Learning Media Design of Concrete Structural Elements Based on Augmented Reality (AR)

Denny Meisandy Hutauruk[1], Harry Wibowo[2], Mintoro Priyadi[3]

{denny_ft@unimed.ac.id[1], harry_ft@unimed.ac.id[2], mintoro_priyadi@unimed.ac.id[3]}

Civil Engineering Study Program, Faculty of Engineering, Universitas Negeri Medan, Jl. Willem Iskandar Pasar V. Medan Estate[1]

Architecture Study Program, Faculty of Engineering, Universitas Negeri Medan, Jl. Willem Iskandar Pasar V. Medan Estate[2]

Educational Building Engineering Study Program, Faculty of Engineering, Universitas Negeri Medan, Jl. Willem Iskandar Pasar V. Medan Estate[3]

Abstract. The application of high technology has permeated all aspects, including the construction industry. Building Information Modeling (BIM) is a system that has now become mandatory in the construction world and can be used by combining Augmented Reality (AR). However, this technology is still unfamiliar among students. Reinforced Concrete Structure Elements are fundamental courses in the Civil Engineering field, concerning the design of reinforced concrete structures. The result of this research is a product in the form of a learning media application based on Augmented Reality, Concrete Structure Elements, then continued with validation by material experts and media experts. The validation results of augmented reality-based learning media are based on the average value, namely in the form of a "decent" interpretation with a score of 4.

Keywords: Augmented Reality For Education, Learning Media, Learning Technology

1 Introduction

The application of high technology has entered all aspects, including the world of construction. Building Information Modeling (BIM) is a system that has now become mandatory in construction projects in Indonesia under certain conditions. The implementation of this system has even been made mandatory through Government Regulation (PP) Number 16 of 2021. Through this system, building construction can be planned, evaluated and can even be used for the maintenance stage by combining Augmented Reality (AR) and Virtual Reality (VR). This technology can display building construction information in very detail.

Educational media is essential in the implementation of education, namely as an intermediary in delivering material and can minimize failure during the teaching and learning process

(Mustaqim, 2017). Four important components that influence the success of learning are educators, learning atmosphere, teaching materials, and teaching media and resources (Saputra, et al, 2020). Therefore, special attention must also be paid to teaching media so that the material presented can be better absorbed, which ultimately leads to student competency.

Elements of reinforced concrete structures is a fundamental subject in the Civil Engineering science group in terms of designing or designing reinforced concrete structures. This course discusses the five main structural elements, namely plates, beams, columns, foundations and stairs. In the design process, students often have difficulty understanding structural elements and their details. It takes a lot of extra effort so that students can understand correctly. In fact, to be able to get a decent design, a civil engineering graduate as a structural planner must be able to understand what is being analyzed, and how to apply the results of the analysis to structural drawings. This is very necessary so that the results of the analysis can be carried out appropriately, namely through plan drawings.

Augmented reality (AR) is a technology that combines digitally produced objects into a real environment through visualization that can be accessed directly (Azuma, 1997). This technology can present objects in 3D+ by using the internet network and can be accessed using a cellphone.

Based on the description above, it is important to develop augmented reality-based learning media, because the advantages of Augmented Reality technology can make it easier for students to learn Concrete Structural Elements. This technology will make it easier for students to recognize the components that go into the analysis. Apart from that, students have the alternative of inspecting concrete structural elements directly which is far away and of course requires costs and administrative processes. Furthermore, both lecturers and students can easily access this media, because it only requires an internet network and a cellphone, which both of them are familiar with. Students can also directly interact with AR models or objects and recognize existing components from various angles.

2 Methodology

2.1 Development Models and Procedures

The teaching media development model that will be used is the 4D model. Due to limited research time, the stages carried out in this research were Define, Design and Develop. The media development procedure that will be implemented is as shown in Figure 3.1.
1. Define
The definition was carried out in the Concrete Structural Elements course in the Civil Engineering study program, Medan State University. At this stage, the curriculum and RPS will be guided in the development of learning media. In addition, concrete structural elements are studied and examples of analysis questions are created.
2. Design
The general sequence of learning media planning is as follows:
   a. Creating 3D objects of concrete structural elements using the Autodesk Revit application.
   b. Inserting 3D objects into Unity 3D software. Then the 3D model is entered into the database and license key using Vuforia.

c. Make markers based on 2D working drawings resulting from example questions.

d. Combining the marker with the 3D object using Unity 3D, followed by determining the location of the 3D object against the marker and its scale so that the 3D object can be easily and clearly seen.

