Development Of Augmented Reality Applications-Flat Geometry And Space In Android-Based Primary School

Eri Widyastuti[1*], Fevi Rahmawati Suwanto[2]

[1,2] Department of Mathematics, State University of Medan,
Jl. Willem Iskandar, Medan, 20221, Indonesia
[*] Corresponding Author:
Email: widyaoke@unimed.ac.id

Abstract.
This study aims to design an Android-based Flat and Spatial Geometry Augmented Reality Application in primary school (SD, Sekolah Dasar) that is valid and practical. This application uses the Vuforia library which is capable of playing sound and displaying animated 3D objects, played by the user in a real environment using the help of books and Android-based smartphones. This research is a Research and Development (R&D) study using the ADDIE model (Analysis, Design, Development, Implementation and Evaluation) to develop Flat and Spatial Geometry Augmented Reality Applications in Elementary Schools as a learning medium that is expected to be able to create a fun and effective learning environment to improve students' mathematical literacy ability. The research subjects were 32 students of class VI at SD Negeri 050660 Kwala Bingai Stabat. The research instruments used in this study included validation sheets to obtain an assessment of the validity of the application, and student response questionnaires to determine the practicality of the application. The results of the research and development show that the Application of Augmented Reality Flat and Spatial Geometry is in very good criteria. The results obtained based on the analysis of the black box test obtained a success percentage of 100% and the white box test obtained a success percentage of 100%. While the average validation score is 90.19% of the total interpretation. In the field test, it was obtained an average practicality percentage of 84.5% from 15 assessment items. So that the application of augmented reality flat geometry and space is included in the very good criteria.

Keywords: *Application development, augmented reality, flat geometry and space, primary school, android.*

I.   INTRODUCTION

Current education is expected to be able to develop students to think creatively, flexibly, solve problems, collaborate and innovative skills needed for success in work and life (Pacific Policy Research Center, 2010). This expectation is reflected in the core competencies in the 2013 Curriculum Content Standards. The cognitive domain core competence (KI) for each subject is to equip students with factual and conceptual knowledge by observing and asking questions based on curiosity about themselves, God's creatures. and its activities, and the objects it encounters at home, at school, and on the playground. The core competence of the skills domain for each subject is presenting factual and conceptual knowledge in clear, systematic, logical and critical language, in aesthetic works, in movements that reflect healthy children, and in actions that reflect the behavior of children of faith and noble character (PerMendikbud , 2018).Based on the Content Standards, mathematics as one of the compulsory subjects is expected to not only equip students with the ability to use calculations or formulas in working on test questions but also be able to involve their reasoning and analytical abilities in solving everyday problems. This is in line with the view of the National Council of Teaching Mathematics (NCTM, 2010) which makes problem solving, reasoning and proof, communication and representation the standard processes in learning mathematics.Improving the quality of education in line with technological developments, contained in Republic of Indonesia Government Regulation Number 19 concerning National Education Standards in chapter 4 regarding process standards, states that "The learning process in educational units is carried out interactively, inspiring, fun, challenging, motivating students to participate active and provide sufficient space for initiative, creativity and independence in accordance with the talents, interests and physical and psychological development of students".

Currently education in Indonesia is influenced by globalization, developments in technology, information, and communication (Asrial et al., 2019). Several technologies have been developed in the field of mathematics, making it easier for students to understand. The widespread use of computers and the internet has driven the development of software (Yalman, 2015). Digital technology has the potential to create new ways for students to construct and understand mathematical knowledge (Bray & Tangney, 2017). Student activities tend to use technology more in all things. This is in accordance with the opinion of Muhasim (2017) that the use of digital technology has become a necessity at all ages. Students in the digital era are the younger generation who live in a world filled with digital equipment and online networks. According to the Ministry of Communication and Informatics (2016) adolescents aged 16-19 years access YouTube more and spend an average of time in front of mobile screens. Students spend more than 6.5 hours a day reading electronic, digital, broadcast and news media (Barni, 2019).In learning geometry in class, for certain topics and levels, the teacher usually presents real objects as props related to the material being studied. The teaching aids presented are not only based on real objects that can be seen, held or touched, but can also be in the form of computer simulations that combine the sophistication of various Information and Communication Technology devices. One of the uses of technology that can be integrated into digital books and interactive learning media is Augmented Reality, or better known as Augmented Reality.Hosch (2021) in the Encyclopedia Britannica states that augmented reality is the process of combining video or photo displays by superimposing images with related computer data.

