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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 implementation of augmented reality and video in instructional media is highly suitable for courses in the field of civil engineering, one of them is the Earthquake Technology. This research employed the Research and Development (R&D) method using the ADDIE model in developing the e-module. The result of this research is an e-module specifically designed for the Earthquake Technology courses. The e-module was validated by media experts, subject matter experts, and students as part of the evaluation process. The average scores from the two media experts were 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 were 89.41 and 88.24, for presentation feasibility were 87.50 and 90.00, and for contextual feasibility were 90.00 and 90.00. Meanwhile, the average score from the students during the pilot study was 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 with "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 implemented in the learning process of Earthquake Technology course at higher education institution.

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 era. The Industry 4.0 and Society 5.0 era 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 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. 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

This study was conducted in one of the state universities in Indonesia (University A). The development method used in this research was the Research and Development (R&D) method, utilizing the ADDIE (Analyze, Design, Development, Implementation, and Evaluation) model as shown in Figure 1.

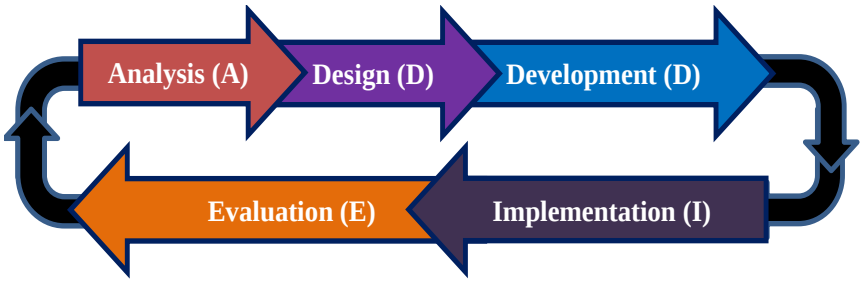

Figure 1. The ADDIE development model

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 was 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 was a marker-based augmented reality model with QRCode in a mobile application based on the Android platform. The development process involved the use of Unity3D and Vuforia SDK to create the application. Subsequently, the application was 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 product validity was carried out by media experts and subject matter experts. The data analysis method used in the study was 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, the product reliability was also tested by using assessment questionnaire given to students during the pilot study of the e-module implementation. The following are the stages of conducting research using the ADDIE development model.

Analysis stage

In this stage, the researcher conducted an initial analysis of the development needs for the e-module, including the data and content to be included in the e-module. This study conducted an initial analysis of the e-module's requirements based on the feedback from the students attending Earthquake Technology courses by using a questionnaire. Additionally, an analysis of the course data within the curriculum was conducted. The initial analysis was performed using a questionnaire filled out by 45 respondents who were students from the 2018 cohort in the Civil Engineering Education Program in University A.

Design stage

In this stage, the researcher conducted the development of the e-module concept and identified the materials requiring video illustrations and 3D visualizations with augmented reality. In this stage, the concept and layout of the e-module based on the findings from the analysis stage were formulated. Additionally, the researcher identified the topics requiring 3D visualization with augmented reality and the topics requiring visualization in the form of videos.

Development stage

In this stage, the process of developing the e-module according to the design concept and also creating 3D visualizations with augmented reality were carry out. The process of creating the Earthquake Technology e-module based on the previously designed concept was also conducted.

The development of the Earthquake Technology e-module involved several steps, which can be seen in Figure 2.

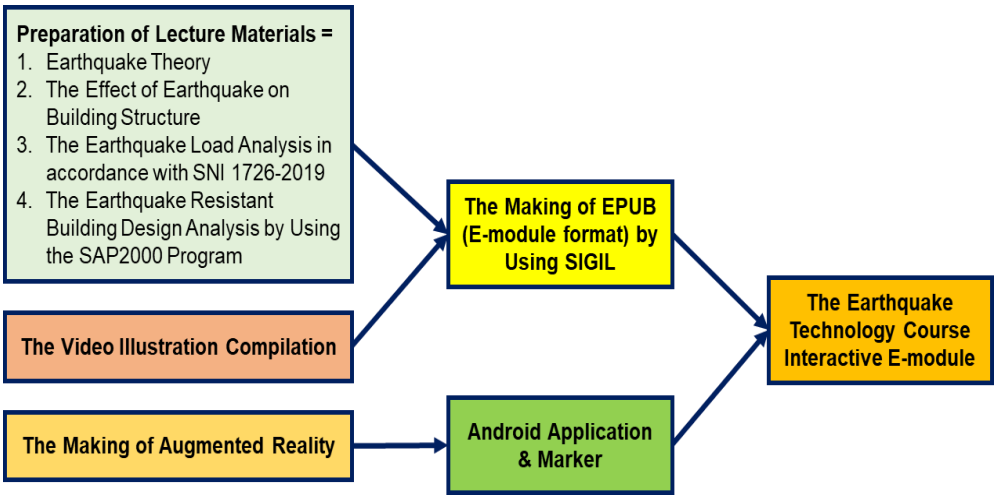

Figure 2. The process of creating the Earthquake Technology e-module

The process of creating an Augmented Reality (AR) model and its Android application can be seen in Figure 3. Meanwhile the process of creating the augmented reality (AR) model in unity is in Figure 4.