3. Develop

This stage takes the form of validation carried out by material experts and media experts. This validation uses an assessment sheet in the form of a questionnaire which is the standard in assessing learning media development. Notes of suggestions and improvements from experts will be used as a reference in media revisions.
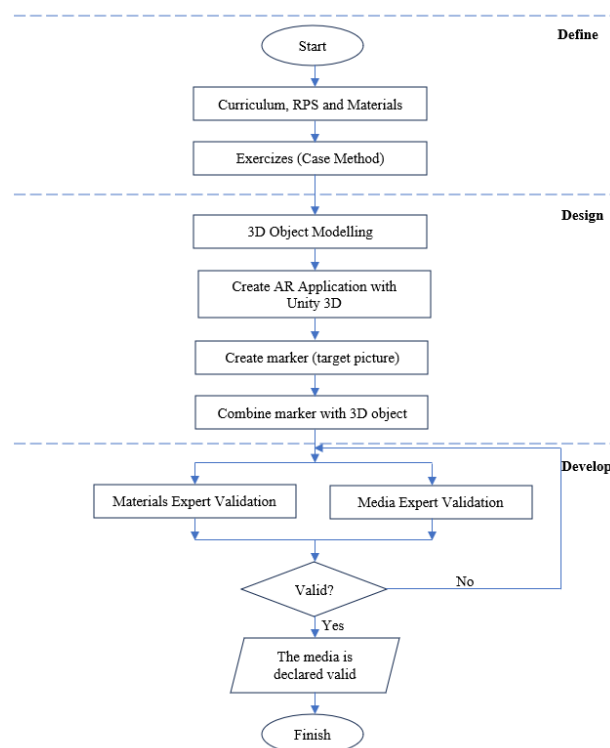

Fig. 1. Research stages.

2.2 Data Sources

1. Primary data sources

Primary data collection was carried out by distributing questionnaires to material experts, media experts and lecturers in the Concrete Structural Elements course at the Civil Engineering study program, Medan State University. This questionnaire was distributed to determine the suitability of learning media for concrete structural elements in the teaching and learning process.

2. Secondary data sources

Secondary data collected was concrete structural elements material from SNI 1726-2019, SNI 2847-2019, and the book Earthquake Resistant Reinforced Concrete Structures. Apart from that, the creation of learning media refers to training modules held by Medan State University and video tutorials available on the YouTube platform.

2.3 Data Collection Methods and Tools

1. Data collection methods

There are several data collection methods used in this research, namely:

a. Direct classroom observations in the form of learning models and student characteristics. The results of observations can be taken into consideration in the process of developing the required learning media.

b. Interviews were conducted with educators to collect data on learning models and student characteristics. The results of the interview will be analyzed using descriptive qualitative, namely by describing the results of the interview so that appropriate media development is obtained.

c. Literature, namely related to the development of AR-based learning media, starting from aspects of material development to media development. The literature used to develop the material is books on earthquake resistant reinforced concrete structures and related SNI. The literature used for developing learning media is modules and journal articles related to the development of augmented reality-based media.

d. Questionnaire, distributed to experts

2. Data collection tools

The data collection tool that will be used is a questionnaire which is distributed to several parties for the purpose of data collection. This questionnaire is intended for educators (lecturers) in the Concrete Structural Elements course with the aim of knowing the aspects or components that can be developed in the concrete structural elements course. The validation questionnaire for augmented reality-based learning media is aimed at validators, namely media experts and material experts. This questionnaire aims to determine the suitability of the media that has been created.

After the data is collected, data analysis is carried out. The analysis method used is quantitative descriptive analysis techniques. Instruments are used to assess the variables to be studied. The measurement scale used is the Likert Scale as seen in table 1 below.

Table 1. Likert scale for questionnaires.