Augmented Reality is a technology that combines two-dimensional and or three-dimensional virtual objects into a real three-dimensional environment and then projects these virtual objects in real time. It can also be interpreted that Augmented Reality, abbreviated as AR, is the embodiment of objects in the virtual world into the real world in either two dimensions or three dimensions. The advantage of this Augmented Reality method is an attractive visual appearance, because it can display 3D objects that seem to exist in a real environment. The Augmented Reality method also has the advantage of being interactive because it uses markers to display certain 3D objects that are directed to the webcam. In addition, the application of the concepts to be used is expected to increase students' reasoning power and imagination (Azuma, 1997).Research conducted by Nugraha (2013) entitled "Efforts to Improve Student Learning Outcomes in Basic Electronics Materials Using Augmented Reality-Based Learning Media" the results of this study concluded that there were significant differences in learning outcomes for students who were given learning using Augmented-based learning media reality. This is based on an increase in student learning outcomes of 53.98% and is included in the medium criteria. The results of measuring student interest through a questionnaire obtained an average result which was in the good category, students had a sense of enthusiasm and a positive impression of learning by using learning media using Augmented Reality-based learning media. Furthermore, Ismayani A (2022) in her study on AR-Geo Implementation in learning through quasi-experimental research stated that the use of AR-Geo in mathematics learning has an impact on improving student learning outcomes.

Based on the description above, it encourages research that focuses on developing android applications based on augmented reality as learning media to create fun and interesting learning for students in developing mathematical literacy skills. This research seeks to answer the following questions: (1) what are the processes and results of developing valid Android-based Augmented Reality learning media for learning mathematics on flat geometry and space in elementary school? (2) how practical is the use of Android-based Augmented Reality learning media in learning mathematics on flat geometry and space in elementary school?

II.   METHODS

The type of research conducted is Research and Development (R&D), namely research conducted to produce certain products and test the effectiveness of these products (Sugiyono, 2015). The R&D method used follows the ADDIE development model which consists of five stages, namely the Analyze, Design stages. Development, Implementation, and Evaluation. The development design based on the ADDIE model can be seen in Figure 1.
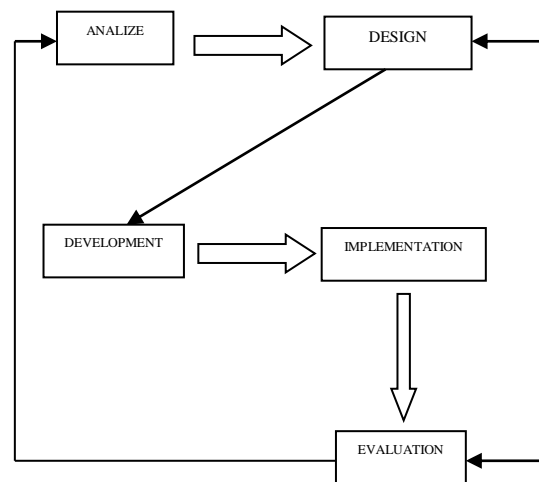
Fig 1.ADDIE Development Model

