Student Perceptions of Augmented Reality (AR) Media in Calculus Courses

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Abstract. Learning media plays an important role in the learning process. The development of technology and science also has an impact on the development of learning media. One of the learning media developments that are currently still new is learning media using Augmented Reality. Augmented Reality is an application that combines the real world with the virtual world in two-dimensional or three-dimensional form which is projected in the real environment at the same time. This research is a descriptive study conducted by using a questionnaire to students. The descriptive analysis in this study examines students' perceptions of Augmented Reality media in Calculus Learning. Augmented Reality media response in terms of aspects of Media Design, Material Content and Benefits. The results obtained by an average Augmented Reality media design is 85.7 with a decent category, the average Augmented Reality Media Material Content is 83 with a decent category and the average aspect of benefits is 83.5 with a decent category. Based on the data, the score for the observation aspect of AR learning media is 84.07 with a decent category. However, many improvements are needed, including a reduction in application capacity and 3-dimensional display.

Keywords: Augmented Reality, Learning Media, Student Perceptions

1. Introduction

Education is one of the important things to determine the progress of a nation because education is one of the processes of producing quality future generations to build the nation into a developed country. It is stated that education which plays a major role in the implementation of learning in schools and an integral part of a nation, even the progress or decline of the quality of a nation can be measured by advancing or not in the education sector. If you want to advance a nation, the first thing that must be done is to improve the quality of existing education. [1]

In its implementation, education must keep up with the times. As we know, the development of education in the world today cannot be separated from the development of the industrial revolution that is taking place in the world, because indirectly changes in the economic order also change the educational system in a country [2]. Along with the development of the Industrial revolution which has entered the stage of the 4.0 industrial revolution, the world of education must also be able to adjust to increased connectivity, interaction and development of digital, artificial, and virtual systems. This condition is known as the 4.0 Industrial Revolution Era Education.

Education 4.0 is a response to the needs of the 4.0 industrial revolution where people and technology are aligned to create new opportunities creatively and innovatively. Fisk (2017) explains "that the new vision of learning promotes learners to learn not only skills and knowledge that are needed but also to identify the source to learn these skills and knowledge.” [3]
A good learning process must be able to create an interactive atmosphere, fun, motivate interest and provide space for students to be able to develop creativity and independent learning [4]. During the pandemic learning period, learning will depend on digital technology or often referred to as e learning. Therefore, it is necessary to have an interactive learning media and guide students' learning independence. Learning activities as expected above are supported by several factors, including learning media.

Learning media is a tool that can help the teaching and learning process so that the meaning of the message conveyed becomes clearer and the objectives of education or learning can be achieved effectively and efficiently [5]. Learning media also plays an important role in the learning process. The development of technology and science also has an impact on the development of learning media. When the world of education is required to develop, the elements in it including learning media must be developed. in other words, the development of learning media can be carried out based on technology and information systems [6].

For teachers, learning media helps to concrete concepts or ideas and helps motivate active learning participants. For students, the media can be a bridge to think critically and act [7]. It can be said that the function and benefits of learning media are to clarify the presentation, facilitate learning, overcome the limitations of space, time and sensory power, generate learning motivation, overcome the passive attitudes of students, increase understanding of the material.

One of the developments in learning media that is currently still new is learning media using Augmented Reality. Augmented Reality (AR) can be defined as a technology that is able to combine virtual objects in two dimensions or three dimensions into a real environment and then bring it up or project it in real time [4]. The development of AR itself began with the discovery of sensorama with visuals, vibrations and smells by Morton Heilig in 1957-1962 [8].

The AR concept was first introduced by Thomas P. Caudell in 1990 in The Term 'Augmented Reality'. There are three characteristics that state a technology applies the AR concept [4]:
1. Able to combine the real world and the virtual world.
2. Able to provide information in an interactive and realtime manner.
3. Able to display in three dimensions.