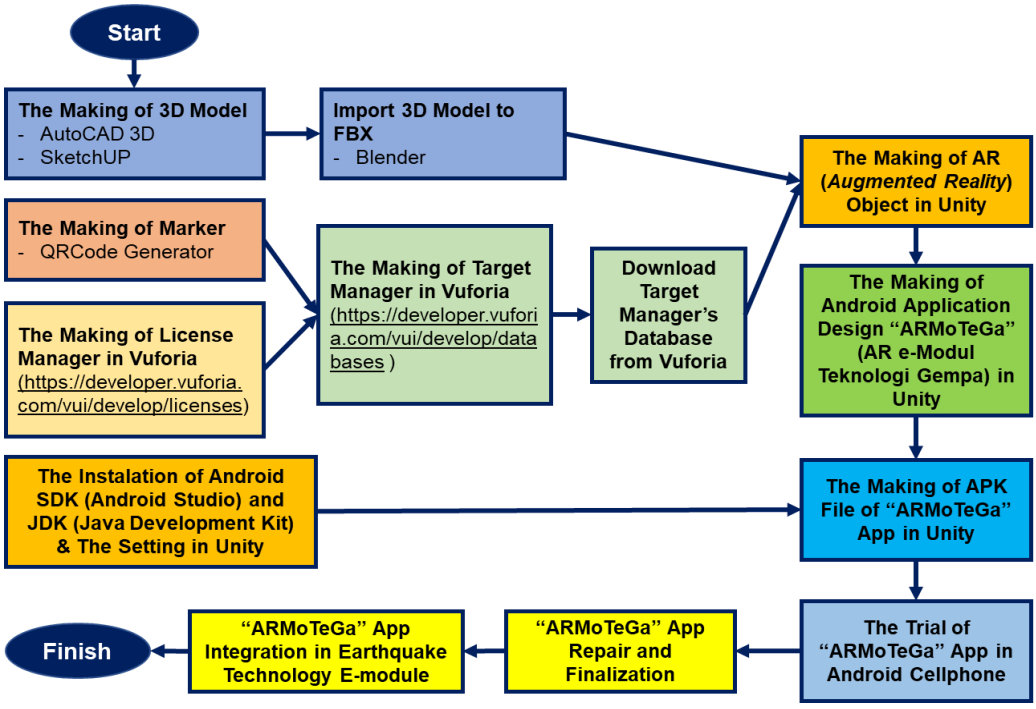

Figure 3. The process of creating the Augmented Reality (AR) model and the Android application