In the Analyze stage, researchers carry out: (1) needs analysis; (2) analysis of geometry and space competence and material in elementary schools. At the Design stage, researchers carry out application design, software functional models, software architectural designs and application interface designs. The next step is the development stage. At this stage, the researcher carried out the activities of making Augmented Reality applications such as the 3D object modeling stage, the animation process, matching 3D objects with markers, and preparing the Flat and Spatial Geometry teaching module media. At this stage a formative test is also carried out which aims to revise the application according to the assessment and suggestions for improvement provided by content experts and media experts.Next is the Implementation stage. At this stage the researcher multiplied the media that had been developed in the form of applications and Augmented Reality books, then conducted training for teachers and conducted field tests. At this stage a summative evaluation is also carried out which aims to analyze and describe student responses in the use of the developed media.The last stage is to evaluate (evaluation). The evaluation phase is carried out to ensure the product being developed is appropriate or needs to be revised. Activities at this stage include product revision by the validator, reflection on implementation, and revision of learning media. This aims to analyze the validator's suggestions, as well as the obstacles faced by students and teachers in learning using Flat and Spatial Geometry AR.

III.   RESULT AND DISCUSSION

Research on the development of learning media with Augmented Reality on flat geometry and space material was carried out at SD Negeri 050660 Stabat, Langkat Regency. The results of the research on Android-based Flat and Spatial Geometry AR application development through the ADDIE Model to improve students' representation abilities and mathematical literacy abilities, have been carried out in this study with 5 (five) stages as follows:

a.   Analyze

In the Analyze stage, researchers carry out: (1) needs analysis; (2) analysis of geometry and space competence and material in elementary schools. In the needs analysis the researcher conducted interviews and conducted tests to determine students' ability to understand the subject matter. The results obtained by researchers when interviewing students with fundamental problems, namely students find it difficult when participating in learning related to flat shapes and geometric shapes in class. This can be seen directly when students say that geometry material is one of the materials that is difficult to learn and easy to understand to the minimum "complete" because it contains many formulas.In direct observation at schools researchers can see teachers directly and the fact that teachers only use textbooks as learning media. In addition, the teacher also said that students often complained when learning flat and geometric shapes because there were too many formulas that were difficult to understand. When the teacher carried out a quiz suddenly many students got bad grades. In interviews with teachers and students, researchers also asked about Augmented Reality

technology, in general they know Augmented Reality technology only as a game that exists on smartphones, not as a learning medium that can be applied in class.The results of competency analysis and material for Flat and Spatial Geometry in Elementary Schools are summarized in table 1 below:

Table 1. Results of Competency Analysis Activities and Materials for Flat and Spatial Constructs

| Activity	Analysis Results
Analysis of potential resources (teachers, students, and ICT facilities & infrastructure).	- Students and teachers mostly have Android-based smartphones - Students and teachers are familiar with the use of smart phones
Analysis of Basic Competency (KD) content based on Permendikbud No 37 of 2018.	- Plane and Spatial Materials appear at every grade level - Details of Basic Knowledge Competency and Basic Competency of Flat and Spatial Building Skills
Analysis of the advantages and disadvantages of student and teacher handbooks for flat and geometric shapes	Student/teacher handbook for compulsory mathematics for elementary schools is good
Analysis of learning media used.	- Learning media used are generally not varied. - Not yet accommodating the use of ICT, especially Android-based smart phones.

