Development of Augmented Reality Multiple Markers Application Used for Interactive Learning Media

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Abstract: Augmented Reality (AR) is a technology that can turn virtual objects in the form of two dimensions (2D) or three dimensions (3D) into an object that looks real, then able to display objects in real-time. Using AR technology, you can visualize learning material into 3D objects to make it easier to understand when using it as a learning medium. This research aims to develop an AR application with multiple marker features that can be used as an interactive learning medium. The method used is Research and Development (R&D), and the development model used is 4D. The evaluation used was the Software Usability Measurement Inventory (SUMI), involving 11th-grade which involved 30 students consisting of 20 male students and 10 female students, the parameters assessed in this evaluation were between others are Efficiency, Affect, Helpfulness, Control, and Learnability. Based on the analysis performed on these parameters, the results show that all five parameters obtain valid and reliable results for each parameter in the validity and reliability tests with a Cronbach's alpha score of 0.934 (Efficiency), 0.868 (Affect), 0.917 (Helpfulness), 0.878 (Control), and 0.919 (Learnability). Thus, this multiple marker-based interactive learning media, Augmented Reality (AR), can be used in learning activities.

Keywords: Interactive Learning Media, Augmented Reality, Multiple Markers

INTRODUCTION

Augmented Reality (AR) is a technology that can turn virtual objects in the form of two dimensions (2D) or three dimensions (3D) into an object that looks real, then able to display objects in real-time (Radu et al., 2023). AR technology has many advantages, including that it can be widely implemented in various media, is practical to use, is more interactive, has easy object modeling because it only displays a few objects, is less costly to manufacture, and is easy to use (Ayustina & Hindarto, 2022). The meaning of real-time is that it is an ongoing process and can be felt, heard, and seen in real-time. Besides that, it can make AR a learning media that can provide its own experience because users can receive direct feedback using the media (Setyawan et al., 2019).

Augmented Reality technology can affect various fields, for example, in the fields of health, entertainment, and education. In the realm of health, AR is used to perform a CT scan or MRI, which can provide surgeons with an overview of the patient's internal anatomy (Setiawan, 2020). AR technology can also provide information related to historical heritage; many people are still lacking information about the form of these historical heritages, so using AR can visualize the shape of these historical heritage objects (Ikhwan & Buyung Nasution, 2022). In addition, AR can also be used to create location services to be combined with the concept of overlaying geographic position information, so this perceptual AR is still one type of AR (Kiswanto et al., 2022).

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While in the field of education, AR technology is widely used for various purposes, using AR in the education sector to make learning activities more exciting and easier, so students can understand the material (Fitri et al., 2018). In addition, the use of AR can improve student memory, and students feel more motivated with the help of AR learning media; with higher motivation, student memory will be easier to improve, so this media can be used as an alternative in companion learning to improve students' memory (Sukirman, I. F. Nur Janah, 2019). AR is also widely used to support learning activities such as increasing student interest and achievement, improving quality and arousing learning activities in students, and can increase student motivation (Anita Puspitarini, 2022).

Marker detection has two methods, and the first is the one-marker method and also the multiple-marker method (Calvin & Suryantara, 2022). The detection method using one marker can only detect one object or one image on each marker and can only display one object or image that can appear on one marker (Burhanuddin, 2018). The multiple marker method is a method that aims to be able to display many objects or images with only one detection of the marker (Jalil, 2020). The multiple marker method is one of the developments of the single marker method so that the camera can detect markers of more than one object or one image (Wibowo et al., 2021).

At the development and implementation stage, the use of the multiple marker method, which can make the markers interact with each other in AR applications, is still relatively small and also limited (Pratama & Ngurah Suryantara, 2022). This is evident from the difficulty of finding references and also the lack of tutorials regarding the multiple marker method, in addition to the AR application that implements the multiple marker method, which uses multiple markers to display objects or 3D images that are a combination of only one object, so the multiple method markers on each marker can be used to relate to each other and can still be improved (Burhanuddin, 2018).

