



Development of Augmented Reality Based Learning Media on The Topic of Spatial Geometry for Elementary School Students

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ABSTRACT

Spatial structures are three-dimensional buildings that contain space or volume within them and are bounded by sides. The rapid advancement of technology in the world of information technology and computers has also influenced the field of education, offering various conveniences and innovations. Augmented Reality (AR) is a technology that can combine two-dimensional or three-dimensional virtual objects into a real environment and then project these virtual objects in real-time. With AR technology, it is expected to provide innovation in the creation of learning media and new learning experiences in understanding and studying spatial structures, thereby attracting the interest of elementary school students to learn this subject matter.

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1. INTRODUCTION

Human life is rapidly changing over time, especially in today's world (Bower et al., 2014). Advances in Science and Technology (SandT) are quickly permeating every aspect of human life, including the field of telecommunications. Progress in this field is marked by the easy exchange of information through films, TV, radio, newspapers, telephones, computers, and the internet. These technological advancements signify that we have entered the era of the Fourth Industrial Revolution. In this era, society is required to be acquainted with all available technologies. In the field of education, technology plays a vital role in facilitating the application of scientific knowledge (Maritsa et al., 2021). However, (Nurhidayati et al., 2022) suggests that technological developments bring negative impacts, one of which is spoiling students and resulting in a decrease in motivation to learn. This implies the emergence of a persistent issue: low student learning outcomes.

Regarding the issue of learning outcomes, mathematics is one of the most frequently complained about subjects by educators and learners. Educators complain about the difficulty of transferring knowledge related to mathematics topics, while learners complain about the challenging nature of understanding the subject matter. The poor understanding of mathematics learning has a negative impact on the low achievement in mathematics (Husna et al., 2022). Although it falls into the category of challenging subjects, mathematics is a compulsory subject in elementary schools. This subject plays a significant role in various dimensions of human life. Mathematics helps individuals understand and solve various problems. In elementary school, mathematics aims to equip students with logical, systematic, analytical, and critical thinking skills. Therefore, students must possess basic mathematical skills, understand various mathematical concepts, and comprehend the existing formulas.

In daily life, many students often make mistakes in understanding mathematical concepts and formulas, resulting in errors when solving problems. This aligns with the opinion of (Zenizela and Agustina, 2022), who state that students face difficulties in memorizing and understanding the numerous formulas involved in spatial geometry topics. Based on research findings (Zulkha and Setyawan, 2022), the evaluation of mathematics content in volume and spatial geometry shows a low level of mastery. Several possible causes of students' low learning outcomes in spatial geometry are attributed to the difficulty children have in comprehending the subject. Spatial geometry involves similarities between different shapes, both in terms of characteristics and calculation formulas, leading to students often confusing and misapplying spatial geometry concepts and formulas. Based on the data mentioned above, the use of appropriate learning media is crucial to assist and facilitate students in improving their mastery of spatial geometry topics (Wu et al., 2013).

Augmented Reality (AR) is a technology that can be utilized to develop learning media (Chen et al., 2017). With Augmented Reality (AR), it is possible to visualize virtual objects as if they are connected to the real world and interact with real-time (Mustaqim, 2016). This means that both two-dimensional and three-dimensional objects in the virtual world can appear as if they are lifted and displayed in the real environment (Suciliyana and Rahman, 2020). Therefore, Augmented Reality (AR) can be utilized as a learning media to introduce students to spatial geometry. This is because spatial geometry involves three-dimensional objects that can be visually represented in an engaging manner using this technology.

The technology of Augmented Reality (AR) can be considered for developing learning media due to several advantages (Kesim and Ozarslan, 2012), including: 1) low cost for development, 2) easy operability, 3) suitability for implementation in various types of media, 4) the product in the form of applications can be installed on smartphones, which are widely

used in everyday life, and 5) interactivity that can create enjoyment in learning (Apriyani and Gustianto, 2015; Aprilinda et al., 2020).

By developing learning media utilizing Augmented Reality (AR) in the form of a spatial geometry introduction application, it is expected that students will gain a better understanding of topics such as various spatial geometries, their characteristics, as well as the formulas and their applications. Through increased student comprehension, it is hoped that their learning outcomes will improve over time. Therefore, this application can be used by teachers as an alternative to achieving learning objectives and creating more diverse learning experiences.

2. METHOD

The research method employed in this study is the Multimedia Development Life Cycle (MDLC) method. This method, developed by Luther (1994), consists of six stages: concept, design, material collecting, assembly, testing, and distribution (Maulana et al., 2020).

