Design of Virtual Map Building Using Unity 3D with MDLC Method

Aristoteles*
Universitas Lampung,
Lampung, INDONESIA

Amelia Jasmine
Universitas Lampung,
Lampung, INDONESIA

Yohana Tri Utami
Universitas Lampung,
Lampung, INDONESIA

Favorisen R. Lumbanraja
Universitas Lampung,
Lampung, INDONESIA

Article Info	Abstract
	Lampung University does routine activities every new academic year for students, especially for new students college in the Faculty of Engineering, Introduction to Campus Life for New Students (PKKMB), one of the main agendas of PKKMB is introducing every building and public facilities in Civil Engineering, also every building and the room in it. The current state of the COVID-19 pandemic makes the University of Lampung conduct learning activities by network (online). The area and number of buildings' public facilities will be an issue for new students and visitors since it takes longer to find information, explore, and understand the layout of the building environment. To address these issues, there is a need for technology that fulfills the requirements of information, efficiency, and new methods in introducing a building to visitors. These problems are expected to be resolved by developing a virtual 3D map application for Building A, the Dean of the Faculty of Engineering, and Building B the architectural engineering. The Multimedia Development Life Cycle (MDLC) method was used to develop this application. The application testing in this research uses two types of testing namely Alpha and Beta testing with a black box scheme. Alpha testing results show that the app is compatible with Android OS 8.1 to 11.1 and smartphones with 5.45 to 6.4-inch displays. It requires at least 4GB to 8GB RAM According to the Beta Testing the application resulted in an outstanding 90.2% satisfaction rate. It can be concluded that the virtual 3D map application for Dean's Office Building A and Architecture Engineering Building B of the Faculty of Engineering at Lampung University functions effectively and is rated as "Very Good" based on the established criteria and index.

INTRODUCTION

The Introduction to Campus Life for New Students (PPKMB) is a routine activity during the beginning of the academic year for new students in the Faculty of Engineering, Lampung University, located at Jl. Prof. Dr. Sumantri Brojonegoro No.1 Rajabasa, Bandar Lampung.

One of the main agendas in PPKMB is to introduce the buildings and public facilities within the Faculty of Engineering by exploring each building and its rooms. The area and number of buildings' public facilities will be an issue for new students and visitors since it takes longer to find information, explore, and understand the layout of the building environment. However, due to COVID-19 [1]. Lampung University has implemented online learning, making it impossible to conduct direct explorations as students must adhere to health protocols that involve avoiding crowds.

Expansive places heavily rely on information media such as maps, both conventional and digital maps [2]. The most common way to convey information is through two-dimensional maps, while another approach is three-dimensional visualization techniques that can depict the design of a building in a highly interactive manner, making it a better choice for conveying information [3].

• **Corresponding author:**
Aristoteles, Universitas Lampung, INDONESIA. ✉ aristoteles.1981@fmipa.unila.ac.id

Based on the current issues, there is a need for technology that fulfills the requirements of information, and efficiency [4]. Therefore, a new method is needed to introduce Building A and B, along with the facilities and layout of the Faculty of Engineering, Lampung University.

These problems are expected to be resolved by developing a virtual 3D Map application for Building A the Dean of the Faculty of Engineering and Building B the architectural engineering using Unity 3D to introduce the environment. The mobile application is created to facilitate new students and visitors who are visiting to obtain information about the location and layout of the buildings [5]. Creating a virtual 3D Map needs several software tools, such as Sketchup [6] and Unity 3D.

Sketch Up is a graphics processing software that produces three-dimensional graphics or objects designed for architects, civil engineers, game developers, and others [7]. SketchUp has several advantages, such as being easy to learn, having a simple interface, being free, and being relatively easy to use [8]. Unity 3D is a cross-platform software for developing video games, computer simulations, and more [9]. Unity [10] 3D software has a quick and convenient advantage in making virtual roaming [11].

This research aims to develop a 3D virtual map application that can be used as a medium for information about the layout of buildings and public facilities in the Engineering Department, specifically focusing on the Dean's Office Building (Building A) and the Architecture Engineering Building (Building B) at the Faculty of Engineering, Lampung University that can run on various types of Android devices, The developed screen sizes will also be different and user-friendly when used, aiming to closely resemble the actual form and condition as much as possible.

In previous research, a study was conducted on using Unity 3D software in a thesis titled "Design of a 3D Virtual Map of the Computer Science Building at Lampung University using Unity 3D." The purpose of this research was to facilitate the introduction of the building to new students of the Computer Science Department at Lampung University, utilizing this advanced technology so that users do not need to physically visit the location to see the layout of the rooms and facilities in the

building. Unity was chosen as the software for developing the application due to its practicality and ease of use [12].

The Introduction to Campus Life for New Students becomes one of the agendas during the new students orientation [13]. The COVID-19 pandemic [14]–[18] has changed the University to welcome and accept new students, the limitation of physical interaction the limitation of mobility has complicated the new students in introducing building conditions and public facilities [19]–[21]. Those obstacles can be handled by relying on informational media, that is online or conventional digital maps [22]. The common thing in informing through 2D map [2], hence 3D map visualization that describes building design interactively is a better option to inform information [23].