Based on those theories, an interactive learning media based on multiple markers AR can increase students' interactive power and understanding. Notes that in developing interactive learning media, it is hoped that it can help students and teachers carry out learning activities. Therefore, this research addresses the following two research questions: How to develop a single marker feature into multiple markers so that there is an interaction between markers, and how is the feasibility of multiple marker-based interactive learning media AR in plant tissues. Based on the problem statements, the primary objective of this research is to develop interactive learning media based on AR with the multiple marker method to increase students' interest in learning. It can make it easier for students to understand the material. This interactive learning media that utilizes AR can help improve the quality of learning and help students understand, digest, and increase student interest in participating in learning activities.

LITERATURE REVIEW

The use of learning methods that are not appropriate and also the lack of use of learning media are one of the causes of the low quality of education (Istiana et al., 2021). One way to improve the learning experience for students is by utilizing learning media (Rahmi et al., 2019). The application of AR in learning activities, especially in school subjects, can provide a more detailed description of material and be presented with a more realistic view in virtual 3D form (Sholeh et al., 2021). AR is a variation of the Virtual Environment or commonly referred to as Virtual Reality, the real world with virtual object elements with the boundaries of the natural world and the virtual world as if they did not exist (Prasetia et al., 2018).

Methods that use markers are usually in the form of objects in the form of pictures or illustrations in black and white (Agustinus Sirumapea et al., 2021). In a single marker, AR can only show objects captured by only one marker (Trianto & Hariyanti, 2020). In addition, in the making, it also only uses one target that can be made (Wedi Pratama et al., 2022). The markers can be scanned on an image using a single marker media for each image only (Riskiono et al., 2020). Multiple markers can also display more than one object in an application in AR (Calvin & Suryantara, 2022).

The Software Usability Measurement Inventory (SUMI) is the development of a questionnaire method for analyzing user reactions (Arh & Blažič, 2008). SUMI is a questionnaire designed to measure user perceptions of software usage. It has been specifically designed to investigate perceptions about the quality of software systems, and SUMI is also applicable to various applications (Lindsey, 2018). SUMI can also be a solution to the recurring problem of measuring user perceptions of the usability of a

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software (Pratomo & Mantala, 2016). Usability testing using SUMI is testing that is used by users who will use the system and find deficiencies (Thoyyibah et al., 2020).

The SUMI (Software Usability Measurement Inventory) method is a survey instrument used to measure a user's perception of the usability of software, so this method is based on a questionnaire developed to see the user experience of the usability of this software product (Khairunisa et al., 2020). Sumi can solve the recurring problem of measuring perceptions of usability on a device, making it a valid and reliable method for product comparisons and different versions of the same product, and it can provide diagnostic information for future developments (Yulianti et al., 2017).

METHOD

The research method used is the 4D model development method (Define, Design, Develop, Evaluation), a model for developing learning tools (Solikin & Amalia, 2019). These four stages consist of Define, Design, Develop, and Evaluation. However, the dissemination part is changed to an evaluation which is adapted from our research (Lawhon, 1976). This development model can be seen in Figure 1.

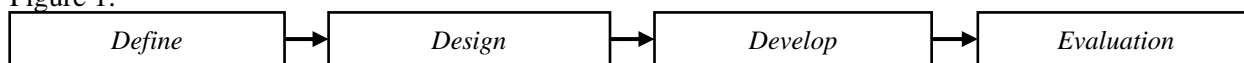| Define	Design	Develop	Evaluation

Figure 1: 4D Development Model

The stages in the 4D method include the following:

1) Define

On the problems encountered during direct observation in class 11 SMA IT-Alhuda, Wonogiri. This observation was made during plant tissue learning activities at school which can be seen from the character of the student's learning styles when the learning activities occur. Based on the results of the observations that have been made, it is known that the teacher only uses learning methods in the form of lectures, textbooks, and PowerPoints only when learning activities take place, which is still not appropriate because students do not necessarily understand the material presented. So we need a learning media that can make students able to understand the material better. After the problem is defined, the next step is to define the research objectives based on the problem's analysis and formulation. This research aims to develop AR-based interactive learning media and evaluate it. In order to create more exciting and interactive learning, the multiple marker method will be used as a medium for creating 3D objects that can interact with the markers. So that students can become interactive and educative in learning because they can play with these markers.