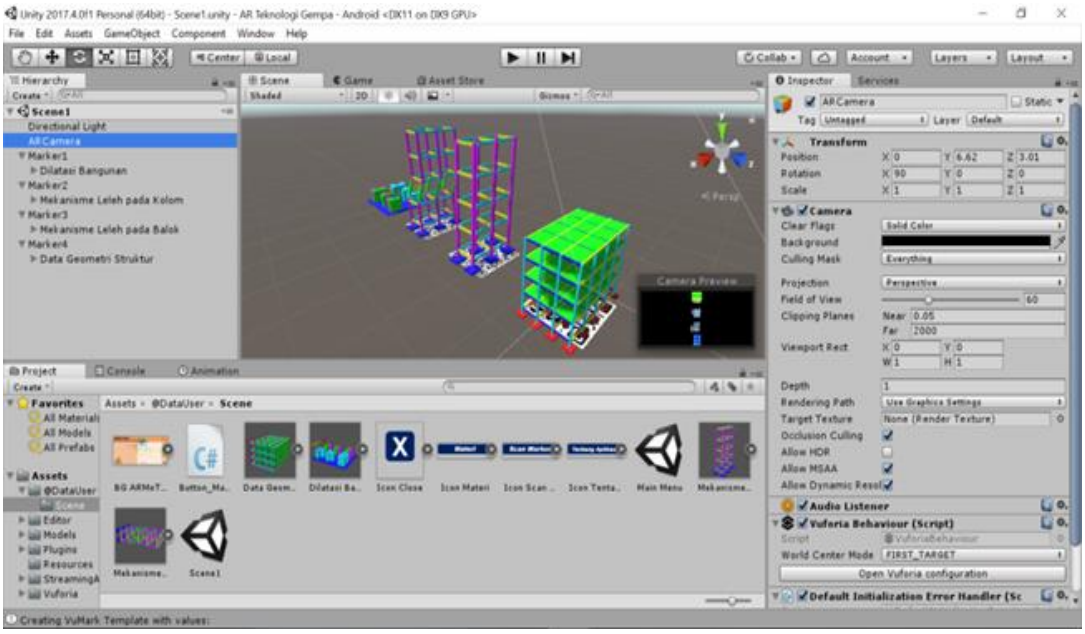

Figure 4. The process of creating the Augmented Reality (AR) model in Unity

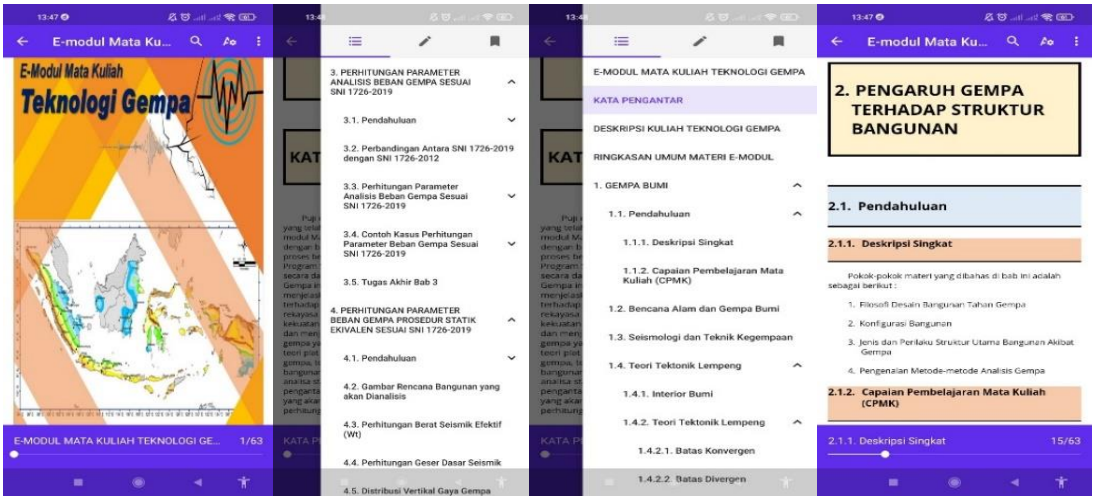

Figure 5. Several E-module Displays Opened Through a Mobile Device

Implementation stage

In this stage, the researcher conducted a pilot study of the e-module implementation with two subject matter experts and two media experts who are competent in their respective fields in the Civil Engineering Education Program. Additionally, a pilot study is conducted with students from the 2019 cohort of the Civil Engineering Education Program in University A to assess their response to the e-module. 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. Pilot study of the Earthquake Technology e-module in classroom learning process

The instruments used in this stage included 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 was obtained using Equation (1).

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

Note:

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

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, evaluation and improvement on the e-module based on the assessments from media experts, subject matter experts, and feedback from students were conducted 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. Furthermore, this study assessed the feedback and assessment results obtained from the media experts, subject matter experts, and students, and then proceeded to evaluate and make improvements to the e-module. The main objective of this evaluation was to ensure that the e-module met the good quality standard to be considered suitable for a second evaluation by the media experts and subject matter experts. It was also effectively implemented in actual classroom learning processes.

3. Results

The process of creating the Earthquake Technology e-module by using the ADDIE development method consisted of five stages: analysis, design, development, implementation, and evaluation.

The assessment results of the Earthquake Technology e-module from the media experts, subject matter experts, and students during the pilot study are shown Table 1.

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

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

Table 1 shows the results for second assessment by media expert validation of the Earthquake Technology e-module which obtained an average score of 95.00 from media expert 1 and 92.33 from media expert 2 which fall into the "very good" category. Assessment result of the e-module by subject matter experts is presented in Table 2.

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

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

The results displayed in Table 2 is for second assessment by material expert validation of the Earthquake Technology e-module which obtained an average score of 88.97 from subject matter expert 1 and 89.41 from subject matter expert 2 which fall into the "good" category.

Assessment result from students perspective is presented in Table 3. The results obtained for the assessment of e-modules from students who took part in the pilot study obtained an average score of 89.06 which was in the "good" category.

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

No	Statements	Average scores per statement
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**

4. Discussion

The results showed that the Earthquake Technology e-module achieved “very good” category. This shows that the e-module was well designed and paid 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 in state university.

Meanwhile, the results for the second assessment by material expert validation of the Earthquake Technology e-module obtained “good” category. This shows that the e-module was well designed and paid attention to subject matter aspects in terms of content, material presentation, and contextual which means that the e-module is in accordance with curriculum standards with complete material presented in an interesting and informative manner. By 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. Students’ perspective on e-module in Table 3 obtained "good" category. This shows that the e-module is useful for 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 was 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.

The results of the assessment from media experts and material experts as well as the results of the assessment from students during the pilot study in the classroom on e-module based on video and augmented reality in The Earthquake Technology courses showed good results. The quality of the Earthquake Technology e-module from the media aspect was categorized "very good" as it was 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 was categorized "good" as it was 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 pilot study in the classroom was also categorized "good" 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.

5. Conclusion

The results of this research indicate that the development of the Earthquake Technology e-module using the ADDIE method resulted in an e-module with "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 was categorized “good”. 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 implemented in the learning process of Earthquake Technology courses at The Civil Engineering Education Program in state university in Indonesia. Based on the data analysis and conclusions, it is suggested for further research to conduct a study on the need to develop more diverse augmented reality models to provide more comprehensive illustrations for each module content. Additionally, further research is needed on the development of e-module 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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