The six stages of the research method are described in the following points:

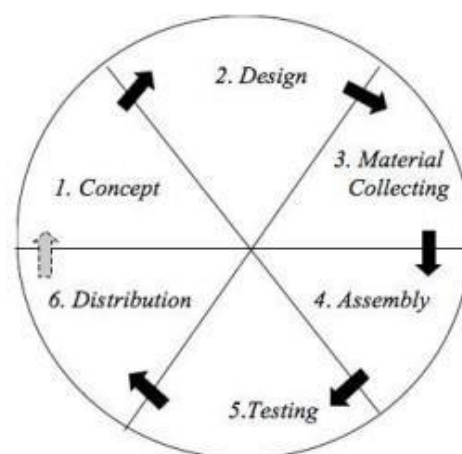


Figure 1. Research Method Diagram

1. **Concept**
Conceptualization is the stage where the goal, audience identification, and product concept are determined (Mustika et al., 2018).
2. **Design**
The design stage is the phase of application design, which includes the design of menus, buttons, and the final output of the application (Jung et al., 2004).
3. **Material Collecting**
This stage involves gathering audio, animations, images, and other necessary materials for the process of creating the learning media (Priyatna, 2020).
4. **Assembly**
The assembly stage is where the learning media is created based on the previously designed design and the materials collected in the previous stage (Priyatna, 2020).

5. Testing

The testing stage is conducted by testing the learning media created by its creator (Sugiarto, 2018).

6. Distribution

This stage is performed by saving the learning media into a storage medium (Mustika et al., 2018).

3. RESULTS AND DISCUSSION

The use of the Multimedia Development Life Cycle (MDLC) research method by Luther resulted in the following research findings, which will be explained as follows:

1. Concept:

In the initial stage, the concept formulation of creating an augmented reality-based learning media for 3D spatial geometry is generated. The target audience for this media is sixth-grade elementary school students. The media is designed to be simple, engaging, user-friendly, and interactive. The purpose of creating this learning media is to attract students' interest and enhance their learning enthusiasm by presenting the content in an engaging manner. Additionally, the media aims to provide meaningful learning experiences for students.

2. Design:

The design stage involves creating specifications for the program architecture, style, visual interface, and material requirements for the program (Mustika, 2018). During this stage, the design of the learning media is developed, including the user interface design that serves as a representation of the media. The user interface design consists of the main menu, content menu, and augmented reality menu.

3. Material Collecting:

In the third stage, the collection of materials related to the learning media takes place. The materials include subject matter, images, and audio. All the materials used in the application are obtained through internet research.

4. Assembly:

The assembly stage is where the actual creation of the learning media takes place based on the previously designed user interface and collected materials. The alignment between the previous stages and this stage aims to create a media product that aligns with the desired outcome (Sugiarto, 2018). In this stage, the learning media is developed using Unity application. The outcome of the learning media creation is as follows.

a. Home Page



Figure 2. Home page screen

The following is the initial screen that appears when users open this learning media. This page displays the title of the learning media application and an engaging sound. Additionally, the page features a "Start" button that, when pressed, will directly take the user to the application's menu page.

b. Menu Page



Figure 3. Menu page screen

On this page, there are several buttons, including the "Start" button, which means "Start Learning". This button leads to the main material of the learning media. There is also a "Guide" button, which, when pressed, will navigate the user to the instruction page on how to use the application. The "Credits" button provides information about the development team, and the "Exit" button allows the user to exit the application. Additionally, there is a background soundtrack that enhances the user's enthusiasm while learning.

c. Main Material Menu



Figure 4. Main material menu screen

On the material menu page, there are four buttons that represent sub-topics. The sub-topics covered in this application are the characteristics and formulas of the volume of a rectangular prism, cube, cylinder, and sphere. Each button, when pressed, will directly navigate to the corresponding sub-topic page.

d. Sub Material Menu



Figure 5. Sub material menu screen

On the sub-topic page, the application will present the material regarding the characteristics and formulas of the volume for each geometric shape. This page has two buttons: the "Scan AR" button and the "Exit" button. If the user presses the "Scan AR" button, they will be directed to the augmented reality page. On the other hand, if the user presses the "Exit" button, they will return to the material menu page.

e. Manual Page



Figure 6. Manual page screen

This page provides instructions on how to use the application. The instructions here explain the functions of each button available in the application. Additionally, this page also has an "Exit" button that, when pressed, will take the user back to the menu page.

