experts, subject matter experts, and students regarding the design and content of the E-module. This research is worth doing because there are no previous researchers who have conducted research on the development of e-module based on Video and Augmented Reality in the Earthquake Technology course in The Civil Engineering Education Program, Universitas Negeri Semarang. Besides that there are also no previous researchers who have conducted research on the development of e-modules that combine augmented reality with videos, such as research that has been carried out by (Firdanu et al., 2020; Hurrahman et al., 2022; Raharjo & Dinata, 2021; Setiawan & Dani, 2021; Sumarna et al., 2019), where the research conducted by these researchers still focuses on the application of augmented reality in learning media.

2. Methods

The development method used in this research is the Research and Development (R&D) method, utilizing the ADDIE (Analyze, Design, Development, Implementation, and Evaluation) model as the e-module development model. The ADDIE model is a systematic approach that involves initial analysis, e-module design, e-module development, e-module implementation, and final evaluation.

This method is used to ensure that the development of the e-module is conducted in a structured manner and produces a high-quality product (Istikomah et al., 2020). The augmented reality model used in this research is a marker-based augmented reality model with QRCode in a mobile application based on the Android platform. The development process involves using Unity3D and Vuforia SDK to create the application. Subsequently, the application is integrated into the e-module in the form of QRCode for each augmented reality object that has been created (Hurrahman et al., 2022; Putri & Hendriyani, 2023). The data analysis method used in this study is to use validity tests from media experts and subject matter experts, the data analysis method used in the study is the same as the data analysis method in the research conducted by (Hurrahman et al., 2022; Raharjo & Dinata, 2021; Sumarna et al., 2019). In addition to using validity tests from media experts and subject matter experts, this study also uses a data analysis method based on the results of the e-module assessment questionnaire given to students during the limited trial of the e-module that has been made.

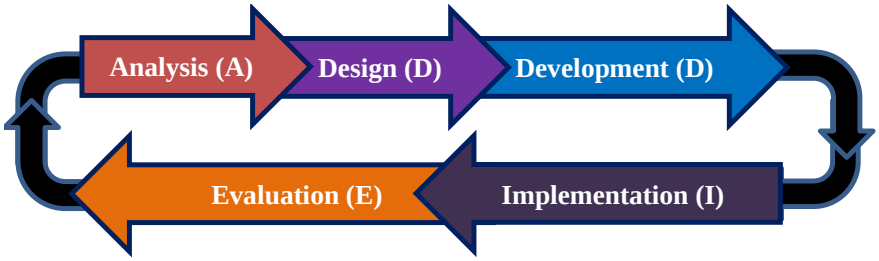

Figure 1: The ADDIE development model

The following are the stages of conducting research using the ADDIE development model, as depicted in Figure 1 above.

Analysis Stage

In this stage, the researcher conducts an initial analysis of the development needs for the e-module, including the data and content that need to be included in the e-module.

Design Stage

In this stage, the researcher conducts the development of the e-module concept and identifies the materials that require video illustrations and 3D visualizations with augmented reality.

Development Stage

In this stage, the researcher carries out the process of developing the e-module according to the design concept and also creates 3D visualizations with augmented reality.

Implementation Stage

In this stage, the researcher conducts a limited trial of the e-module implementation with two subject matter experts and two media experts who are competent in their respective fields, all of whom are lecturers in the Civil Engineering Education Program at UNNES. Additionally, a limited trial is conducted with students from the 2019 cohort of the Civil Engineering Education Program to assess their response to the e-module. The instruments used in this stage include assessment sheets from the media experts, assessment sheets from the subject matter experts, and assessment

sheets from the students. The quality score of the e-module is obtained using the following equation:

$$P = (\Sigma S / N) \times 100 \quad (1)$$

With:

P = quality score of the e-module
ΣS = sum of the obtained scores
N = maximum score

Note:

E-module score categories:

< 70.01	= Not eligible
70.01 - 80	= Adequate
80.01 - 90	= Good
90.01 - 100	= Very good

Evaluation Stage

In this stage, the researcher conducts evaluation and improvement on the e-module based on the assessments from media experts, subject matter experts, and feedback from students. This is done to make the e-module better and suitable for the second assessment by media experts and subject matter experts, as well as to ensure its usability in the actual classroom learning process.

3. Results

The process of creating the Earthquake Technology e-module by using the ADDIE development method consists of five stages: analysis, design, development, implementation, and evaluation. In the analysis stage, the researcher conducts an initial analysis of the e-module's requirements based on the feedback and needs of students who have taken the Earthquake Technology course. This is done through the use of a questionnaire. Additionally, an analysis of the course data within the curriculum is conducted. The initial analysis is performed using a questionnaire filled out by 45 respondents who are students from the 2018 cohort in the Civil Engineering Education Program at UNNES.