No.	Interpretation	Value Score
1	Very good	5
2	Good	4
3	Enough	3
4	Not enough	2
5	*Very less*	1

After that, the average score of the learning media assessment results was carried out using descriptive statistics. The level of feasibility is differentiated into four groups with an ideal mean of 2.5 as the feasibility limit score. If the mean score is less than the ideal mean then it is categorized as "not feasible", while the mean score consists of three levels, namely less feasible, "decent" and "very feasible" as seen in Table 2.

Table 2. Interpretation of the Feasibility of Learning Media.

No.	Interpretation	Interval Mean Score
1	Not feasible	1.00 – 2.49
2	Not Worth It	2.50 – 3.32
3	Worthy	3.33- 4.16
4	Very Worth It	4.17 – 5.00

Eligibility can be determined using the following formula

$$\bar{X} = \frac{\sum X}{n} \tag{1}$$

Where,

$\bar{X}$: Mean answer score

$\sum x$: The total of all data

N   : Number of scales on the instrument

To analyze the overall media feasibility using the following equation,

$$\bar{X}_t = \frac{\sum X}{n} \tag{2}$$

Where,

$\bar{X}$: Meanwhole

$\sum x$: Total amountitem score

N   : Amountaspects of the instrument

3 Results and Discussion

3.1 Media Development Results

1. Analysis Stage

   The first analysis carried out was the analysis of learning media needs. At this stage, observations and interviews were carried out on research subjects. It is known that the concrete structural elements course studies the analysis of dimensional and reinforcement requirements for structural elements. After dimensional and

reinforcement analysis, proceed with 2D working drawings. It was found that students still had difficulty interpreting the reinforcement analysis results into real objects. Currently the teaching materials used are books where AR media has not been used as a learning tool.

Based on the results of interviews and observations, it was concluded that there is a need for AR-based learning media in the Concrete Structural Elements course.

Next, material analysis is carried out. The results of the material analysis are as shown in table 3 below

Table 3. Material Study Materials.

No.	Study of Concrete Structural Elements
1	Types of Structural Elements
2	Relationship of structural elements
3	Reinforcement in structural elements

Students are also analyzed to determine their characteristics in the teaching and learning process. Data was found that all students did not have physical disabilities and were active in class. Therefore, there is no problem in the ability to use AR-based media.

2. Design Stage
   The data obtained in the first stage is used to design the AR application. The first design was a 3D model of reinforced concrete elements as seen in Figure 2.
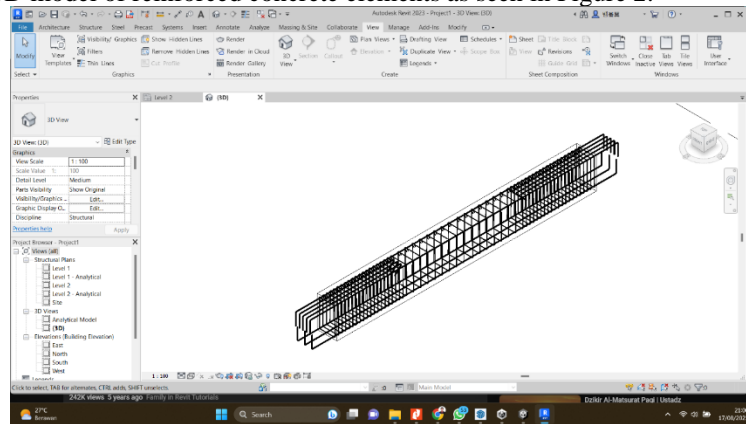

Fig. 2. 3D modeling of structural elements.

After the modeling of the structural elements is complete, it is continued with the use of Vuforia which is accessed online. Vuforia is used to create licenses and markers. One of the markers can be seen in Figure 3.

Fig. 3.3D modeling of structural elements.

After the marker and license are created, the next stage is to create an AR application using the Unity application. The application design includes the main page and camera page as seen in Figure 4 and Figure 5. When the application is redirected to the camera page, once the marker is detected, the 3D model of the concrete structural element will be visible.