Technology can overcome this challenge by helping to display information about the building environment [24]. An innovative solution is to use a virtual map-based 3D unity and SketchUp [25]. Sketch Up is a graphics processing software that produces three-dimensional graphics or objects designed for architects, civil engineers, game developers, and others [26], [27]. SketchUp has several advantages, such as being easy to learn, having a simple interface, being free, and being relatively easy to use [28]. Unity 3D is a cross-platform software for developing video games, computer simulations, and more [29]. Unity [30]–[32] 3D software has a quick and convenient advantage in making virtual roaming [33], [34], students can explore the campus environment virtually in depth [35], providing a more interesting and interactive experience [36], easily understanding information and building architectural layouts.

Research trends regarding virtual design using Unity 3D are being explored in various topics [37], including 3D modeling of smart cities using the point cloud algorithm method [38], implementation of virtual reality presentations [39], and 3D modeling of virtual artificial environments using observation and analysis methods. And comparison of objects [40], 3D modeling of the built environment in the case study of Fort Kilburun [40], visualization of the new globe at Charles University [41], virtual campus tour using survey methods [19], design and realization of a 3D virtual campus based on a roaming system

Int. J. Electron. Commun. Syst, 3 (1) (2023) 21-32

23

[13], and panoramic campus tour using the MDLC methods at Padang University [35]. However, there has been no research on designing virtual building maps using Unity 3D with the MDLC method.

Using Unity as a development platform for creating virtual map building applications is the right choice in this research, which aims to develop a 3D virtual map application that can be used as a medium for information about the layout of the engineering department building at the University of Lampung.

METHOD

This research focuses on the Dean's Office Building (Building A) and the Architecture Engineering Building (Building B) at the Faculty of Engineering, Lampung University. Using the Multimedia Development Life Cycle (MDLC) method. This method begins with analyzing a problem and then creating a concept that includes software development objectives and determining the target users. In the design phase, an application interface design is created and followed by collecting materials such as images, audio, animations, and text. In the implementation or application development phase, the software is created, tested, and distributed [42].
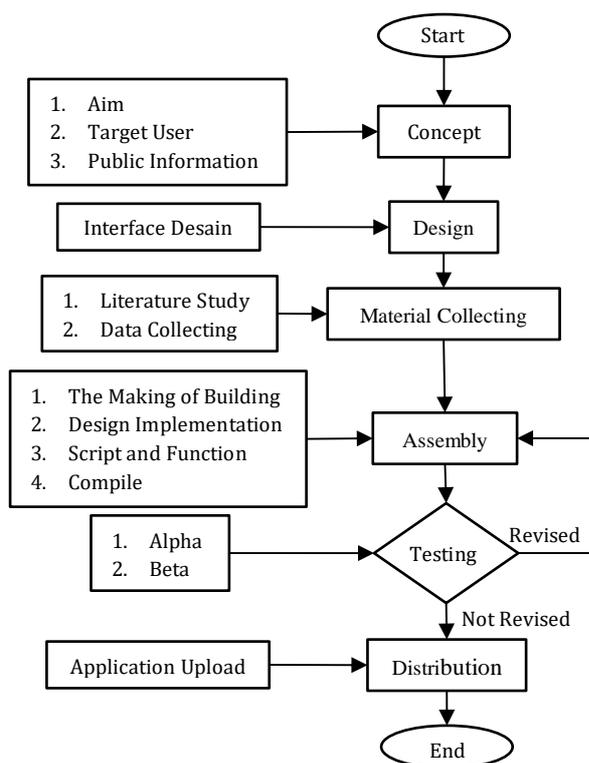

Figure 1. Flow Chart of Research Work

Concept

The concept phase determines the program's objectives, general specifications, and users to be developed [43] This application aims to provide information about the layout of buildings in the Faculty of Engineering, specifically the Dean's Office building (Building A) and the Architecture Engineering building (Building B). The target users are aimed at new students, current students, and the general public around Lampung University. The application can be used on the Android platform with specific specifications. The following is the concept formulation of the virtual 3D map application.

Table 1. The Application Concept Formulation

Concept Category	Concept Description
Title	Design Of 3D Virtual Map Of Building A The Dean's Office Of The Faculty Of Engineering And Building B The Architectural Engineering University Of Lampung Using Unity 3D.
Multimedia Type	Information media about the location, names, facilities, and shapes of buildings based on Android.
Purpose	To develop a virtual 3D map application that serves as a new means to introduce and provide information about the layout and facilities of the Faculty of Engineering.
Target Audience	The target users are aimed at new students, current students, and the general public around Lampung University.
Audio	Background music and audio effects are in .wav format.
Images/Objects	Using 2D images and using 3D objects.