2) Design

At this stage, it is designed using use cases to determine the function of learning media, as shown in Figure 2. It shows that this application consists of 6 functions that can be executed, as shown in the following figure:
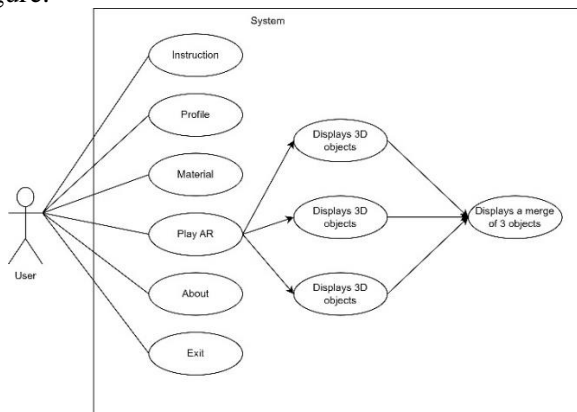

Figure 2 : Use Case

Based on Figure 2, the first flow of the application process is to display the application's main menu, which contains six functions: the instructions menu, profile menu, material menu, main AR menu, about the menu, and exit menu. Each menu has various functions, such as:
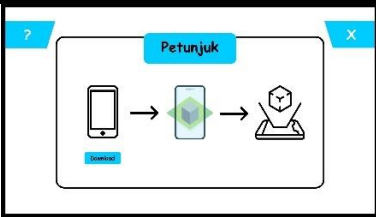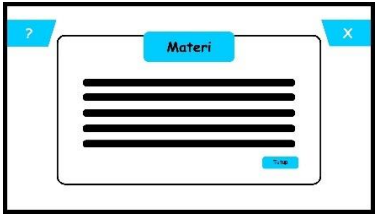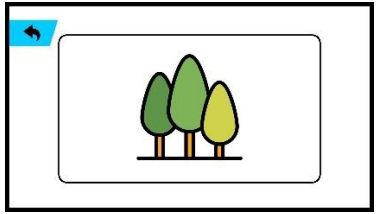
*name of corresponding author

1) Help menu   : This guide menu has a function as a guide for using the application, which aims to make it easier for the user or users to operate the application.
2) Profile menu   : This profile menu has a function to display the identity of the application maker.
3) Material menu : This material menu has a function to display a summary of the material that will be studied through this AR.
4) AR Play Menu : Play menu has a function to start using the application. To play this application, select one of these markers, then point the camera at the marker provided, and 3D object will appear.
5) About menu   : The about menu has a function to provide information related to this application.
6) Menu exit   : The exit menu has a function to making it easier for users to exit the application.

3) Develop

This development stage is the stage where AR applications using multiple markers are developed. Some of the activities carried out at this stage are making the initial design of the application and making storyboards. The storyboard making a plan can be seen in Table 1.

Table 1 : Application Storyboard

No	Page	Design	Information
2.	Help menu	Figure 3 : Instructions menu	The instructions menu contains the use of the application, which aims to make it easier for the user or users to operate the application. Apart from that, the instructions for downloading the marker will be used later.
4.	Material menu	Figure 4: Material menu	This material menu has a function to display a summary of the material to be studied. So that students can better understand what material will be displayed on the AR.
7.	After the marker is found	Figure 5: After the marker is found	If the marker has been successfully detected, the application will display a 3D object. After that, the user can try other markers, and the user can combine these markers.

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4) Evaluation

The evaluation stage is the last in the research. This evaluation is used to measure the usability of interactive learning media based on AR multiple markers that have been developed. The testing technique that will be used is Software Usability Measurement Inventory (SUMI) testing, which is a questionnaire that has been developed by College Cor University which aims to measure the quality of using the software based on user observations and trials when using the software, so that users can find out in using the system that has been built is based on testing the software or system (Sriwulandari et al., 2014)

5) Participant

The participants involved in this study were IT-Alhuda high school students, Wonogiri. This research involved class XI students who were taking plant tissue subjects. The students involved in this study were 30 people consisting of 66.7% (20) boys and 33.3% (10) girls. Students are between 16 years old (57%) and 17 years old (43%).