b.   Design

The design of the AR-based Space Geometry android application begins with designing a story board, then designing the initial appearance of the application when loading, designing the main menu display, and continuing to design the material appearance. Product design in this study focuses on creating a system that is easy to use and understand by users, as can be seen in Figure 2 below:
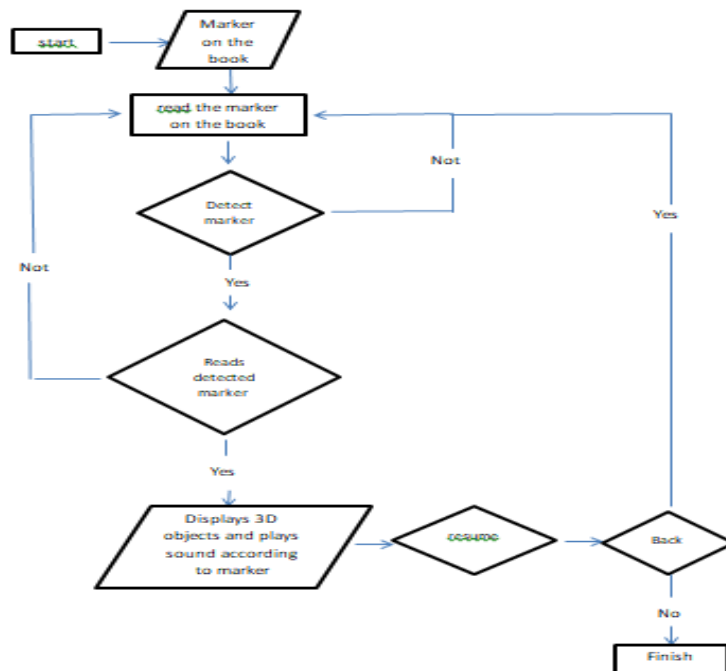
Fig 2. Application Design Flowchart

After that, a functional model of the software is created which describes the general description of the software. Starting from creating 3-dimensional objects, creating sound files, searching and forming images so that they become library markers, combined into one augmented reality project plus an AR (augmented reality) library and the coding process which is the main component of augmented reality software development.

The design of the software architecture can be seen in Figure 3 below:
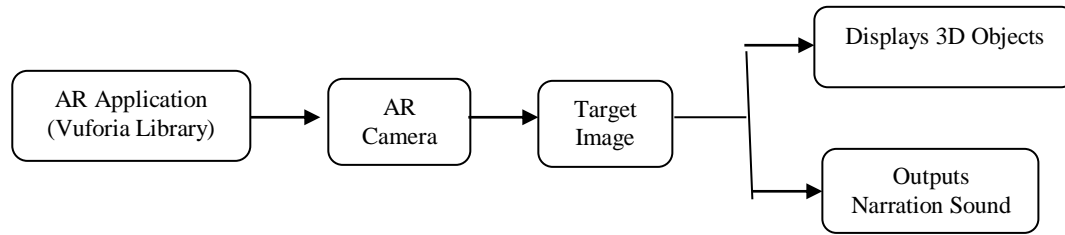
**Fig. 3.** AR Application Structure Chart

c.   Development

The learning media for the AR-based Space Geometry application consists of a splash screen display and several main menus. The splash screen display of the Elementary School-level AR-based Flat Geometry and Space application is as shown in Figure 4 below:
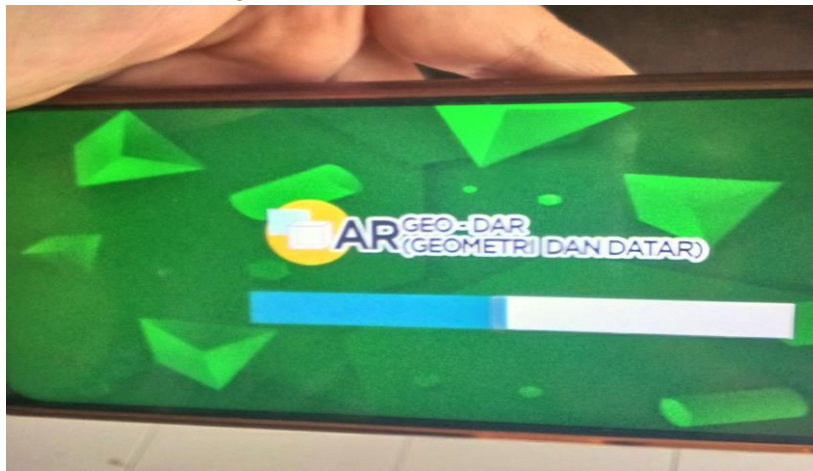
Fig 4. Display splash screen

