Calcu card: Developing augmented reality-based learning media on the three-dimensional shapes with curves lesson for junior high school student

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Abstract. This study aims to: 1) produce Augmented Reality-based Calcu Card learning media on the Three-Dimensional Shapes with Curves lessons that are valid, practical, and effective, 2) test the suitability of applying the learning media to determine the application effect. The subjects of study were 9th Grade Student of SMP Pesantren Guppi Samata. The development model was using the PIE development model or plan, implement, and evaluate. Meanwhile, the data to be collected were in the form of questionnaires and learning outcomes tests. This research was carried out in 2 ways, namely first a small-scale test for the 9th Grade Student, then a large-scale test for 9th Grade Student of SMP Pesantren Guppi Samata, they were 20 students. The results showed that the average validator's assessment of the Calcu Card application was 3.25. Based on the student assessment, it can be obtained that the average response of students through a questionnaire to the Calcu Card application was 3.19. Furthermore, the percentage of students 'completeness was 75% while the percentage of students' incompleteness was 25%. Therefore, it can be concluded that the Augmented Reality-based Calcu Card learning media is suitable for 9th Grade Student of SMP Guppi Samata by meeting the criteria of validity, practicality, and effectiveness.

1. Introduction

The rapid development of science and technology requires a person to master various information and knowledge. So, it takes the ability to be able to obtain, select, and process various kinds of information and knowledge. These abilities require critical, systematic, logical, and creative thinking. On the other hand, education is an important part of human life. Because through education, humans can develop themselves so that they are able to face various changes that occur as the advances of science and technology. Therefore, by looking at the important role of education, an educational program is needed that can develop critical, systematic, logical, and creative thinking and prepare the nation's successor who is able to face the various changes that occur due to the advances of science and technology. One of the educational programs that can develop critical, systematic, logical, and creative thinking skills is mathematics.

Mathematics is a very important branch of science because it is the foundation of several other branches of knowledge. Mathematics is a science that is learned from the primary school level to the tertiary level. According to Law No. 20 of 2003 article 37 paragraph 1, it states that the primary and secondary education curriculum is required to contain mathematics. This shows that mathematics is very important to learn. However, mathematics is one of the subjects that is less attractive for students, this
occurs because students assume that mathematics is a difficult subject and less interesting learning for students so that they are reluctant to study mathematics more deeply. Therefore, interesting learning must be done to positively respond from students to mathematics [1]. To support the achievement of mathematics learning objectives, it needs efforts to improve the quality and results of mathematics learning. In this case, a mathematics teacher must have broad insight into various methods or strategies of learning mathematics. Teacher-centered learning should be transformed into student-centered learning. Learning that is not teacher-centered helps students build their own understanding while they act as facilitators [2].

Gunawan in [2] argued that teachers are planners, implementers, and evaluators of classroom learning, so students are directly involved in the process to achieve educational goals. According to Supatmono[3], this teaching staff factor is considered to be the main cause of students having low interest in mathematics. Supatmono[3], if it is compared with other fields of study, teaching staff in mathematics is the most irritating towards their students. Therefore, we need a solution to improve the quality of mathematics learning. Implementation of the 2013 curriculum requires teachers to be more creative in the learning process. In the implementation, teachers must have various concepts that are able to make students enjoy the learning process. One way to improve the quality of learning is the use of instructional media. The use of media in the learning process cannot be separated from the role of the teacher in it. Currently, technology media is needed which can be used anywhere and anytime [4].

Learning media is a physical component that is useful for educators/teachers to convey information so that learning objectives can be achieved [5]. According to Ariani [6], learning media is a practice media in the development, utilization, management, and assessment of the learning process. Learning media also functions as a supplement, which means that this makes e-learning as an additional learning resource that can enrich students’ knowledge [7].