Design

The stages of designing the reference for creating the interface and functionality of a 3D Virtual Map application [44]. The design phase is the stage of outlining the application workflow to be developed. The application design is depicted as interface layout designs that represent the menus within the application, aiming to facilitate the application

development process [45]. The design is created by designing menus, image quality settings, feature displays, buttons, and functions. The design is created using the CorelDRAW application, as shown in Figure 2 and Figure 3.
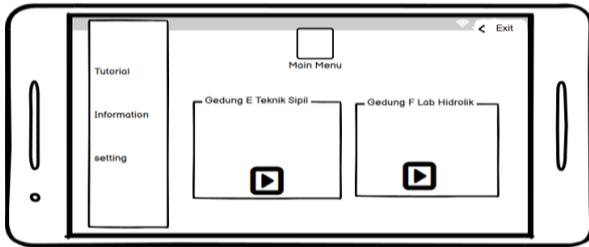

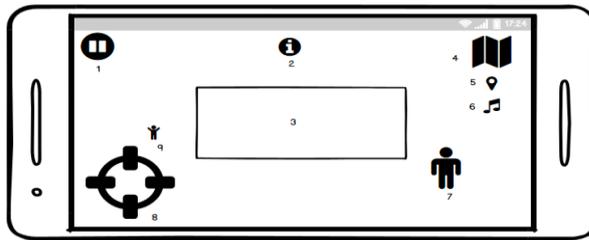**Figure 2**. Example of an application interface design.

Figure 3. Example of an application interface design 2.

Material Collecting

The material collection phase is carried out through two methods: literature review and direct data collection. The literature review aims to find sources that can be used as references, including research outputs such as thesis, dissertations, lab reports, and others. The data collection process starts with capturing photographs of buildings, rooms, and the interior of Building A and Building B of the Faculty of Engineering. These images will facilitate the assembly process during application development.

Assembly

This stage is the creation of 3D objects for Building A and Building B of the Faculty of Engineering Lampung University or any multimedia materials required for the application. This phase is carried out using two supporting applications. The 3D object creation process is done using SketchUp based on the data obtained from the previous stages [46]. Then, the 3D building objects are exported in fbx format and imported into the Unity 3D application for adding features and user interface elements [47]. The targeted output is

in the form of a 3D map that has been built into an Android application in the form of apk so that users can use it.

Testing

The testing phase is conducted in two stages to assess the feasibility and functionality of the application, ensuring that it meets the desired criteria. The first stage involves Alpha testing using the black box scheme, where the developer tests the menu functionality, application integration, performance, and compatibility with different screen sizes and Android versions [48]. The second stage involves Beta testing, which tests whether the application performs well and meets the actual conditions of Building A and Building B of the Faculty of Engineering at Lampung University. This is done by distributing questionnaires to 40 respondents, including 30 students and 10 faculty members or staff in the department. The obtained results determine the usability and feasibility of the application [49].

Distribution

The distribution stage is when the developed application has completed various steps, such as creation, testing, and evaluation. The application will be distributed so students or the public can benefit from it. The distribution process involves storing the application, which is the Virtual 3D Map application for Building A (Dean's Office) and Building B (Architecture Engineering) of Lampung University, in .apk format for Android devices, and uploading it to Google Drive. The application will be distributed by sharing the Google Drive link with the students around the Faculty of Engineering, Lampung University.

RESULTS AND DISCUSSION
Results

The 3D virtual map application for the Faculty of Engineering is an Android-based application that displays information about the layout, similar to a First Person Shooter (FPS) game [50]. The virtual 3D map application [51] has several accessible menus and features, including the Main Menu, Settings, Information, Tutorial, Pause, Teleport, Navigation, and Exit.

Main Menu

The main menu is the application interface that displays several buttons, including the

tutorial, information, settings, exit, and play buttons for each building. The play button is located below the building image and is used to enter the play mode. The settings button is used to adjust the graphic quality, with four levels available: Low, Medium, High, and Ultra. The tutorial button displays instructions on how to use the application, while the exit button is used to exit the application.

Figure 4. Main Menu Display

medium with moderate graphics quality, high with high-quality graphics, and ultra with the highest graphics quality. Additionally, in the settings menu, users can adjust the background sound volume by sliding the corresponding slider.

Figure 5. Settings Menu Display

Information Menu

The information menu is a menu that serves to display information about the development team and the 3D virtual map application.

Figure 6. Information Menu Display

Tutorial Menu

The tutorial menu provides instructions on how to use the 3D virtual map application [52]. The next button and previous buttons are used to navigate between different tutorial images. The provided images contain instructions on how to use features like Navigation and Teleport. This menu also includes a back button to return to the main menu.
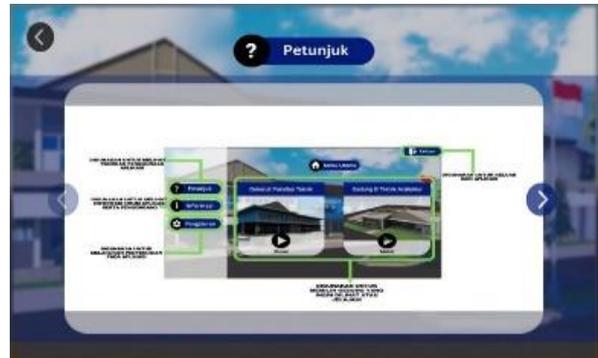

Figure 7. Tutorial Menu Display

Play Mode Menu

The play mode menu is the display when the application is started. In this menu, several buttons are shown, including the joystick button to move the character, the information button to provide information about the building and rooms, the camera view button to change the character's perspective, the interaction button to open/close doors, the pause button to pause the play mode, and the run button to make the character move quickly without using the joystick. At the top, there is a mini-map that shows the character's current position, and a compass as a directional indicator.