Mobile AR was first developed by Bruce Thomes in 2000 and then after that Augmented Reality is increasingly developing in mobile applications. For example, the Wikitude AR Travel Guide was launched in 2008. Currently, the advancement of Augmented Reality system technology is increasing and there are new applications being produced. AR technology has now been applied in various fields, including in the fields of medicine, entertainment, military training, engineering design, education and for media promotion. [9]

The main role of Augmented Reality (AR) is to increase a person's perception of the world around him through the integration of the virtual world and the real world into a new interface [10]. The use of learning applications using AR technology can simplify the teacher's task in presenting material, shorten the duration of time required and can create a more interactive learning atmosphere [11]. The advantage of this application is that it has high interactivity, namely the presence of AR virtual objects that can interact directly with users [12].

Differential calculus is a subject that must be taken by early semester students in the Department of Mathematics Education at Unimed. In the pandemic lecture period, a medium is needed that requires students to be active in learning which makes the learning process more varied and less boring. Based on the researcher's experience of teaching differential calculus, in conditions of learning outside the network students need interactive learning media. so that calculus learning can take place effectively and efficiently.

Considering the success of augmented reality as an interactive learning medium, as researched [13] concluded that augmented reality has great potential in the renewal of mathematics teaching materials. Through Augmented Reality, teachers can create learning media that is fun, interactive, and easy to use. Augmented Reality can also replace learning modules that do not yet exist in schools in virtual or virtual form [4]. Students can still see and use modules like the original module, but in virtual form.
Therefore, Augmented Reality learning media is made for calculus learning. Through this new breakthrough, it is hoped that students will be interested in learning even in a pandemic condition. In addition, it is an effort to keep up with the industrial revolution 4.0, so as to create a learning media that optimizes the use of technology as an educational aid which is expected to be able to produce output that can keep up with or change the times for the better.

2. Research Methods
The research design used is descriptive research with a quantitative approach. Descriptive study is research intended to gather information about the status of an existing symptom, which is the state of the symptom according to what it was at the time the study conducted. Research conducted does not provide treatment, manipulation, or alteration on the independent variables, but describes a condition as is [14]. The approach used is a quantitative description using size, number, or frequency.

This research was conducted in the first semester of mathematics majoring in differential calculus who is undergoing online lectures due to the pandemic. The research data were obtained using a questionnaire that was filled out online by students using the Google Form.

The stages carried out in this study are as follows:

a. AR Media Development.
   The media will be made in the form of an application that will be downloaded on the student's smartphone. The application made will capture the markers contained in the calculus textbook as a means of providing markers. Markerless Augmented Reality begins with an image that is detected using the camera from an Android device in real time, then from the marker, other information will appear virtually (in the form of 2 dimensions, 3 dimensions, video, sound, etc.) on the smartphone screen used by students. More details can be seen in the Figure below. [15]

![AR Workflow](image)

b. AR Media Validation
   Product validation is an activity process to assess whether the product design has been effective or not. This validation is done based on rational thinking, not field facts. Validation is carried out to determine the weaknesses and strengths of the media. Furthermore, it is revised before being tested.

c. Testing on students
   AR media that was inserted into the Calculus textbook was tried out on students.

d. Distribution of response questionnaires
   After 2 weeks of use, the response questionnaire was distributed via google form to see students' perceptions of the use of AR media in calculus learning.
3. Result and discussion
The AR media developed was tested on differential calculus material. The applications needed to build Augmented Reality are unity, blender, android studio and Vuforia and their accounts. AR media that has been developed in the form of an application is distributed to students as shown in Figure 2.

![Image](image1.png)

**Figure 2.** Display Applications on a smartphone

To support its use, students are given softcopy of calculus books in which there is a marker for using Augmented Reality as shown in Figure 3. Students who have installed the application and have printed books can use Augmented Reality media during calculus learning.