Media has a long history as a forum for education, a forum for politics, a place for entertainment, and as a forum for political aspirations. The media has modernized, which means changing from traditional to be more advanced [8]. “Technology is growing rapidly, it can be seen from various activities that have been supported by technology [9]. “Now, as we enter a new world of global digital communication, it is no surprise that there is a growing interest in the relations between mobile technology and learning” [10]. “A theory of learning must be based on contemporary accounts of practices that enable successful learning” [11]. According to Usman [12], the media that is presented or used in the teaching and learning process is designed according to the student’s needs. Therefore, mobile learning must take into account the ubiquitous use of personal and shared technology.

Technology is a broad term relating to the use and knowledge of tools and skills [13]. Technology is currently being used in the learning process so that learning technology can be anywhere and anytime [14]. Of course in technology, innovation is also needed so that students not only learn and understand, but they are more critical in identifying problems or materials related to life and finding solutions [15]. Figueredo [16] said that in some countries, many teachers and students do not use learning technology in teaching, even though this is very important to indicate that students are the technology generation. Smartphone is also an important thing for teachers and students in everyday life. So it is important to use a smartphone in learning [17]. According to Hapsari, Wibawanto, & Sudana [18], the use of mobile phones can be applied as a medium of learning via mobile devices or mobile learning that aims the learning to be done anywhere. Students nowadays use smart phones more for playing games than studying, they are able to spend 10,000 hours playing games but spend less than 5,000 hours studying, students today represent the first generation who grew up with this new technology [19].

An education communication and technology AECT (Association Education Community And Technology) is the originator of learning activities accompanied by technology [20] which said that educational technology is not only a media and a field of science but a process that connects people, ideas, and media [21]. Not only that, according to AECT, learning technology is complex because it is not only a learning media but also analyzing a problem and finding solutions that are related and always developed [22]. Media and technology that support mathematics have increased and developed, such as
the use of online education or the internet, the web is able to encourage the metacognitive abilities of students [23]. There are several applications that can be accessed such as online learning forums or internet-based e-Learning which are easier to use and help teachers to be more creative in the learning process and improve the quality of their teaching [24].

Some teachers still use conventional learning media, where they only convey information, explain material on the blackboard, and give assignments to do at home. Meanwhile, students only listen to the material and do the assignments given. So that to attract the attention of students in the industrial era of 4.0, the subjects addressed are very difficult, especially in the material of geometry in junior high schools, because the material in mathematics contains many formulas that are somewhat difficult to understand and difficult to remember for students of junior high school. According to Saefi, Lukiat, & Suarsini [25] Students’ Cognitive Comprehension 2017, “Learning Media facilitate students to learn wherever and whenever so that the frequency of student learning can be higher graduate to high student retention”.

Based on the author's observations in the field, the teaching staff at the SMP Pesantren Guppi Samata did not use any learning media at all in teaching Mathematics. What is done during the teaching and learning process was only delivering material and then giving assignments or exercises at school and homework. Therefore, in the industrial era 4.0, all educators are deemed necessary to modify or improve the learning media used during the learning process, especially in the field of mathematics studies in Geometry materials. This is because students in this era are the millennial generation who are greatly influenced by the rapid development of technology, so to attract their attention and interest, it is also necessary to apply this technology development to their learning process. The combination of Augmented Reality with the concept of education is one example of technology that is often developed in this industrial era 4.0. Augmented Reality with educational content can create new applications that are useful to increase the attractiveness of teaching and learning for students. Augmented Reality-based applications are also considered superior because they can run on Android [26]. From this description, the researcher is interested in developing a calcu card learning media based on augmented reality of the Three-Dimensional Shapes with Curves material for 9th Grade Student of SMP Pesantren Guppi Samata. The Augmented Reality based Calcu Card application is applied to the android platform by using a card as a supporting tool for the application. This application is expected to increase students' interest in learning, especially in the field of Mathematics, the material of Three-Dimensional Shapes with Curves. Through the Augmented Reality-based Calcu Card application with the PIE development model, the concept that students accept will be more interesting and fun so that it can attract attention especially those who have low interest in Mathematics.