Figure 8. Play Mode Menu Display

Pause Menu

The pause menu functions to pause the application temporarily and display the navigation button, which serves as a directional

26

Int. J. Electron. Commun. Syst, 3 (1) (2023) 21-32

guide to the intended room, and the teleport button, which allows the character to move to the desired room quickly. The back button to return to the initial building, and the main menu button to return to the main menu scene.

Figure 9. Pause Menu Display

Teleport Menu

The teleport menu functions to move the characters quickly to another room. The teleport menu helps users move places without walking to the selected location.

Figure 10. Teleport Menu Display

Navigation Menu

The navigation menu functions to display directions to the room that is the user's target.

Figure 11. Navigation Menu Display

Exit Menu

The exit menu functions to terminate or exit the application.


**Figure 12.** Exit Menu Display

The difference between the actual state and the application

Users will see the building and its interior when running the application and entering the play mode. The design of the building in the application is made to resemble and replicate the actual state of the building as closely and accurately as possible. The following is an example of the comparison between the results created in the actual state and the application of the building, which is available in Table 2.
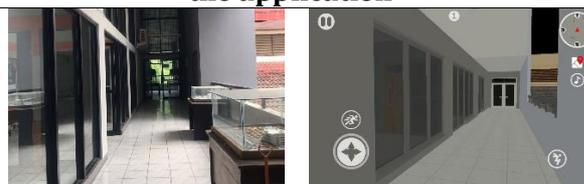
Table 2. Comparison between the application

Comparison between the actual state and the application
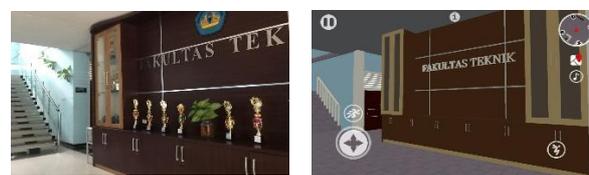
Comparison between the actual state and the application
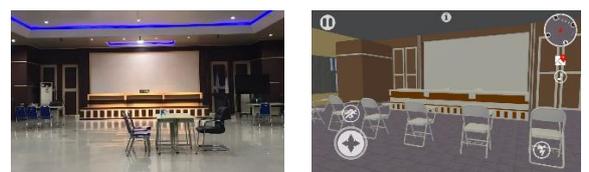
Comparison between the actual state and the application

Application Testing

The testing process of the developed application is conducted in two stages: by the developer (Alpha Testing) and by the users (Beta Testing).

Alpha Testing

Alpha testing is conducted to identify any errors in the application from the developer's perspective [53]. Testing is performed on menu functionality, component integration, screen size compatibility, Android version compatibility, and application performance. The results obtained from this testing are as follows.

Table 3. The Results of Application Testing by Developers.

Testing	Testing Results
Menu Functionality	All menus, features, and buttons have been functioning well and as expected.
Component Integration	All components can integrate well, and there are no issues when running on other components.
Screen Size Compatibility	The application can display a proportional view on devices with a screen size of 5,45 inches to 6,4 inches.
Android Version Compatibility	The application can be installed and runs smoothly on devices with Android versions 8.1 to 11.1.
Application Performance	The applications run smoothly and perform well on devices with a minimum processor speed of 2.0 GHz and 6GB of RAM.

The alpha testing showed that the application runs smoothly and the buttons can be used according to their functions.

Beta Testing

This testing was conducted to measure the level of acceptance of the application by users. The measurement was done through a questionnaire to generate conclusions in the form of an application assessment [54]. The questionnaire was distributed to 40 respondents within the Faculty of Engineering, with the following details.

Table 4. Questionnaire Respondents.

Total Respondents	Description
10	Faculty members or staff in the department
30	Students in the Faculty of Engineering

The ratings provided by the respondents will be adjusted using a Likert scale [55]. One of the most common summative scales for the measurement of attitudes is known as the Likert scale [56]. The Likert scale consists of answer preferences with the following rating categories.

Table 5. Answer Preference level.

No	Assessment Category	Score
1	Very Good (SB)	5
2	Good (B)	4
3	Good Enough (CB)	3
4	Less Good (KB)	2
5	Not Good (TB)	1

In addition, the data interval values for the assessment criteria and the interval classes based on the calculation using the Likert scale can be seen in Table

Table 6. Assessment based on interval classes.

No	Assessment Category	Interval Classes
1	Very Good (SB)	168 - 200
2	Good (B)	136 - 167
3	Good Enough (CB)	104 - 135
4	Less Good (KB)	72 - 103
5	Not Good (TB)	40 - 71

The distributed questionnaire contained 5 statements and was assessed with a predetermined assessment category. The results of the assessment can be seen in the following table.

Table 7. Questionnaire Statement.