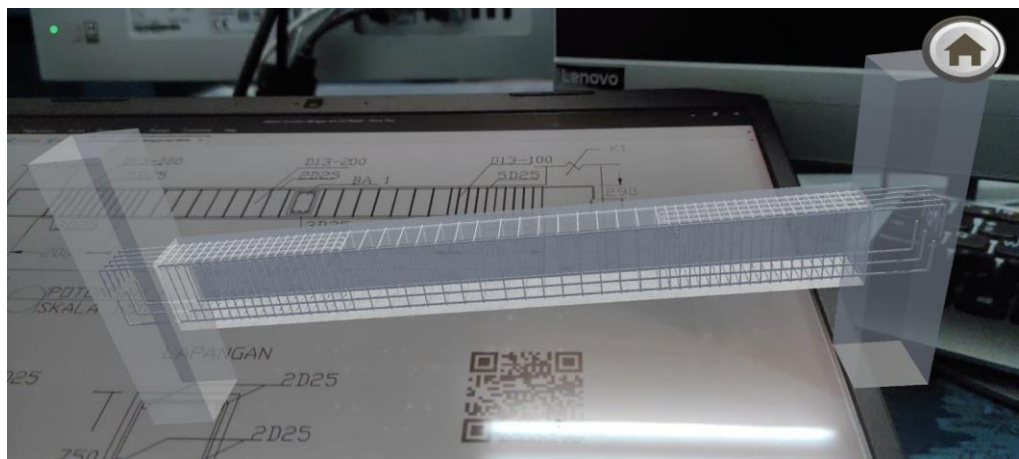**Fig. 4.**Home page of the AR application Concrete Structure Elements.

Fig. 5. Concrete Structure Elements AR app camera page.

3. Development stage

This stage includes initial product creation, product validation and product revision. The product manufacturing stage is adjusted to the product design. Next, determine the instrument and validate it by an expert. After that, material experts and media experts validate the product. The next step is to revise the product according to comments and suggestions from validators.

3.1 Product Validation

Based on the assessment given by material experts, a total score of 97 out of 120 was obtained with an average of 4.04 which was included in the "decent" category. Tabulation of data from validation results by material experts can be seen in Table 3. For the media aspect, the expert gave an assessment with a score of 97 out of 120. Based on this score, the media created is included in the feasible category where the average value achieved is 4.04 . Tabulation of data from media results can be seen in table 4. Tabulation of data from material expert validation results can be seen in table 5.

Table 4. Tabulation of data from validation results from media experts.

No	Assessment Statement/Aspect	Media Expert	Average	Interpretation
1	The AR ESB learning media is in accordance with the KD for the Concrete Structural Elements course	5	5	Very good
2	Design the display of attractive learning media with the right color selection	5	5	Very good
3	The component layout in the AR ESB application is precise and neat so it is comfortable to look at	4	4	Good
4	The AR ESB design is attractive	4	4	Good
5	The text inside AR ESB is easy to read	2	2	Not enough
6	The text inside the AR ESB app is easy to read	2	2	Not enough
7	The text layout in AR ESB is well organized	2	2	Not enough
8	The images contained in AR ESB correspond to the material presented	5	5	Very good
9	The 3D image displayed when scanning the marker is clearly visible and can represent the shape of the original object	5	5	Very good
10	Determining the size of 3D images well	5	5	Very good
11	The camera can display 3D images when scanning markers	5	5	Very good
12	Marker designs can introduce parts of concrete elements	4	4	Good
13	The appearance of the menu buttons is clear with the use of contrasting colors	4	4	Good
14	Arrangement of menu buttons well and neatly	5	5	Very good
15	Easy to access navigation buttons	4	4	Good

No	Assessment Statement/Aspect	Media Expert	Average	Interpretation
16	Instructions for using learning media are clearly displayed	4	4	Good
17	Learning media is used smoothly	4	4	Good
18	Scan markers to display 3D images of concrete structural elements can be operated easily	4	4	Good
19	AR ESB learning media is easy to use	4	4	Good
20	Communicative AR ESB learning media	3	3	Enough
21	Interactive AR ESB learning media	5	5	Very good
22	The use of AR ESB learning media fosters student enthusiasm for learning	4	4	Good
23	AR ESB learning media increases students' understanding of concrete parts	4	4	Good
24	AR ESB learning media makes it easy to introduce the parts of concrete structural elements to students without bringing the goods directly	4	4	Good
Overall Rating Average		**97**	**4.04**	**Worthy**

Table 4. Tabulation of data from material expert validation results.