2. Methods
This type of research used by the author was a research development. This means that this research was to develop a product, namely the Augmented Reality based-Calcu Card learning media. This development research was expected to be able to produce quality new products. In addition, this research was not conducted to test a hypothesis, but the output produced was a product that was developed. This research and development activity was based on several basic reasons, combining essential elements to create a new product. Some of the media and learning technology development models that the author used were the PIE Model. The PIE model (Plan, Implement, and Evaluate). This model was developed by Timonty J. Newby, Donald A. Stepich, James D. Lehman, James D. Russel, and Anne Ottenbreit-Leftwich. This model is especially for the development of learning technology that can be used by educators and students in implementing learning. This PIE model consists of three components, namely planning, implementation and evaluation.

a. Planning, planning is focused on product design and what students really need to learn, including when, why, and how to effectively obtain quality learning outcomes. In this planning stage, conceptual patterns, steps, and designs are drawn up that will be applied to the program or product in its development process.
b. Implementation, implementation is focused on putting planning into action based on the constraints and obstacles that may occur using pre-selected learning materials, and various forms of activities that support the implementation of learning. At this stage, it can be seen how the appearance or utilization of the product is.

c. Evaluation, emphasizes how to assess the effectiveness of media, technology, strategies, and learning materials. At this stage, it is known what the advantages and disadvantages of the product are [20].

The application development stages consist of drafting, designing, manufacturing, and distributing.

a. Drafting, the concept stage is to determine the goals and characteristics of target user application program. The purpose of making this application is as an Augmented Reality-based learning tool that can attract and increase the interest of students. While the character of target of this application are junior high school students.

b. Designing, this design stage concerns the display style required by the application program being made. At this stage, the AR technology supporting markers are shaped by the Canva application support. The marker is designed according to the character of students who, in fact, are children who like colorful things.

c. Manufacturing, the manufacturing stage is the manufacture of all the materials needed in the application program. At this stage, marker is inputted into the Vuforia SDK which is linked to the Unity 3D application using certain keywords listed in the SDK. At this stage, 3D object is created using the blender application and exported, then inputted into Unity 3D. Within the 3D application, all markers are programmed in such a way to be matched with the corresponding 3D objects.

d. Distributing, this distribution stage, the application is exported with the support of various types of Android platforms and stored on the desired storage media. After that, the application program files are distributed into Android to be used and used as evaluation.

The data collection technique used was validity test data, practicality test data, and effectiveness test data. Validity test data is obtained from the results of validation assessments by experts who will assess two aspects, namely media and material. The criteria for the level of validity of learning media can be seen in table 2. The following are the criteria for the level of validity used as a reference for the validity of learning media, where X is the average value of the product validity aspect.

| Value          | Criteria     |
|----------------|--------------|
| $0 \leq X < 1.5$ | Invalid      |
| $1.5 \leq X < 3$ | Enough Valid |
| $3 \leq X < 4.5$ | Valid        |
| $4.5 \leq X \leq 5$ | Very Valid  |

Practicality test data were obtained from questionnaires to be filled out by students regarding the application of products in the learning process in the classroom. The criteria for the level of practicality of learning media can be seen in table 2. The criteria for the level of practicality used as a reference for the validity of learning media, where $P$ is the average value of the practical aspect of the product.

| Value          | Criteria     |
|----------------|--------------|
| $0 \leq P < 1.5$ | Impractical  |
| $1.5 \leq P < 3$ | Quite Practical |
| $3 \leq P < 4.5$ | Practical    |
| $4.5 \leq P \leq 5$ | Very Practical |

The criteria of practicality level above was used as a reference or guide to find out the results of the practicality of learning media, and where $P$ was the average value of the practical aspect of the product.
Furthermore, the effectiveness test data was obtained from the test results of students in the form of scores from the work on the practice contained in the developed application. The criteria for the effectiveness of learning media can be seen in Table 3 below.

| Percentage of Value | Criteria       |
|---------------------|---------------|
| 0 – 35              | Ineffective   |
| 36 – 70             | Effective     |
| 71 – 90             | Effective     |
| 91 – 100            | Very Effective|

The criteria of effectiveness above was the reference from the test results of the effectiveness of learning media obtained from the test results of students, where the standard value of the KKM used is 76. The results of the effectiveness test that have been analyzed are as follows.