6) Data Collection and Analysis

Table 2: SUMI Measurement Criteria

No	Question
	Efficiency
1	The user successfully opens the AR application
2	Users do not feel difficulty in moving from one page to another.
3	Users can easily use the available features.
4	The desired results of an activity can be obtained by the user, such as a material menu that will appear after the user presses the material button.
5	This application can help users in carrying out teaching and learning process activities.
	Affect
6	This application is recommended for use.
7	This application makes users feel satisfied and happy when using it.
8	Users plan to utilize this application in learning activities.
9	The appearance of this application is good enough to attract users to try it.
10	The menus available in this application are easily visible to the user.
	Helpfullness
11	The availability of features and functions can help users.
12	The information provided in the application is easy to understand.
13	The layout for each menu is easy for the user to explore.
14	Information when running scan markers in Augmented Reality is beneficial, such as ensuring the camera is in good lighting.
15	Users get reminder information if the marker being scanned encounters problems or errors.
	Controlability
16	The application never stops suddenly while in use.
17	The application is easy to access again.
18	Users feel familiar with existing features.
19	The user controls the application completely.
20	This application is fast enough to respond to actions/activities from the user.
	Learnability
21	It takes little time to learn the application.
22	Users have used all the existing features.
23	Users do not need a manual to use this application.
24	The features or functions in the application are easy to remember when reaccessed.
25	I did not find it challenging to use this application even though it was my first time.

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RESULT

The learning media developed is an AR multiple marker application that can assist plant tissue learning activities in class XI. This application system is an application that can detect markers using the user pointing the smartphone camera at the marker object; if so, then the marker, a 3D virtual object will appear, which is displayed in real-time, as shown in Figure 8 and Figure 10. Before that, if you do not have a marker, go to the instructions menu; this guide menu has instructions on how to use this application. Namely, we download the marker first on the button; after the marker is ready, we then detect the marker that has been downloaded, which can be seen in Figure 6. Object virtual 3D can be displayed in the form of plant parts divided into 2, namely meristem tissue and mature tissue. In meristem tissues, there are apical meristems, intercalary meristems, and lateral meristems; mature tissues include protective tissue, ground tissue, reinforcing tissue, and transport tissue.

Figure 6 : Display of the help menu   Figure 7: Material menu display

In Figure 7, the material menu section of this application will display a summary of the prepared lesson material so that users can understand the material first before playing AR. On the material menu, there is an explanation of plant tissue material, starting from an explanation of meristem tissue and mature tissue.
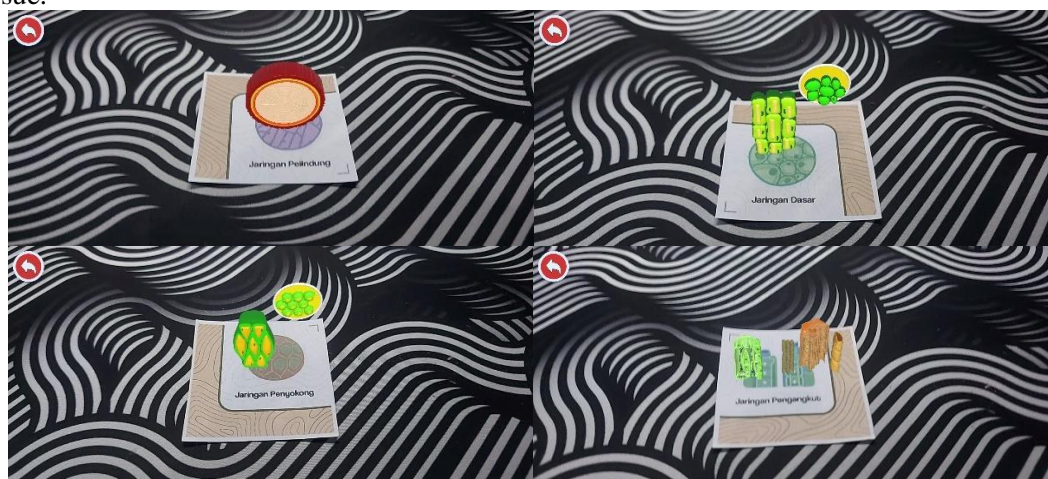

Figure 8: Single marker object display

After students understand the material on the material menu, then students can scan or detect the AR object menu in the application found on the smartphone; if the marker has been detected by the smartphone, a 3D virtual object will appear, following what the marker is scanned, it can be scanned. Observe Figure 8. The objects that come out are parts of the mature network, which includes protective tissue, essential tissue, reinforcing network, and transport network. With AR, students can see in 3D the shape of the fingers of the plant tissue after the students have detected the adult tissue marker.