![Image](image2.png)

**Figure 3.** Marker view on differential calculus book

After the media was successfully developed, the user response test was carried out in the PSPM 2020 class, majoring in Mathematics Education, as many as 25 students who have downloaded the New Unity Project application.
Figure 4. Display of AR media usage by students

The data obtained were product assessments by students in the form of questionnaire entries as many as 13 statements with 4 answer choices and 2 short questions. The statements in the questionnaire cover aspects of AR media design, AR media material content, and aspects of benefits. Based on the data obtained from the user response test by 25 students, it is known that the results of the value conversion on a scale of four can be seen in Table 1 with standard deviation in formulas (1).

| IntervalScore | Category         |
|---------------|-----------------|
| 87.45         | Very Feasible   |
| 84            | Eligible        |
| 81.05         | Fairly Feasible |
| 77.1          | Not Feasible    |

Table 1. Conversion of mean student responses

| No | Aspect | Mean score | Category |
|----|--------|------------|----------|
| 1  | Media  | 85.7       | Eligible |
| 2  | Material | 83        | Eligible |
| 3  | Benefit | 83.5      | Eligible |
|    | Sum Score Mean | 84.07     | Eligible |

Table 2. Results of Shiva Response Assessment

| IntervalScore | Category         |
|---------------|-----------------|
| 88            | Very Feasible   |
| 85            | Eligible        |
| 82            | Fairly Feasible |
| 79            | Not Feasible    |
Table 4. Conversion of Average Score Scale of Four Material Aspects

| Interval Score | Category     |
|----------------|--------------|
| 83.5 ≤ x ≤ 85 | Very Feasible|
| 82 < x ≤ 83.5 | Eligible     |
| 80.5 < x ≤ 82 | Fairly Feasible|
| 79 < x ≤ 80.5 | Not Feasible |

Table 5. Conversion of Average Score Scale of Four Benefit Aspects

| Interval Score | Category     |
|----------------|--------------|
| 83.75 ≤ x ≤ 86 | Very Feasible|
| 81.5 < x ≤ 83.75 | Eligible     |
| 79.25 < x ≤ 81.5 | Fairly Feasible|
| 77 < x ≤ 79.25 | Not Feasible |

Standard Deviation of Student Response Score, namely:

\[
s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}
\]

\[
s = \sqrt{\frac{2141.12}{24}}
\]

\[
s = \sqrt{89.21}
\]

\[
s = 9.44
\]  \hspace{1cm} (1)

Overall student response

From the results of the questionnaire given to students:

1. Media

Based on table 3, the mean score obtained for the use of the media is 85.7 with the feasible category. From the results of the questionnaire analysis in the form of direct questions, it was concluded that the learning media based on Augmented Reality (AR) used were interesting, the text and video displayed when the marker scan was clear. The use of AR media will be difficult for students who do not print calculus books that have been distributed in soft copies. AR media requires a large capacity, so if the cellphone does not have a large capacity, it cannot download AR applications, because not all students have cellphones with large storage capacities. When using AR media, students find it difficult because they have to scan the marker continuously if they want to see the learning video. Media AR requires quite a lot of quota. (due to the marker based AR method)

2. Material

Based on table 4, the mean score obtained for calculus material in AR media is 83 with the feasible category. From the results of the questionnaire analysis in the form of direct questions, it was concluded that the differential calculus material contained in AR media was easy to understand and in accordance with the learning objectives, the language used was communicative and could help in understanding the material.

3. Benefits

Based on table 5, the mean score obtained for the use of media is 83.5 with the feasible category. From the results of the questionnaire analysis in the form of direct questions, it was concluded that AR media was useful for use during learning, because there were learning
videos that made it easier for students to understand learning. Presentation of material helps students understand questions and can support learning calculus.

4. Conclusions
From all aspects of observation, it can be concluded that students’ perceptions of the use of AR media in calculus learning based on the observation aspect score of AR learning media are 84.07 with a feasible category. This value is obtained from the observation score of the media, material and benefits aspects provided to students. As for the aspect of AR Media used an average score of 85.7 with a decent category, the material aspect in AR media with an average score of 83 in the feasible category and aspects of the benefits of AR media used were 83.5 with a decent category. From the analysis of the questions given to students, suggestions and input can be described on the development of AR media by students where overall the use of AR media is very interesting, especially this media is being used for the first time in learning. Input from students hopes that the display of AR media used can be in 3-dimensional form, the application capacity is not too large, the AR method is not marker based but on the markless method which does not need to use barcode scanner scans and can play video material without having to continuously point the smartphone on the marker.

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