The main display of this program is the Instructions menu, Core Competencies and Basic Competencies, Virtual Lab, Practice Questions, About (which contains Applications and Developer Info), and Exits. For the main view of this application as shown in Figure 5 below:
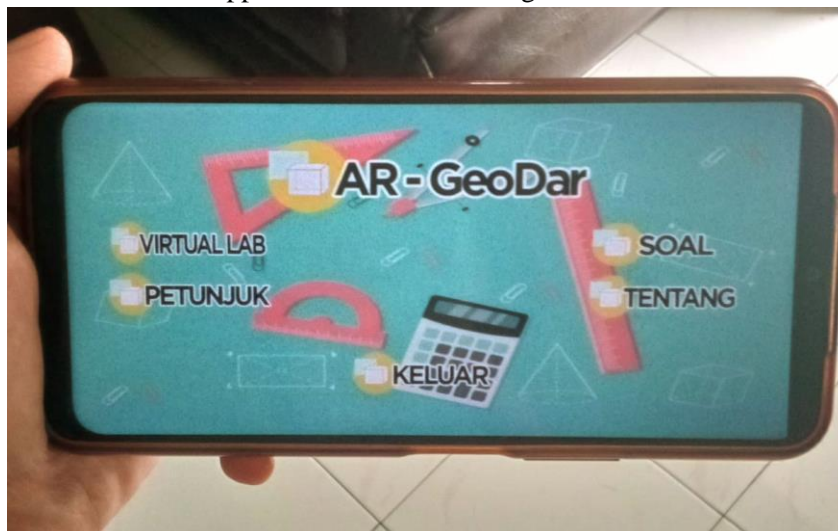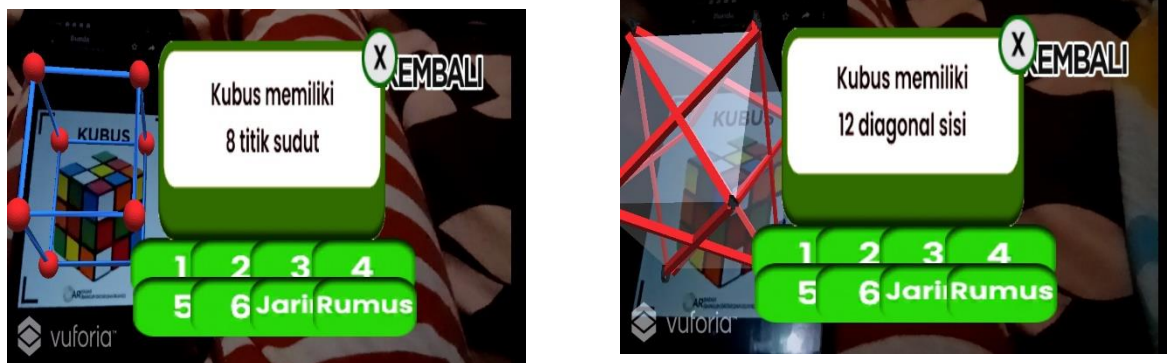

Fig 5. Main view

The virtual lab menu contains flat shape material and builds space for the AR camera to display markers on books. The appearance of the AR-based Space Geometry android application is as follows:

Fig 6. Display of the Virtual Lab menu

Fig 7. Example of a 3D object display on a Cube

At this stage of development, the Flat and Spatial Geometry AR application was tested formatively with the aim of revising the application according to the assessment and suggestions for improvement provided by content experts and media experts.

1. Blackbox Test Results

   In testing test case 1, it aims to test the correctness of the Augmented Reality Geometry Flat and Spatial process. From the test results, a success percentage of 100% was obtained and in test case 2 it was carried out to find out whether the application that was made was running properly and correctly and could be used by other people. With the test results using some hardware, the test results are obtained with a percentage of 100% success.