No	Statements	Frequency					Total
		SB	B	CB	KB	TB	
1	The application can provide information about the layout of the Dean's Office Building (Building A) and the Architecture Engineering Building (Building B).	21	18	1	0	0	180
2	The form and layout of the buildings in the application are consistent with the actual conditions.	22	17	1	0	0	181
3	The buttons and menus in the application are functioning properly.	21	18	1	0	0	180
4	The provided features are supportive of the application's needs.	22	15	3	0	0	179
5	The application is easy to operate (user-friendly).	25	12	3	0	0	182

Based on the evaluation results, each statement will receive its respective total score. The Total Score is the sum of each rating multiplied by the weight of the rating. Here is an example of the calculation:

$$\text{Total} = (21 \times 5) + (18 \times 4) + (1 \times 3) + (0 \times 2) + (0 \times 1) = 180$$

The assessment results obtained from the respondents are used to determine the percentage of user ratings for the application. The calculation is done using the following equation:

$$\text{Index} = \frac{\text{Total}}{\text{Highest Value Weight} \times \text{Total Respondents}} \times 100\%$$

Explanation:
Index = User rating percentage
Total = User rating result

Table 8. Percentage rating of the application by users.

No	Statements	Percentage
1	The application can provide information about the layout of the Dean's Office Building (Building A) and the Architecture Engineering Building (Building B).	90%
2	The form and layout of the buildings in the application are consistent with the actual conditions.	90,5%
3	The buttons and menus in the application are functioning properly.	90%
4	The provided features are supportive of the application's needs.	89%
5	The application is easy to operate (user-friendly).	91%

Based on the calculation of the questionnaire, statement 1 states that the application can provide information about the layout of Building A, the Dean's Office, and Building B, the Architecture Engineering Building, obtained a percentage of 90%. Statement 2, which states that the form and layout of the buildings in the application are consistent with the actual conditions, received a percentage of 90.5%. Statement 3, which states that the buttons and menus in the application function properly, obtained a percentage of 90%. Statement 4, which states that the provided features are supportive of the application's needs., received a percentage of 89.5%. Statement 5, which states that the application is easy to operate (user-friendly), obtained a percentage of 91%.

The high percentage of agreement with statements regarding the application's ability to provide information about the building layout and its user-friendly operation suggests that when users perceive the application as useful and easy to navigate, their satisfaction with the system increases. Simple visualization techniques are widely preferred [57].
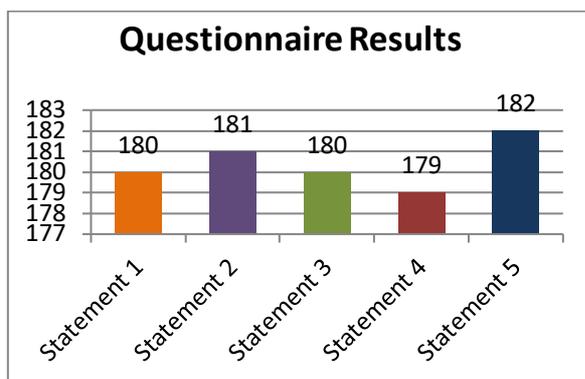
Figure 13. Questionnaire Results

Based on the calculations, the average total score from the Building A and Building B questionnaire in the Faculty of Engineering is 180.4, which translates to a percentage index of 90.2%.

Percentage Index = 180.4/200 x 100% = 90.2%

Therefore, it can be concluded that the evaluation of the 3D virtual map application falls into the category of "Very Good" (SB) based on the total score and the assessment categories previously conducted using the Likert scale.

CONCLUSION

Based on the conducted research, it can be concluded that the Virtual 3D Map Application of the Dean's Office Building A and the Architecture Engineering Building B of the Faculty of Engineering Lampung University, is functioning well and can provide an informative representation of the layout and facilities within the Faculty Of Engineering, depicting the actual conditions. This application can be categorized as "Very Good" (SB) based on the index and criteria.

The suggestion for the development of this research is to add a feature of directional audio to guide users to specific rooms in the Navigation Menu. Additionally, it would be beneficial to provide information about the user's current location in the teleportation and navigation menu.

REFERENCES

[1]   C. Di Mitri *et al.*, "COVID-19 and Non-COVID-19 Pneumonia: A Comparison," *Ann. Med.*, vol. 53, no. 1, pp. 2321–2331, 2021, doi: 10.1080/07853890.2021.2010797.

[2]   R. F. Rahmat, Anthonius, M. A. Muchtar, A. Hizriadi, and M. F. Syahputra, "Virtual Reality Interactive Media for Universitas Sumatera Utara - A campus Introduction and Simulation," *J. Phys. Conf. Ser.*, vol. 978, no. 1, 2018, doi: 10.1088/1742-6596/978/1/012101.

[3]   H. H. Ghazala, I. M. Ibraheem, M. Lamees, and M. Haggag, "Structural Study Using 2D Modeling of The Potential Field Data and GIS Technique in Sohag Governorate and Its Surroundings, Upper Egypt," *NRIAG J. Astron. Geophys.*, vol. 7, no. 2, pp. 334–346, 2018, doi: 10.1016/j.nrjag.2018.05.008.

[4]   M. R. Anggara, D. Kurniawan, A. Ardiansyah, and A. R. Irawati, "Smart Village: Mobile-Based Community Reporting Application," *Int. J. Electron. Commun. Syst.*, vol. 2, no. 1, pp. 31–38, 2022.

