Using Augmented Reality Media in Three-Dimensional Geometric Shape Material

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\textbf{Abstract.} This research was a development research with a mix method approach. This study aimed to develop augmented reality learning media that was used to help students visualize three-dimensional mathematical objects. Important research because could replace the use of teaching tools that were limited in number, so they could assist teachers in learning process. This research was based on the Plomp model so that it consists of four phases as the following: (1) Preliminary assessment; (2) Designing; (3) Realization; and (4) Tests, Evaluations, and Revisions. The purpose of this study was to examine the validity, implementation, and effectiveness of augmented reality media. The results of this study revealed that augmented reality media was valid to use based on the results of expert validation, practical to use based on the observation sheet of teacher learning and response implementation, and effective to use based on learning outcome tests and student response questionnaires.

\textbf{Keywords:} Learning Media, Augmented Reality, Geometry

\section{Introduction}
The quite challenging of mathematics material to teach was Three-Dimensional. One of the difficulties was faced by a teacher in teaching three dimensional is that the students difficult to imagine how the actual shape in geometry. According to [1], the lesson that contains abstract objects such as three dimensional is difficult to understand by students and to explain by the teacher. The teachers are less creativity and innovation to create their own teaching tools. Sometimes teachers use only a two-dimensional plane so that the actual geometry is less visualization. Some teachers also use manipulative media like geometry structure, but the media was limited. As technology develops, there is a technology to visualize geometry objects into a three-dimensional shape called Augmented Reality to solve this problem. This is an android based so that the students can use them properly. Especially, 98\% of students in South East Asia have been used gadget nowadays [2]. This leads the authors to investigate the usage of augmented reality media to visualize the learning object in three-dimensional material in mathematics.

The term Augmented Reality was proposed by many experts. According to [3], Augmented Reality (AR) is a direct or indirect presentation of a real object and added/augmented the virtual data from the computer inside it. There are two methods to describe AR; wide and narrow method. The wide method is a technology that gives feedback as an object while the narrow method is the user uses a screen to observe the real world [4]. The other opinion about AR in wide approach was stated by [5], AR is some technologies that mixe real and virtual information so that users can get beneficial experiences. AR may allow the users to observe the real world, with an additional virtual object which combined in real-time.
Moreover, AR could be developed by varied hardware, such as head-mounted display, hand-held devices, desktop, laptop, handphone, etc. Although many definitions explain AR in general, the definition establishes on Milgram Reality Virtuality Continuum. This definition is presented in figure 1.

The Virtual-Reality Milgram series is a scale from a real condition that can observe the real world with the virtual condition. In this scope, the border between the real world and virtual condition named as Mixed Reality (MR). It has two elements; Augmented Reality and Augmented Virtuality. AR is a combination of a real and artificial object which consists of some virtual data [6]. Based on the definitions above we can conclude that Augmented Reality is an environment of the real world combine with virtual data as an object.

[7] also mentioned that the construction of an AR (Augmented Reality) system needs some items such as (1) a 3D model from an object will be combined with the real-world; (2) Calibration of correspondence between a real-world with the 3D model; (3) Tracking which was used to determine the point of view from user towards the real word; (4) Real-Time Display from original image and computer graphic based on the model; and (5) Response time to movement and accuracy between image and graphic affect the effectiveness of the system, greatly. This system is used on a smartphone with android based. Android is an open-source of operation system and google releases its code under license from Apache. This code with open source and legal license on android may allow the software which is freely modified and distributed by the developer. Furthermore, Android has many developer communities that enlarge the device’s functionality. It was generally transcribed in Java programming [8]. The application of the flow chart is described in figure 2.

![Flow Chart](image)

**Figure. 1** Milgram’s reality-virtuality continuum (Cerqueira C and Kirner C, 2012)

**Figure. 2** Augmented Reality’s Scheme

According to [9], some points need in Augmented Reality construction, such as (1) Marker or the sign, is a tracking method that usually uses in AR application, because it has a simple identification
system. The marker accurate was affected in Augmented Reality; (2) Unity is a game engine that routine
to design, apply, and create a game. Unity can be used to develop a multi-platform game which easy to
practice; (3) Vuforia is a Development Augmented Reality supportive library on Android. By using the
marker, Vuforia can analyze an image and produce 3D information from the marker that has been
detected through API. Vuforia also allows to develop 3D virtual object on camera; (4) Head Mounted
Display (HMD) was used as entertainment media, for example, a game; (5) 3D object display was
costumed to design and process a virtual object seem a real object.