f. Developer Page



Figure 7. Developer page screen

This page displays the developer's identity, including the developer's name and student ID, as well as the supervising lecturer for the development of the augmented reality-based spatial geometry learning media.

g. Exit Page



Figure 8. Exit page screen

The exit page is designed to confirm whether the user really wants to exit the application or not. On this page, there are two buttons: a cross button, which, when pressed, will return the user to the menu screen, and a checkmark button, which, when pressed, will immediately exit the application.

h. Augmented Reality Page

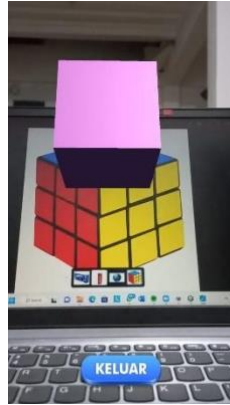




Figure 9. Augmented reality page





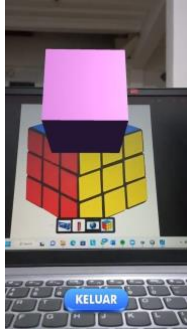

The augmented reality page is where users can view three-dimensional objects of geometric shapes. On this page, users will be prompted to scan a pre-determined image. Once the scanning is done, the three-dimensional geometric shape will appear. In addition to viewing the three-dimensional shape, users can also utilize the zoom in, zoom out, and rotate features by using their fingers. The page is also equipped with an exit button, which, when pressed, will return the user to the sub-topic view.






5. Testing

The purpose of this stage is to identify any errors or issues in the learning media when it is executed, or to ensure that the media functions correctly. This can be examined through Black Box testing. Black Box testing is a method used to determine the presence or absence of errors or issues in each button or component (Rahman and Haryanto, 2020.). The Black Box testing for the geometric shapes learning media is documented in the following table.

Table 1. Learning media black box testing

Test Activity	Test Form	Expected Result	Test Result
Start button test	Pressing the start button and waiting for 5 seconds 	Home page display  When clicked start after waiting for 5 seconds, it will switch to the menu section	Valid

Test Activity	Test Form	Expected Result	Test Result
2nd start button test	Press the start button and wait 10 seconds to go to the next page 	 When clicked on the start button 2, it will go to the building space menu section.	Valid
Cube volume button test	Pressing the "volume of cube; volume of block; volume of tube; volume of sphere" button on the building space menu. 	Material page display of cube volume, beam volume, tube volume, and sphere volume 	Valid
AR button test	Pressing the AR button and the camera is directed at the cube image, it will display a 3D image of the cube space building 	Display when turning on AR 	Valid
Hint button test	Pressing the hint button and waiting for 5 seconds 	When clicked start after waiting for 5 seconds will switch to the instructions section	Valid

Test Activity	Test Form	Expected Result	Test Result
Credit button test	Pressing the credit button and wait for 5 seconds 	When clicking the credit button after waiting 5 seconds will switch to the credit section 	Valid
Exit button test	Pressing exit button 	Pressing the exit button, 2 options will appear, namely the checklist button and the cross button 	Valid
			

From the media test table using black box testing above, it can be concluded that each command was successfully implemented as expected.

6. Distribution

In this stage, the learning media is stored in various storage media, including Google Drive, flash drives, and hard disks. This is done to ensure that the learning media is accessible and can be distributed to the intended users. By storing the media in different storage devices, it becomes easier to share and distribute the learning materials to different individuals or institutions. The choice of storage media depends on factors such as the intended audience, convenience, and availability of resources.

4. CONCLUSION

The purpose of this research using the MDLC method is to explain the development of spatial geometry learning media at the elementary school level. The augmented reality-based

learning media created using the Unity application aims to provide learning variations so that students do not feel bored and create a meaningful learning atmosphere. Through this learning media, it is hoped that students can have a good understanding of spatial geometry.

This learning media is equipped with augmented reality features, background sound, and an attractive interface that can be accessed by users, making them engaged and preventing boredom. These advantages adequately address the objectives of the developed learning media. Suggestions for future research include integrating virtual reality models into the learning media to make it more engaging and diverse. Additionally, it is necessary to add other spatial geometry topics to broaden students' knowledge and understanding.

5. AUTHOR'S NOTE

The authors declare that there are no conflicts of interest associated with the publication of this article. The authors also ensure that this paper is free from plagiarism.

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