[5]   P. Sintiya, "Rancangan Bangun Peta Virtual 3D Gedung K , Gedung H, Gedung I DAN Gedung R Fakultas Pertanian Universitas Lampung Menggunakan UNITY 3D," Jan. 2023.

[6]   A. Nurwijayanti, Budiyono, and L. Fitriana, "Combining Google Sketchup and Ispring Suite 8: A Breakthrough to Develop Geometry Learning Media," *J. Math. Educ.*, vol. 10, no. 1, pp. 103–115, 2019, doi: 10.22342/jme.10.1.5380.103-116.

[7]   W. Bhirawa, "Penggunaan Google Sketch Up Software dalam Merancang Kopling Flens," *J. Teknol. Ind.*, vol. 4, no. 1, pp. 1–7, 2015.

[8]   H. W. C. Rizal Nur Ahmad, "Kelayakan Medi 3D SKETCUP dan Perangkat Pembelajaran pada Materi Detail Penulangan Balok dan Kolom," *J. Kaji. Pendidik. Tek. Bangunan*, vol. 06, no. 3, pp. 1–13, 2020.

[9]   I. Buyuksalih, S. Bayburt, G. Buyuksalih, A. P. Baskaraca, H. Karim, and A. A. Rahman, "3D Modeling and Visualization Based on the Unity Game Engine - Advantages and Challenges," *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. 4, no. 4W4, pp. 161–166, 2017, doi: 10.5194/isprs-annals-IV-4-W4-161-2017.

[10]   R. Imam and Q. M. Areeb, "Game Effect Based on Particle System in Unity 3D," *Acad. Lett.*, no. November, 2021, doi:

10.20935/al2447.

[11] R. Gupta, R. Nawani, and V. P., "Virtual Reality Content Creation using Unity 3D and Blender," *Int. J. Comput. Appl.*, vol. 156, no. 3, pp. 8–12, 2016, doi: 10.5120/ijca2016912395.

[12] S. Friston, C. Fan, J. Dobǒs, T. Scully, and A. Steed, "3DRepo4Unity: Dynamic Loading of Version Controlled 3D Assets into the Unity Game Engine," *Proc. - Web3D 2017 22nd Int. Conf. 3D Web Technol.*, Jun. 2017, doi: 10.1145/3055624.3075941.

[13] J. Chen, P. Hu, and Z. Huang, *Design and Realization of 3D Virtual Campus Roaming System Based on unity3D*, vol. 905, no. 152. Springer International Publishing, 2020.

[14] C. Di Mitri *et al.*, "COVID-19 and non–COVID-19 Pneumonia: A Comparison," *Ann. Med.*, vol. 53, no. 1, pp. 2321–2331, 2021, doi: 10.1080/07853890.2021.2010797.

[15] B. Feng *et al.*, "Impact of Short-Term Ambient Air Pollution Exposure on the Risk of Severe COVID-19," *J. Environ. Sci. (China)*, vol. 135, pp. 610–618, 2024, doi: 10.1016/j.jes.2022.09.040.

[16] R. B. Brown, "Biases in COVID-19 Case and Death Definitions: Potential Causes and Consequences," *Disaster Med. Public Health Prep.*, vol. 17, no. 2, pp. 0–3, 2023, doi: 10.1017/dmp.2022.281.

[17] S. Saidi, N. Herawati, and K. Nisa, "Modeling with generalized linear model on covid-19: Cases in Indonesia," *Int. J. Electron. Commun. Syst.,* vol. 1, no. 1, pp. 25–33, 2021.

[18] K. G. Aziz, B. M. Faraj, and K. J. Rostam, "Online and Face-to-Face Learning during COVID-19 Pandemic: A Comparative Analysis of Instructors and Student's Performance," *Online Learn. Educ. Res.,* vol. 2, no. 2, pp. 75–83, 2022.

[19] N. P. Murnaka and Suwarno, "Virtual Campus Tour (Student Perception of University Virtual Environment)," *J. Crit. Rev.*, vol. 7, no. 19, 2020, doi: 10.31838/jcr.07.19.584.

[20] Y. Zhang and T. Nakajima, "Exploring the Design of a Mixed-Reality 3D Minimap to Enhance Pedestrian Satisfaction in Urban Exploratory Navigation," *Futur. Internet*, vol. 14, no. 11, 2022, doi:

10.3390/fi14110325.

[21] A. O. Abdulrahman and K. M. H. Rawf, "Usability Methodologies and Data Selection: Assessing the Usability techniques on Educational Websites," *Int. J. Electron. Commun. Syst.,* vol. 2, no. 2, pp. 49–56, 2022.

[22] R. Marhayati, R. Diani, A. Saregar, D. Fujiani, F. G. Putra, and M. R. Fitri, "Optimization of Online Learning During the Covid-19 Pandemic in Rural Areas," *Smart Soc. Community Serv. Empower. J.,* vol. 2, no. 1, pp. 33–38, 2022.

[23] I. M. Ibraheem, M. Haggag, and B. Tezkan, "Edge Detectors As Structural Imaging Tools using Aeromagnetic Data: A case study of Sohag area, Egypt," *Geosci.*, vol. 9, no. 5, May 2019, doi: 10.3390/GEOSCIENCES9050211.