In this study, the author made an AR system with using Unity and Vuforia. As mentioned before,
three-dimensional material will combine with augmented reality media. The materials inculede: (1) The
position of points, lines, and planes, (2) Define the length of points, lines, and planes; and (3) Define
the amount of the area in a plane. All of the material needs good imagination and visualization.

2. Methodology
This study is a development research with mixed-method based on the Plomp model [10]. The subject
of this study was the students in class 12 IPA and teachers at SMA Negeri (Senior High School) 15
Makassar which not forbidden the students to take the smartphone at school. This study develops
learning media for a three-dimensional object equipped with a marker to use Augmented Reality (AR)
media. This will help the students to understand a three-dimensional object. This study adopted the
Plomp model [10], which consist of stages (1) preliminary investigation is a curriculum identification,
learning analysis, and technology analysis; (2) design, is an organization of augmented reality learning
media, three-dimensional learning module, filling the validation questionnaire, evaluation of students
learning outcomes, student response questionnaire, and teachers response questionnaire towards the
learning media; (3) realization/construction is a model comprehension from stage 2; and (4) test,
evaluation, and revision which focus on two things, i.e validate and test in real study subject. This stage
will perform some following analysis:

2.1 Validation Analysis
Lawshe & Martuza [11] reviewed a statistic method to determine the substance and reliability of a test
through expert appraisal. Overall, the relevance between two experts turns out to be substance validity.
Gregory [11] offered a method to establish the overall substance validity as coefficient validity. The
deal between experts in substance validity is shown in Table 1. To ensure which attitude appraisal
instrument had been valid, the deal between validator at least must have ‘a strong relevance’. If the
result of coefficient validity is high (V > 75%), it means the measurement result was valid [11]. The
validity of an instrument is presented in Table 2.

| Table 1. The Deal model between experts for substance validity [11] |
|---------------------------------------------------------------|
| 2nd Expert Assessment                                         | Low relevance | High relevance |
| 1st Expert Assessment                                         |               |               |
| Low relevance (score range 1 or 2)                           | A             | B             |
| High relevance (score range 3 or 4)                          | C             | D             |
Table 2. Average data conversion into qualitative data [12]

| Average Score Interval | Classification |
|------------------------|----------------|
| $\bar{x} > 4.8$        | Very valid     |
| $3.6 < \bar{x} \leq 4.8$ | Valid          |
| $2.4 < \bar{x} \leq 3.6$ | Good           |
| $1.2 < \bar{x} \leq 2.4$ | Less valid     |
| $\bar{x} \leq 1.2$     | Less than valid|

2.2 Analysis of Learning Compliance
The learning compliance data was obtained from an observation sheet which observed during the learning process. The analysis was done of appraisal results from an observer on the learning process using augmented reality media. The category of learning compliance can be seen in Table 3. This compliance can be measured if the learning process at least partially done (Mulbar, 2013).

Table 3. Learning compliance category [13]

| Range          | Explanation       |
|----------------|-------------------|
| $T < 2.5$      | Unhappen          |
| $2.5 \leq T < 3.5$ | Some parts completed |
| $3.5 \leq T < 4.5$ | Almost completed  |
| $4.5 \leq T$   | Completed         |

2.3 Analysis of Effectiveness
This study search for the data about effectiveness in learning media, which use simple data analysis technique to get the percentage of effectiveness in counting the resulting test. The instruments were used to measure the effectiveness of a learning media were learning outcome tests and students questionnaire towards the learning media. The effectiveness criteria are performed in Table 4.