In the design stage, the researcher formulates the concept and layout of the e-module based on the findings from the analysis stage. Additionally, in this stage, the researcher identifies the topics that require 3D visualization with augmented reality and the topics that require visualization in the form of videos. In the development stage, the researcher carries out the process of creating the Earthquake Technology e-module based on the previously designed concept. The development of the Earthquake Technology e-module involves several steps, which can be seen in the following figure:

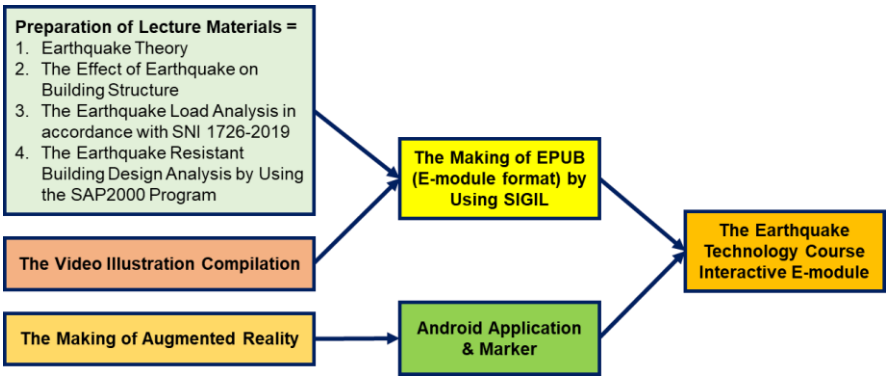

Figure 2: The process of creating the Earthquake Technology e-module

Meanwhile, the process of creating an Augmented Reality (AR) model and its Android application can be seen in the following figure.

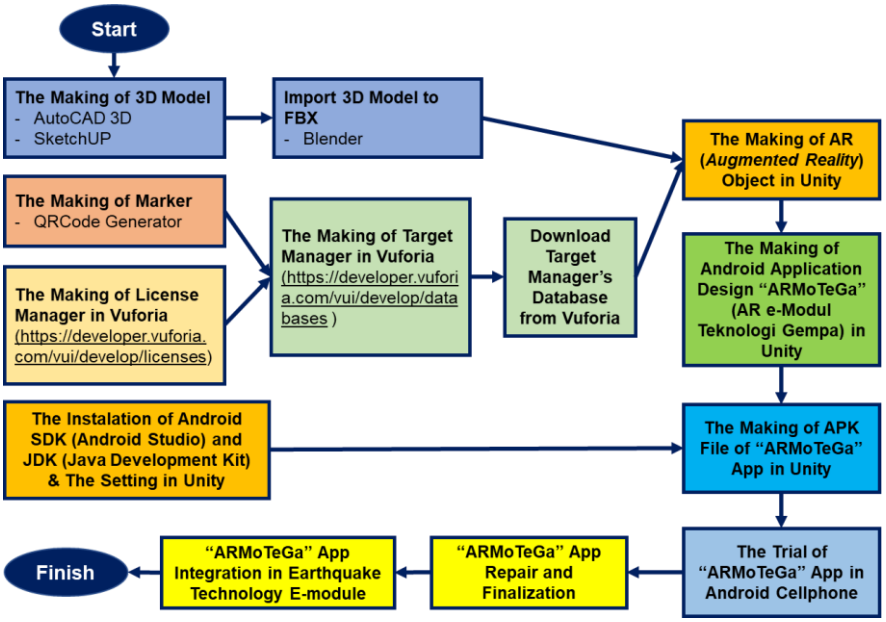

Figure 3: The process of creating the Augmented Reality (AR) model and the Android application