3. Results and Discussion

The procedure in using the Calcu Card application based on Augmented Reality consists of planning, implementing, and evaluating based on the components of the PIE development model used. The description of the components of the application utilization is as follows.

a. Planning. As explained in the application development stage, the Augmented Reality application design used the Vuforia and Blender tools. At first, the markers were designed using the Canva application, then inputted into the Vuforia SDK. Vuforia was given a specific key to connect to Unity. Then, the 3D object was created using the blender software and then exported and inputted to Unity. In Unity, markers and objects were linked in a way. The application program design can be seen in Figure 2.

![Figure 1. Flowchart of the application program](image)

The flow of the application program starts with the main menu display and the "start" button. When the user presses the button, the AR Camera properties will appear. Then, the user shows the card as a code or marker. The application program will automatically identify the marker and display the 3D object rendering based on the marker card. After that, users can exit the application by pressing the "back" button on each Android.

b. Implementation. The result of implementing the above application design was the first marker display that can be seen in Table 4.
| No. | Marker | Explanation |
|-----|--------|-------------|
| 1   | ![Marker 1](image1.png) | This marker is a characteristic marker of a Three-Dimensional Shapes with Curves that functions to display a three-dimensional cone object. |
| 2   | ![Marker 2](image2.png) | This marker is also a characteristic marker that can display three-dimensional spherical objects. |
| 3   | ![Marker 3](image3.png) | This marker is also a characteristic marker as a code for displaying three-dimensional tube objects. |
| 4   | ![Marker 4](image4.png) | This marker is a marker that can display the three-dimensional formula of a cone shape. |
| 5   | ![Marker 5](image5.png) | This marker is also a marker for a three-dimensional formula for the spherical shape. |
| No. | Marker | Explanation |
|-----|--------|-------------|
| 6   | ![Image](Image1.png) | This marker is also a marker as a code that can display the formula of the tube shape. |
| 7   | ![Image](Image2.png) | This marker is the code for the first practice question to display the final answer from the first question. |
| 8   | ![Image](Image3.png) | This marker is a marker for the second question that can display the answer to the second question. |
| 9   | ![Image](Image4.png) | This marker is a code for the third question which functions to display the answer to the third question. |
| 10  | ![Image](Image5.png) | This marker is the fourth question code which serves to display the final answer to the fourth question. |
c. Evaluation. In the third component (evaluation), it consists of the validation stage, the practicality test stage, and the product effectiveness test stage which has respective test criteria as a measuring tool. And at this evaluation stage, the advantages and disadvantages of the product or program that have been implemented will be shown.

- Validation Stage, the following is a summary of the assessment results by the validator regarding the learning media that has been developed.

| Table 5. Validation Results |
|-----------------------------|
| **Aspects of Assessment**   | **Assessment Results** | **Category** |
| Menu Display Design         | 2,5                      | Enough Valid |
| Marker and Object Design    | 4                        | Valid        |
| Material Completeness       | 3,5                      | Valid        |
| Material Content            | 3                        | Valid        |
| Average                     | 3,25                     | Valid        |

Based on table 5 of the validation results above, the average validator's assessment of the Calcu Card application is 3.25. From this average, it can be concluded that the Calcu card application's learning media is in the valid category and it is suitable to use in the learning process for 9th Grade Student of SMP Guppi Samata.