Table 4. Effectiveness Criteria [14]

| Average Score Interval | Classification |
|------------------------|----------------|
| 1%-24%                 | Not effective  |
| 25%-49%                | Less than effective |
| 50%-74%                | Less effective |
| 75%-100%               | Effective      |

3. Results and Discussion
This study obtains a product as an android based on augmented reality learning media in three-dimensional for class XII. This media was designed by using Unity and Vuforia. The 3D model was fabricated using Blender, and for developing the model was utilized Plomp model (initial assessment (preliminary investigation), design, realization/construction, test, evaluation, and revision/improvement, and implementation). This stages can be explained as follow:

3.1. Preliminary Investigation
The initial assessment is the first step that must take before the study was performed. The result from this stage is used as guidelines and considerations in preparing the augmented reality media. Three analyses are used in this stage. Firstly, curriculum analysis is a 2013 curriculum used by SMA 15 Makassar in the three-dimensional study material. The next stage is learning analysis with interviewed
the teachers and students in SMA 15 Makassar. The result showed that the teachers were not applied yet a learning media with multimedia based. The teacher still used the lecture method and assignment to students because of lacking demonstration media. To illustrate three-dimensional, the teachers usually use two-dimensional pictures and classrooms as media to describe three-dimensional geometry. According to teachers, through this augmented reality, the student more enthusiastic in the learning process, while the students will be facilitated with this media in understanding the characteristic of diagonals in three-dimensional objects. The last is technical analysis, a study about the compatibility of augmented reality as learning media. Corresponding to this initial assessment was obtained that augmented reality in education especially in mathematics, has many advantages in three-dimensional geometry, particularly. For example, the students will get a better perspective in visualizing the three-dimensional objects, aid the students to identify the characteristic of three-dimensional visually, and resolve the problem of lacking the learning media. From these advantages, the augmented reality is appropriate to develop as learning media in three-dimensional geometry material.

3.2. Design
This phase was aimed to design the problem solving which have identified in the first phase. In this stage, the augmented reality media will design. The author made a flow chart design to describe the use of augmented reality process. Then, the material which was adapted from the indicator will organize in this stage with the purpose of the well-defined scheme when using the media as follow the understand the material.

3.3 Realization
This stage is the construction of augmented reality media. At this stage, the author initiates the media by using the vuforia and unity. This media was developed by using Unity 5.3 and some reinforcement software such as Blender, Microsoft PowerPoint, Corel Draw, and Bandicam. The advance of this media was made based on indicators on the syllabus for class XII. After that, these indicators were converted into a flow chart and storyboard. A Flow chart is a parameter to unite between the menu, whereas the storyboard was utilized to guidelines to fill in the material based on the flow chart [15]. The type of augmented reality media in this study is user-friendly multimedia. It means simple and easy to use without confusing the students. Students only need to scan on the marker to use this media. Figure 3 shown the AR media.

Figure 3 Augmented Reality in Three Dimension Materia
Figure 3 shown that the result of multimedia development consists of two parts; application and marker. The application was divided into the main menu and content. In the main menu, there is four sub-menus. It contains an AR menu, explanation, direction, and exit. Augmented reality was pointed on
the AR menu, directly. The explanation menu will lead the students to material explanation video. After that, the direction menu comprises of guidelines to use augmented reality media. The last, the exit menu will stop the program. The next item is a marker, the authors display the markers that are used for three-dimensional material into a subtitle which was easy-accessed by students. It made the material well-organized. The marker for this media was arranged as print out. The process of this AR application is presented in Figure 4. Click on ‘Start AR’ then the visualization image will appear. But, it must be considered that the smartphone camera faced the designing image.

![Figure 4. Augmented Reality’s work](image)

3.4 Test, Evaluation, and Revision

This stage focuses on two systems; validate and try out. Before doing try out, it must be validated by experts to get the improvements until the better learning media was constructed. Moreover, each expert was given the questionnaire to scoring with a scale of 1 to 5. The validation result of augmented reality media was revealed in Tables 5 and 6 below:

| Table 5. Result Validity Description of 1st Expert on Augmented Reality Media |
|---------------------------------|-----------------|-----------------|
| No       | Aspects          | Average Score   | Category       |
| 1        | Content quality  | 3.67            | Valid          |
| 2        | Learning quality | 3.37            | Less valid     |
| 3        | Display interaction | 3.86          | Valid          |
| 4        | Display quality  | 3.56            | Less valid     |
|  | Average Score    | 3.62            | Valid          |

| Table 6. Result Validity Description of 2nd Expert on Augmented Reality Media |
|---------------------------------|-----------------|-----------------|
| No       | Aspects          | Average Score   | Category       |
| 1        | Content quality  | 4.20            | Valid          |
| 2        | Learning quality | 3.51            | Less valid     |
| 3        | Display interaction | 3.33          | Less valid     |
| 4        | Display quality  | 3.50            | Less valid     |
|  | Average Score    | 3.64            | Valid          |