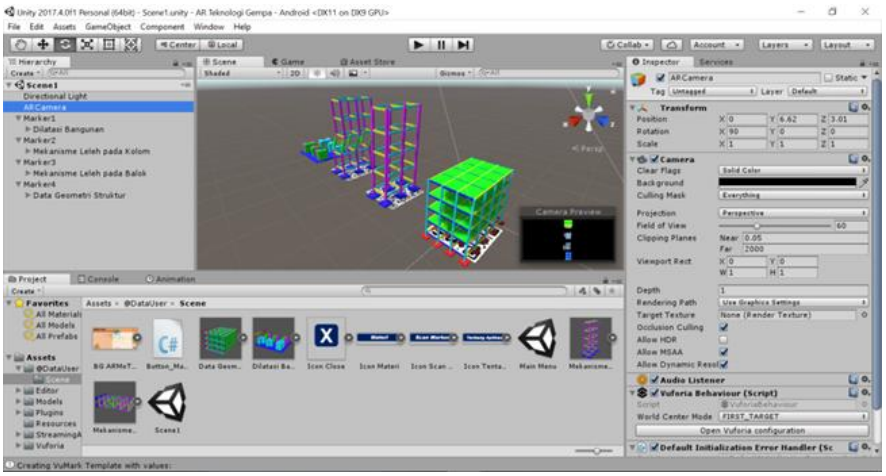

Figure 4: The process of creating the Augmented Reality (AR) model in Unity

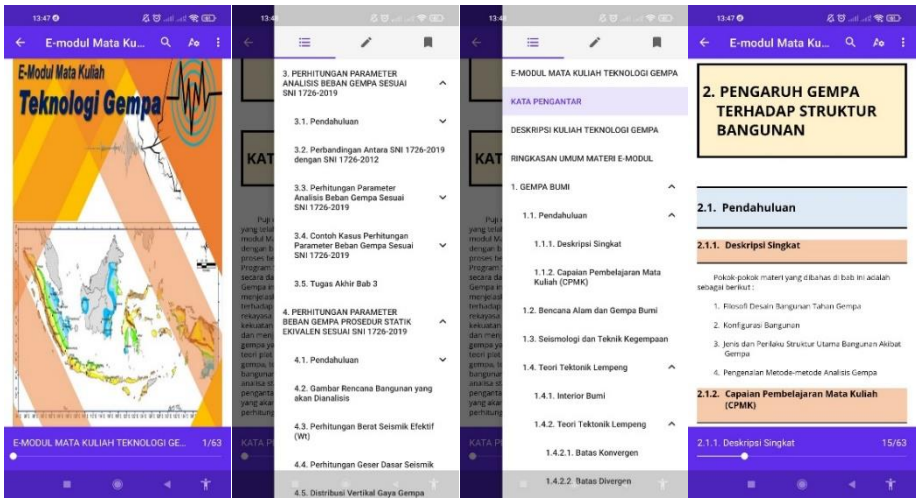

Figure 5: Several E-module Displays Opened Through a Mobile Device

In the implementation stage, the researcher conducted a limited trial of the e-module with 2 subject matter experts and 2 media experts who are competent lecturers from the Civil Engineering Education Program at UNNES. Additionally, a limited trial was also conducted with 35 respondents who were students from the 2019 cohort in the Civil Engineering Education Program at UNNES. The purpose of this trial was to gather feedback and responses from the experts and students regarding the prepared e-module. The instruments used in this phase included assessment sheets from the media experts, assessment sheets from the subject matter experts, and assessment sheets from the students. The assessment sheets from the media experts were used to evaluate the media aspects and presentation in the e-module. The assessment sheets from the subject matter experts were used to evaluate the accuracy and relevance of the content in the e-module. Meanwhile, the assessment sheets from the students were used to obtain feedback and evaluation regarding the quality, clarity, readability of the e-module, as well as their understanding of the presented materials.

Figure 6: Limited trial of the Earthquake Technology e-module in classroom learning process

In the evaluation stage, the researcher assesses the feedback and assessment results obtained from the media experts, subject matter experts, and students, and then proceeds to evaluate and make improvements to the e-module. The main objective of this evaluation is to ensure that the e-module meets the desired quality standards. By doing so, the e-module will be considered suitable for a second evaluation by the media experts and subject matter experts, and it can be effectively implemented in actual classroom learning processes.

4. Discussion

Here are the assessment results of the Earthquake Technology e-module from the media experts, subject matter experts, and students during the limited classroom trial.

Table 1: Assessment results of the e-module by media experts

No	Aspects Assessed	Score		Category
		Media Expert 1	Media Expert 2	
1	Graphic feasibility aspect	93.33	91.33	Very good
2	Language feasibilty aspect	96.67	93.33	Very good
Average score of e-module from media experts		**95.00**	**92.33**	**Very good**

Based on table 1 above, the results for second assessment by media expert validation of the Earthquake Technology e-module obtained an average score of 95.00 from media expert 1 and 92.33 from media expert 2, both of which fall into the "very good" category. This shows that the e-modules have been well designed and pay great attention to the media aspects in terms of graphics / appearance feasibility and language feasibility. With these results, it is expected that this e-module can be an effective and interesting learning resource for students when participating in lecture activities in the Earthquake Technology course at The Civil Engineering Education Program, Universitas Negeri Semarang.

Table 2: Assessment results of the e-module by subject matter experts

No	Aspects Assessed	Score		Category
		Subject Matter Expert 1	Subject Matter Expert 2	
1	Content feasibility aspect	89.41	88.24	Good
2	Presentation feasibility aspect	87.50	90.00	Good
3	Contextual feasibility aspect	90.00	90.00	Good
Average score of e-module from subject matter experts		**88.97**	**89.41**	**Good**

Based on table 2 above, the results for second assessment by material expert validation of the Earthquake Technology e-module obtained an average score of 88.97 from subject matter expert 1 and 89.41 from subject matter expert 2, both of which fall into the "good" category. This shows that the e-modules made have been well designed and pay attention to subject matter aspects in terms of content feasibility, material presentation feasibility, and contextual feasibility. Which means that the e-modules made are in accordance with curriculum standards with complete material presented in an interesting and informative manner. With these results, it is expected that this e-module can be an appropriate learning resource for students when attending lecture activities in the Earthquake Technology course at The Civil Engineering Education Program, Universitas Negeri Semarang.