Figure 8 : Display of multiple marker objects

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After detecting each marker and bringing out a virtual 3D object, students combine the marker images according to the images and instructions that have been conveyed. When finished, students combine markers and then students detect the combined markers; then, a different object will be displayed, namely a combination of these markers, which include protective networks, virtual networks, reinforcing networks, and transport networks, into 3D virtual objects of adult networks as shown in Figure 9.

This study uses the SUMI Instrument Test to test the applications that have been made. The stages of usability testing with the SUMI questionnaire include several items, including Efficiency, Effect, Helpfulness, Controllability, and Learnability. The results obtained in this test can be seen in Table 4, where the Pearson correlation results are more significant than the r table (0.361), and Cornbach's alpha is greater than the reliability test requirement, namely 0.6 so that the results obtained by this system are valid and reliable.

Table 2: Results of the Analysis of the Validity Test and Reliability Test

Nama	N	Mean	Person Correlation	r tabel	Cronbach's Alpha	Information
Efficiency	5	13,9	0,892	0,361	0,934	Valid
Affect	5	10,9	0,823	0,361	0,868	Valid
Helpfullness	5	13,9	0,869	0,361	0,917	Valid
Controlability	5	10,9	0,829	0,361	0,878	Valid
Learnability	5	13,7	0,872	0,361	0,919	Valid

The validity test aims to measure whether this research is accurate or not. Validity is evaluated using the Person Correlation. If the personality correlation is more significant than Table r, then the instrument can be valid, and vice versa. The instrument is declared invalid if the correlation value is less than the r table. In Table 2, all correlations for each question (Q1 to Q25) are higher than the r table (0.361). So each statement meets the valid criteria. The reliability test measures whether the resulting assessment is stable and consistent. This test uses Cronbach's alpha value with a minimum limit of 0.6. It can be seen in Table 2 that all items (Efficiency, Effect, Helpfulness, Controllability, and Learnability) show a value higher than 0.6. Therefore it can be concluded that Cronbach's alpha value for all criteria is acceptable and reliable.

DISCUSSIONS

In learning activities at IT-Alhuda High School, the teacher only uses learning methods such as lectures, textbooks, and PowerPoint during learning activities, which are still inappropriate because students need to understand the material presented. So we need a learning media that can make students able to understand the material better.

Developing interactive learning media based on AR multiple markers uses the 4D method with the use case in Figure 2. Students can download markers already available on the instructions menu and then detect markers until virtual 3D objects appear. If students have detected each marker, students can then detect using multi markers by combining the markers according to the image and material being used. Then the marker will display virtual 3D objects, a combination of these markers.

The tests carried out in this study used the usability test with the SUMI questionnaire, which consisted of several items, namely Efficiency, Affect, Helpfulness, Controllability, and Learnability. The usability test results showed that this questionnaire is valid and reliable in assessing the usefulness of multiple marker AR-based systems shown in Table 3. The validity test on each item produces a person correlation of 0.892 (Efficiency), 0.823 (Affect), 0.869 (Helpfulness), 0.829 (Controllability)), and 0.872 (Learnability), where the results obtained are more significant than r table (0.361), it can be concluded that the validity test was successful for each item. In addition, the reliability test for each item produced Cornbach's alpha greater than 0.6, namely 0.934 (Efficiency), 0.868 (Affect), 0.917 (Helpfulness), 0.878 (Controllability), and 0.919 (Learnability). This shows that the AR application can be said to be valid or reliable. So with the AR multiple marker-based interactive learning media that can visualize 3D virtual objects in real-time, it can make students more understanding and interact with the material presented.

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CONCLUSION

Based on the results of the discussion, it can be concluded that interactive learning media based on AR multiple markers developed in this study can be used as learning media so that students are more accessible and more interactive in understanding the learning material delivered by teachers at school. In addition, the evaluation carried out using the SUMI questionnaire on multiple marker AR learning media showed that in the validity test and reliability test, the value of each parameter was more than 0.6, which stated that it was reliable.

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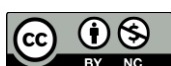
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