[24] B. Sun, H. Pan, and S. Shao, "Countermeasures for Improving Rural Living Environments under The Background of A Rural Revitalization Strategy Based on Computer Virtualization Technology," *Sustain.*, vol. 15, no. 8, 2023, doi: 10.3390/su15086699.

[25] A. Nurwijayanti, Budiyono, and L. Fitriana, "Combining Google Sketchup and Ispring Suite 8: A Breakthrough to Develop Geometry Learning Media," *J. Math. Educ.*, vol. 10, no. 1, pp. 103–115, Jan. 2019, doi: 10.22342/JME.10.1.5380.103-116.

[26] W. T. Bhirawa, "Penggunaan Google Sketch up Software dalam Merancang Kopling Flens," *J. Teknol. Ind.*, vol. 4, no. 0, Apr. 2021, doi: 10.35968/JTI.V4I0.669.

[27] E. A. Mamaeva, N. I. Isupova, T. V. Masharova, and N. N. Vekua, "Modeling in the Environment of Three-Dimensional Graphics as a Method of Forming Students' critical thinking," *Perspekt. Nauk. i Obraz.*, vol. 50, no. 2, pp. 431–466, 2021, doi: 10.32744/PSE.2021.2.30.

[28] L. Vinet and A. Zhedanov, "A 'Missing' Family of Classical Orthogonal Polynomials," *J. Phys. A Math. Theor.*, vol. 44, no. 8, 2011, doi: 10.1088/1751-8113/44/8/085201.

[29] I. Buyuksalih, S. Bayburt, G. Buyuksalih, A. P. Baskaraca, H. Karim, and A. A.

Rahman, "3D Modeling and Visualization Based on the UNITY Game Engene-Advantages and Challenges," *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. IV-4-W4, no. 4W4, pp. 161–166, Nov. 2017, doi: 10.5194/ISPRS-ANNALS-IV-4-W4-161-2017.

[30] R. Imam and Q. M. Areeb, "Game Effect Based on Particle System in Unity 3D," *Acad. Lett.*, Jul. 2021, doi: 10.20935/AL2447.

[31] A. Villarroel, D. Toapanta, S. Naranjo, and J. S. Ortiz, "Hardware in the Loop Simulation for Bottle Sealing Process Virtualized on Unity 3D," *Electronics*, vol. 12, no. 13, p. 2799, 2023, doi: 10.3390/electronics12132799.

[32] I. Logothetis, M. Sfyrakis, and N. Vidakis, "EduARdo—Unity Components for Augmented Reality Environments †," *Inf.*, vol. 14, no. 4, 2023, doi: 10.3390/info14040252.

[33] W. Suwandi, Tri. Padmasari, Ayung Candra. Sriwulan, "Virtual Garden: Development and Student's Perceptions," *J. Technol. Sci. Educ.*, vol. 9, no. 3, pp. 326–339, 2019.

[34] R. Gupta, R. Nawani, and V. Talreja, "Virtual Reality Content Creation using Unity 3D and Blender," *Int. J. Comput. Appl.*, vol. 156, no. 3, pp. 8–12, Dec. 2016, doi: 10.5120/IJCA2016912395.

[35] A. D. Samala, F. Ranuharja, B. R. Fajri, Y. Indarta, and W. Agustiarmi, "ViCT—Virtual Campus Tour Environment with Spherical Panorama: A Preliminary Exploration," *Int. J. Interact. Mob. Technol.*, vol. 16, no. 16, pp. 205–225, 2022, doi: 10.3991/ijim.v16i16.32889.

[36] A. Batistatou, F. Vandeville, and Y. N. Delevoye-Turrell, "Virtual Reality to Evaluate the Impact of Colorful Interventions and Nature Elements on Spontaneous Walking, Gaze, and Emotion," *Front. Virtual Real.*, vol. 3, no. June, pp. 1–17, 2022, doi: 10.3389/frvir.2022.819597.

[37] S. Aydin and B. Aktaş, "Developing an Integrated VR Infrastructure in Architectural Design Education," *Front. Robot. AI*, vol. 7, no. October, 2020, doi: 10.3389/frobt.2020.495468.

[38] Y. Wu and Z. Zhou, "Intelligent City 3D Modeling Model Based on Multisource Data Point Cloud Algorithm," *J. Funct. Spaces*, vol. 2022, 2022, doi: 10.1155/2022/6135829.

[39] M. Turan, "Virtual Reality Implementation for University Presentation," *WSEAS Trans. Syst. Control*, vol. 16, pp. 696–704, 2021, doi: 10.37394/23203.2021.16.63.

[40] I. Tytarenko, I. Pavlenko, and I. Dreval, "3D Modeling of a Virtual Built Environment Using Digital Tools: Kilburun Fortress Case Study," *Appl. Sci.*, vol. 13, no. 3, 2023, doi: 10.3390/app13031577.

[41] E. Štefanová, E. Novotná, and M. Čábelka, "Digitization, Visualization and Accessibility of Globe Virtual Collection: Case Study Jüttner's Globe," *ISPRS Int. J. Geo-Information*, vol. 12, no. 3, 2023, doi: 10.3390/ijgi12030122.