Table 3: Assessment results of e-module from students

No	Statements	Average scores per statement
1	This e-module provides various sections that allow me to explore and understand the concepts independently.	88.00
2	This e-module contains questions that stimulate my thinking.	88.57
3	The delivery of the material in this e-module inspires me to discuss with other colleagues.	88.57
4	The content in this e-module sparks my curiosity about the topics discussed in the Earthquake Technology course.	90.86
5	This e-module includes tasks designed to assess the extent of my understanding of the materials taught in the Earthquake Technology course.	88.57
6	The use of sentences and paragraphs in this e-module is clear and easy to understand..	88.57
7	The language used in this e-module is simple and easy to understand.	87.43
8	The text in this e-module uses simple and easily readable fonts.	90.29
9	The design of this e-module is visually appealing and captures the user's attention.	89.71
10	This e-module successfully creates a sense of joy and enthusiasm in the learning process of the subject matter of Earthquake Technology.	88.57
11	By utilizing this e-module, the desire to learn can increase and become more motivated.	90.29
12	The utilization of this e-module helps me to direct and organize my learning in a more structured and systematic manner.	88.57
13	The presence of video illustrations and 3D augmented reality objects in the material provides additional motivation to study the subject matter.	90.29
14	The utilization of this e-module has successfully made the learning process more engaging and less tedious.	88.57
Average score of e-modul from students		**89.06**

Based on table 3 above, the results obtained for the assessment of e-modules from students who took part in the limited trial obtained an average score of 89.06 which is in the "good" category. This shows that the e-modules made are liked by students because according to them, using e-modules based on video and augmented reality can increase their interest, motivation, and enthusiasm for learning. In addition, the e-module is also arranged with an attractive and informative display with an easy-to-understand language style and illustrations, making students feel less boring when studying the material in the Earthquake Technology course at The Civil Engineering Education Program, Universitas Negeri Semarang.

The results of the assessment from media experts and material experts as well as the results of the assessment from students during the limited trial in the classroom on e-modules based on video and augmented reality in The Earthquake Technology courses gave good results. The quality of the Earthquake Technology e-module from the media aspect falls into the "very good" category as it falls within the range of 90.01 - 100 (average score from media experts = 95.00 and 92.33). On the other hand, the quality of the e-module from the subject matter aspect falls into the "good" category as it falls within the range of 80.01 - 90 (average score from subject matter experts = 88.97 and 89.41). The assessment by the students during the limited trial in the classroom also falls

into the "good" category with an average score of 89.06. So it can be concluded that the Earthquake Technology e-module based on video and augmented reality can be totally applied in the learning process of Earthquake Technology course at The Civil Engineering Education Program, Universitas Negeri Semarang.

5. Conclusion

The results of this research indicate that the development of the Earthquake Technology e-module using the ADDIE method has resulted in an e-module of "very good" category in terms of media and "good" category in terms of content. The assessment results from students also indicate that the Earthquake Technology e-module falls into the "good" category. Based on the assessment results from the media experts, subject matter experts, and students, it can be concluded that the Earthquake Technology e-module based on video and augmented reality can be totally applied in the learning process of Earthquake Technology course at The Civil Engineering Education Program, Universitas Negeri Semarang. Based on the research analysis and conclusions, some suggestions for further research include the need to develop more diverse augmented reality models to provide more comprehensive illustrations for each module's content. Additionally, further research is needed on the development of E-modules using dynamic augmented reality objects.

Author contribution

Listiyono Budi: Writing – Original Draft, Writing – Review & Editing, Analysis Design, Collecting Data, Instrument Making, Augmented Reality Application Making. Aris Widodo: Writing – Review & Editing, Analysis Design, Supervision. Eko Nugroho Julianto: Writing – Review & Editing, Result Data Analysis, Supervision. Moch Husni Dermawan: Augmented Reality Application Making, Supervision. Retno Mayasari: Analysis Design, Collecting Data, Result Data Analysis, Supervision. Angelique Chonora: Augmented Reality Application Making, Instrument Making, Result Data Analysis. Angelia Nilam Soraya: Augmented Reality Application Making, Instrument Making, Result Data Analysis. Ridwan Ardiansah: Augmented Reality Application Making, Instrument Making, Result Data Analysis.

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Competing interest

The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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