As mentioned in Table 2, that developing augmented reality media reached a valid category with an accomplishment score is 3.62 and 3.64. This assessment includes content quality, learning quality, display interaction, and quality. According to validation results from two experts, it can be concluded that augmented reality media was valid to examine in real subjects. However, each expert gave the notes or comments on the questionnaire. Then, the author will revise and improve the part of augmented reality media. After the improvement was finished, a limited try out was held on students in class XII IPA 5. This aimed to obtain learning compliance and effectiveness.
3.4.1 Learning Compliance Analysis

This analysis was done to measure the teacher’s capability to supervise in the learning process. In this stage was used the questionnaire to assess that the learning stages were complete and to evaluate the teacher’s skill in teaching. It was assumed that all the stages well-finished it means learning design was comprehended. The teacher skill in learning supervise was establish in five phases, such as (1) Students oriented to a problem. This involves four activities include greeting and praying, checking the attendance, giving motivation, and environment observation and correlate it with three-dimensional material. The teacher obtains an average 5 on this phase with the completed category; (2) Students organizing. In this phase, the teacher divided the students into some groups, each group made up of 5-6 students. This group was aimed at media sharing for students about problems and given information. This stage the teacher gets an average 4 score with the almost completed category; (3) Leading the individual exploration. This phase consists of five activities such as the students have to monitor the learning media, write the monitoring result in the group, seek the differences from material on media, teacher ask students to give an example from the material, and the teacher guide them to solve the problem based on the illustration was given. The result was almost done with an average 4 score; (4) Develop and present the attainment. There are two activities in this stage, the group delegation presented their discussion result and the rest of the students analyze the other groups and give responses and corrections. The average score was 3,6 and include mainly complete; and the last (5) Analyze and evaluate the problem-solving process. The teacher guides the students to analyze and evaluate the answer of each group to get the conclusion. Each student attempt to combine their idea and refuse everything outside the concept. The teacher acted as a mediator. The average score was 4 as the category was almost complete. Based on the compliance analysis, it was found that the mean result of the learning compliance was 4,09 and according to Table 3, it was almost complete.

3.4.2 Effectiveness Analysis of Learning Media

The effectiveness of a learning media was measured on students’ questionnaires toward the augmented reality media and learning outcome. It was assessed with effectiveness criteria in Table 4 and was measured using students’ questionnaires. It has three aspects; first (a) content and purpose, with a positive response about 82,07% with the effective category; (b) technique quality aspect, with 84,12% positive responses as an effective category; and (c) learning and instructional quality, 86,26% positive responses with effective category too. Therefore, it can be concluded that the average response of three aspects was 84,41% with an effective category.

The outcome of learning in this study used the essay test which comprises five questions. The first and second questions were a structured question. The test was given to students after they completed the learning process with augmented reality media. According to KKM mathematics in SMA 15 Makassar, the individual completeness score was 75. It was summarized in Table 7.

| No | Category   | Total | Percentage % |
|----|------------|-------|--------------|
| 1. | Completed  | 22    | 85,19        |
| 2. | Incomplete | 5     | 14,81        |
| Total |          | 27    | 100          |

Table 7 above shows that the completeness score increased to 85,19%. It can be inferred that augmented reality media was effective based on the outcome learning score. As the score classification of the student in this study is shown in Table 8.

| Tabel 8. Student’s Score Result Category |
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Referring to the student response questionnaire toward learning media and outcomes, it can be concluded that augmented reality media satisfied the effectiveness criteria and can be used without revision.

4. Conclusions
Based on the study on students class XII at SMA 15 Makassar, it can be concluded some conclusions. (1) Augmented reality media was used as valid media in learning three-dimensional. It corresponded with result validity by the first expert with compliance score and the second expert was 3.62 and 3.68, respectively. This media can be tested; (2) Augmented reality media qualified as learning media for three-dimensional material. This was shown by the compliance result questionnaire and teacher response toward the media, and (3) This media was effective as learning media based on student questionnaires.

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