No	Assessment Statement/Aspect	Materials Expert	Average	Interpretation
1	Material suitability with the selected RPS	5	5	Very good
2	Suitability of material to learning objectives	4	4	Good
3	Conformity of material with competency standards	4	4	Good
4	Suitability of material with basic competencies	4	4	Good
5	The truth of the material is correct	5	5	Very good
6	Material Completeness	4	4	Good
7	The material is arranged sequentially	4	4	Good
8	The material is arranged systematically and specifically	4	4	Good
9	The material is written in standard language	4	4	Good
10	Accompanied by clear examples of images	5	5	Very good
11	The accuracy of image selection is related to the material	4	4	Good
12	Accompanied by information that is easy to understand	3	3	Enough
13	The component images displayed are easy to understand	3	3	Enough
14	Accuracy of images to explain the material	4	4	Good
15	Presentation of material is more coherent	5	5	Very good
16	Make it easier for educators to deliver material	4	4	Good
17	Make it easier for students to understand the material	4	4	Good
18	Easy to understand overall	4	4	Good
Overall Rating Average		**74**	**4.11**	**Worthy**

4 Conclusion

Based on validation results by media experts and material experts, the AR learning media for Concrete Structure Elements is suitable for use. However, it is recommended to carry out testing on large classes.

References

[1] Arkadiantika, I., et al. Pengembangan Media Pembelajaran Virtual Reality pada Materi Pengenalan Termination dan Splicing Fiber Optic. Jurnal Dimensi Pendidikan dan Pembelajaran, Vol. 8, No. 1.

[2] Arywiantari, D. (2015). Pengembangan Multimedia Interaktif Model 4D Pada Pembelajaran IPA Di SMP Negeri 3 Singaraja. Jurnal Edutech Undiksha, Vol. 3, no. 1.

[3] Azuma, R. (1997). A Survey of Augmented Reality. Presence Teleoperators Virtual Environ., Vol. 6, no. 4.

[4] Cahyadi, RAH (2019). Pengembangan Bahan Ajar Berbasis ADDIE Model. Halaqa: Islamic Education Journal, Vol. 3 No. 1.

[5] Figueiredo, M., et al. (2014). Augmented Reality Tools techniques for developing interactive materials for mobile0learning. Journal recent advances educational technologies and methodologies, 395, 63-72.

[6] Gladston, A.; and Duraisamy, A. (2019). Augmented Reality Indoor Navigation Using Handheld Devices. Int. J. Virtual Augment. Real., Vol. 3, no. 3.

[7] Kustandi, C.; and Sutjipto, B. (2011). Media Pembelajaran Manual dan Digital, Edition 1. Ghalia Indonesia Publisher: Bogor.

[8] Mustaqim, I. (2016). Pemanfaatan Augmented Reality sebagai Media Pembelajaran. JPTK FT UNY, Vol. 13, No. 2.

[9] Mustaqim, I. (2017). Pengembangan Media Pembelajaran Berbasis Augmented Reality, Electrical Education Journal, Vol 1, No 1.

[10] Saputra, HN, et al. (2020). Augmented Reality-Based Learning Media Development. Al-Ishlah Journal of Education, Vol 12, No 2.

[11] Sugihartini, N. (2018). ADDIE Sebagai Model Pengembangan Media Instruksional Edukatif (MIE) Mata Kuliah Kurikulum dan Pengajaran. Jurnal Pendidikan Teknologi dan Kejuruan, Vol. 15 No. 2.

[12] Syahidi, AA, et al. (2020). Autoc-Ar: A Car Design And Specification As A Work Safety Guide Based On Augmented Reality Technology. Journal of Technology and Vocational Education, Vol 26, No 1.

[13] Tafonao, T. (2018). The Role of Learning Media in Increasing Student Interest in Learning. Journal of Educational Communication, Vol 2, No 2.