- Practicality Test Stage, the following is a summary of the results of the assessment of the students regarding the learning media that has been developed.

| Table 6. The results of the questionnaire analysis. |
|-----------------------------|
| **No** | **Pernyataan** | **Value** | **Average** |
|      |                | 1 2 3 4 5 |             |
| 1    | The design of the Calcu Card application is unique and attractive. | - - 5 9 6 | 4,05         |
| 2    | I prefer learning to use the Calcu Card application instead of using conventional props | - 2 8 9 1 | 3,45         |
| 3    | The lesson of Three-Dimensional Shapes with Curves is in the complete Calcu Card application | 2 5 7 6 | 2,85         |
| 4    | I gain more knowledge from the Calcu Card application. | 1 3 10 5 | 3,1          |
| 5    | I find it easier to understand the material through the objects displayed in the Calcu Card application. | 2 4 5 7 2 | 3,15         |
| 6    | The images shown are in accordance with the material | - - 10 8 | 2             |
| 7    | The sentences are clear and easy to understand | - 10 9 - | 1,2           |
| 8    | The language presented is very commutative | - 10 7 2 | 1             |

| Sum | 5 34 61 46 14 | 25,55 |
| Average |             | 3,19  |
Based on table 6, it can be obtained that the average response of students through a questionnaire to the Calcu Card application is 3.19. From the average response to the questionnaire, it can be concluded that the learning media of the Calcu Card application are included in the practical category (according to the references or criteria previously described), suitable to apply, and can be used by teachers and students in the learning process in the classroom.

Effectiveness Test Stage, the following is a summary of student learning tests after using the learning media that has been developed.

| Value | Category | Frequency | Percentage |
|-------|----------|-----------|------------|
| 0 – 25| Very Low | -         | 0%         |
| 26 – 50| Low      | 4         | 20%        |
| 51 – 75| Medium   | 1         | 5%         |
| 76 – 87| High     | 12        | 60%        |
| 88 – 100| Very High| 3         | 15%        |

Based on table 7, the percentage of students' completeness is 75% while the percentage of students' incompleteness is 25%. From the results of the effectiveness analysis, it can be concluded that the Calcu Card application learning media is effective and suitable to use in the learning process in the classroom. After conducting a whole series of validity tests, practicality tests, and effectiveness tests, the author has also tested Android applications and found the advantages and limitations of the Calcu Card application learning media. The advantages of learning media for the Calcu Card application are that they are valid, practical, and effective learning media, which can attract students to learn mathematics, as a substitute for 3D props which have a new, unique, and interesting design so that students are more enthusiastic in learning geometry materials of Three-Dimensional Shapes with Curves, has a full color display to strengthen the appeal of students, makes it easier for educators to provide information on the shape of Three-Dimensional Shapes with Curves, formulas and practice questions, can be used anywhere and anytime, easy to carry anywhere, no need internet quota, and the application size is not too big. Agustin & Ambarawati said that the presence of android-based learning is a complement in learning that can facilitate students to relearn material that is not mastered anywhere and anytime [27]. Therefore, it can be concluded that the use of technology-based learning media or Android has a good impact in improving student learning outcomes and can help the quality of teacher learning based on the current student characteristics. Setyaningrum & Waryanto [28] said that today's digital are already familiar with the use of technology, therefore using technology in the learning process is considered to increase student involvement.

4. Conclusion

Based on the description of the results and discussion, it can be seen that: The learning media developed in this study was an Augmented Reality based Calcu Card application learning media that can be used on the android platform without internet quota and it was valid, practical, and effective. This learning media was designed and created using Unity 3D, Vuforia, Canva, and Blender, as well as markers as materials for AR cameras to detect and display objects. The objects displayed in this learning media are the Three-Dimensional Shapes with Curves, the surface area formula and its volume, and practice questions related to the Three-Dimensional Shapes with Curves. The Augmented Reality-based Calcu Card application was used as a mathematical teaching aid, especially in Three-Dimensional Shapes with Curves material to increase the interest of students with a new, unique, and interesting look. The results showed that the average validator's assessment of the Calcu Card application was 3.25. Based on the student assessment, it can be obtained that the average response of students through a questionnaire to the Calcu Card application was 3.19. Furthermore, the percentage of students' completeness was 75% while the percentage of students' incompleteness was 25%. Therefore, it can be concluded that the
Augmented Reality-based Calcu Card learning media is suitable for 9th Grade Student of SMP Guppi Samata by meeting the criteria of validity, practicality, and effectiveness.

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