2. Whitebox Test Results

   Whitebox testing is used to find out how a software works internally. From the white box test results obtained a success percentage of 100%.

3. Content Expert Test Results

   The content expert test was carried out by two mathematics teachers at SD Negeri 050660 Stabat. In this test, the results of the overall percentage of the assessment were 93.67% with very good criteria.

4. Media Expert Test Results

   In the media expert test, the test was carried out by 2 experts from Mathematics and Computer Science study program lecturers. The media expert test results obtained that the overall percentage of the assessment was 87.23% with very good criteria.

The average content feasibility score is 93.67% and is in very good criteria. This AR-GeoDar application can be used because the material in it is in accordance with KI and KD, and stimulates students' curiosity. This is in line with Hamdani (2011) which states that learning media is a medium that carries messages or information that is instructional or contains teaching purposes.In the media feasibility aspect,

the average score is 87.23%. This includes the visual appearance, sound quality and ease of use of the application. Good learning media must pay attention to learning objectives and effectiveness (Sungkono, 2009).Overall, the average validation result is 90.19% of the total interpretation. This is in accordance with Akbar's (2013) validity criteria, which is between 85.01% - 100% at the level of validity without revision.After the AR-Geodar product was declared valid, a limited trial was conducted to see the user's (student) response, and the final result concluded that the AR-Geodar was declared feasible for use in learning flat geometry and space materials.

d.   Implementation

The implementation phase begins with an introduction, which explains the core/basic competencies and learning objectives. Learning materials related to core competencies are presented in the form of pictorial slides and AR. In this process, it appears that students pay attention and enjoy observing the material provided by the researcher. The media used can arouse students' curiosity about the questions given in the developed book. Learning media helps teachers to educate students who are mostly "Digital Native", by integrating technology as a necessity (Umar & Yusoff, 2014).

Fig 8. AR=GeoDar Implementation

Based on the field test involving 32 students and accompanied directly by the teacher, it was obtained from the field test analysis that the average percentage of 15 assessment subjects (items) was 84.50%.

e.   Evaluation

The final stage of development is evaluation. Based on the explanation above, it can be concluded that flat geometry AR and android-based space have met the predetermined criteria and are valid and practical. This android-based flat geometry and space AR is said to be feasible because it obtains results in very decent categories. This is in accordance with the opinion expressed by Arsyad (2013) where learning media is an object or tool or device that can be used by teachers in the learning process, to help teachers clarify the material being taught and make it easier for students to understand learning material. The media developed by the researcher is said to be feasible, so this media can be said to be able to facilitate students in the learning process in class. As a learning medium, flat geometry AR and android-based space have advantages and disadvantages. Here are the advantages and disadvantages.

a. The advantages of learning media:

    i.   The Android-based flat geometry and space AR application is a new innovation in Geometry learning media.

    ii.   Android-based flat geometry and space AR applications can be used at any time, because students can learn independently even without meeting face to face with the teacher.

    iii.   The application has a simpler design so it doesn't feel complicated when used.

    iv.   The application does not use an internet connection so it can be used anywhere

b. Disadvantages of learning media:

    i.   The application can only be used on smartphones, if you want to use it on a computer you must use an Android emulator and a camera on a computer or webcam.

    ii.   This application is not yet available in the playstore so it cannot be downloaded and if there is an update it must be downloaded manually.

    iii.   This application can only be used on Android while for iOS it cannot be used.

IV.   CONCLUSION

Based on the research results, it can be concluded that:

1.   Android-based flat geometry and space AR applications have been developed using the ADDIE model with 5 stages, namely Analize, Design, Development, Implementation, and Evaluation. Android-based flat geometry and space AR application design development relevant to the 5 stages of the ADDIE model.

2.   The Android-based Flat Geometry Augmented Reality Application in SD that is developed is valid and practical. The average validation score from content experts and media experts was 90.19% of the total interpretation and in the field test it was obtained an average practicality percentage of 84.5% from 15 assessment items.

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