[42] I. Binanto, *Multimedia Digital Dasar Teori + Pengembangannya*. Yogyakarta: Andi Offset, 2010.

[43] Mustika, "Rancangan Bangun Aplikasi Sumsel Museum Berbasis Mobile Menggunakan Metode Pengembangan Multimedia Development Life Cycle (MDLC)," *Mikrotik J. Manag. Inform.*, vol. 8, 2018, Accessed: Sep. 15, 2023.

[44] E. Yulsilviana, dan Hanifah Ekawati, M. Informatika, S. Widya Cipta Dharma Samarinda, J. M. Yamin No, and S. - Kalimantan Timur, "Penerapan Metode Finite State Machine (FSM) pada Game Agent Legenda Anak Borneo," *Sebatik*, vol. 23, no. 1, pp. 116–123, Jun. 2019, Accessed: Sep. 15, 2023.

[45] A. Maulana, V. Rosalina, and E. Safaah, "Implementasi Teknologi Virtual Tour Perpustakaan Menggunakan Metode Pengembangan Multimedia Development Life Cycle (Mdlc)," *JSiI (Jurnal Sist. Informasi)*, vol. 7, no. 1, p. 1, 2020, doi: 10.30656/jsii.v7i1.1875.

[46] N. Kumala Dewi *et al.*, "Konsep Robot Penjaga Toko Di Kombinasikan Dengan Pengendalian Virtual Reality (VR) Jarak Jauh," *IKRA-ITH Inform. J. Komput. dan Inform.*, vol. 5, no. 1, pp. 33–38, 2021, Accessed: Sep. 15, 2023.

[47] A. N. Rachman, M. Adi, K. Anshary, and I. N. Hakim, "Pemanfaatan Teknologi Virtual Reality (VR) Pada Aplikasi 3D Bangunan Perusahaan," *CESS (Journal*

Comput. Eng. Syst. Sci., vol. 5, no. 2, pp. 204–209, Jul. 2020, doi: 10.24114/CESS.V5I2.18672.

[48] N. Nurrizqa, S. Syahrial, R. Munadi, and Y. Yunidar, "Penerapan Metode Perancangan Virtual Reality: Tinjauan Literatur," *InfoTekJar J. Nas. Inform. dan Teknol. Jar.*, vol. 5, no. 2, pp. 289–295, Feb. 2021, doi: 10.30743/INFOTEKJAR.V5I2.3458.

[49] P. R. Shalih and I. Irfansyah, "Perancangan Game Berbasis Multimedia Development Life Cycle (MDLC) Tentang Tokoh Pahlawan Indonesia Masa Kini untuk Generasi Z," *J. Pendidik. Multimed.*, vol. 2, no. 2, pp. 83–92, Dec. 2020, doi: 10.17509/EDSENCE.V2I2.26690.

[50] P. Almeida, V. Carvalho, and A. Simões, "Reinforcement Learning Applied to AI Bots in First-Person Shooters: A Systematic Review," *Algorithms*, vol. 16, no. 7, p. 323, 2023, doi: 10.3390/a16070323.

[51] G. Miller *et al.*, "The Virtual Museum: Interactive 3D Navigation of a Multimedia Database," *J. Vis. Comput. Animat.*, vol. 3, no. 3, pp. 183–197, Jul. 1992, doi: 10.1002/VIS.4340030305.

[52] A. Devaux, M. Brédif, and N. Paparoditis, "A Web-Based 3D Mapping Application using WebGL Allowing Interaction with Images, Point Clouds and Models," *GIS Proc. ACM Int. Symp. Adv. Geogr. Inf. Syst.*, pp. 586–588, 2012, doi: 10.1145/2424321.2424422.

[53] C. Yuksel, "Alpha Distribution for Alpha Testing," *Proc. ACM Comput. Graph. Interact. Tech.*, vol. 1, no. 1, Jul. 2018, doi: 10.1145/3203185.

[54] S. Masripah and L. Ramayanti, "Penerapan Pengujian Alpha dan Beta Pada Aplikasi Penerimaan Siswa Baru," *Swabumi*, vol. 8, no. 1, pp. 100–105, 2020, doi: 10.31294/swabumi.v8i1.7448.

[55] S. Syofian, T. Setiyaningsih, and N. Syamsiah, "Otomatisasi Metode Penelitian Skala Likert Berbasis Web," *Pros. Semnastek*, vol. 0, no. 0, Nov. 2015, Accessed: Sep. 15, 2023.

[56] J. Van De Poll, "An Alternative to the Likert Scale When Polling Employees," *Int. J. Bus. Manag.*, vol. 9, no. 5, May 2021, doi: 10.24940/THEIJBM/2021/V9/I5/BM2 105-044.

[57] E. Markoska and S. Lazarova-Molnar, "Usability Requirements for Smart Buildings' Performance Testing Solutions: A Survey," *2019 4th Int. Conf. Fog Mob. Edge Comput. FMEC 2019*, pp. 265–270, Jun. 2019, doi: 10.1109/FMEC.2019.8795308.