Augmented Reality (AR) and Java Application Development for Geometry Learning Medium

Andy Satria[1], Amru Yasir[2], Zelvi Gustiana[3], Sabrina Aulia Rahmah [4], Welnof Satria[5]

[12345]Teknologi Informasi, Faculty of Teknik dan Ilmu Komputer, Universitas Dharmawangsa

andysatria@dharmawangsa.ac.id

Abstrak

In the context of mathematics education, specifically in the domain of solid geometry, conventional instructional media, such as textbooks, have been the norm. However, their efficacy is constrained by the reliance on two-dimensional representations, impeding students' comprehension of the concepts conveyed by educators. Many students encounter difficulty in recognizing three-dimensional geometric shapes, resulting in disengagement and a lack of focus. The incorporation of spatial concepts can be significantly enhanced by employing Java-based desktop applications capable of converting tangible objects into three-dimensional graphics. This technological approach offers a more creative means of identifying mathematical spatial formulas. For instance, through the utilization of mobile device cameras, users can practically visualize three-dimensional representations of spatial structures. The presentation of geometric shapes in three dimensions facilitates accelerated learning, allowing students to swiftly comprehend, memorize, and apply formulas accurately to each solid shape. The interactive learning media, based on augmented reality and Java Desktop, attained an expert validation score of 84.1%, indicating a classification of excellence. Furthermore, design experts validated the media with a score of 80%, qualifying it as excellent. Learning media experts provided a validation score of 81.5%, categorizing the augmented reality and Java Desktop-based interactive learning media as excellent. Group testing results indicated a noteworthy 86.7%, falling within the excellent category.

Keywords: Augmented Reality, Java Application, Geometry

I. Introduction

Mathematics is a fundamental subject taught in primary education classrooms. To transform abstract ideas into more comprehensible and understandable concepts, individuals need to grasp the fundamentals of mathematics. Mathematics education is intended to assist students in developing self-confidence and competence in communicating with others, as well as solving problems and cases that arise in their daily lives (Jupri et al., 2020).

One of the most crucial topics in mathematics is spatial geometry. Spatial geometry encompasses specific three-dimensional objects that are bound by inherent laws, characterized by axes, sides, and vertices. Some of the well-known geometric shapes taught in schools include cubes, rectangular prisms, cylinders, prisms, cones, pyramids, and others (Rusalam et al., 2019). Mathematics learning media is a crucial component in effective mathematics education. However, mathematical concepts can often be intricate and challenging for some students due to the inadequate support provided by the learning media used in the teaching process. Tafanao (2018) delineates several reasons why teachers may refrain from utilizing instructional media, as follows.

1. Teachers perceive that creating instructional media requires extensive preparation.
2. The use of instructional media is considered sophisticated and tends to be costly.
3. Teachers are not accustomed to using instructional media, particularly technology-based ones.
4. Instructional media is seen as a form of entertainment in the learning process, while learning is often perceived as a serious endeavor.
5. Schools do not provide instructional media that supports the learning process.
6. Teachers may not fully comprehend the benefits of instructional media in enhancing student success.
7. Teachers lack knowledge and skills in creating their instructional media.
8. Teachers lack the proficiency to leverage instructional media effectively.
9. Time constraints hinder teachers from preparing instructional media.
10. Teachers may be too comfortable with lecture-based methods and may not see the need to involve instructional media.

To address these challenges, the use of technology-based mathematics instructional media has become popular in educational settings. One advantage of employing technology-based mathematics instructional media is the visualization of concepts, aiding students in picturing abstract mathematical ideas. Graphics, diagrams, animations, and simulations contribute to illustrating mathematical concepts more vividly, facilitating students' understanding (Istikomah et al., 2022).

The creation of interactive learning media is one way to address this issue. One educational technology with the potential to significantly elevate learning standards is interactive learning media. Interactive multimedia is a combination of various media formats, including images, videos, graphics, sound, and animations, packaged into digital files that can be utilized to convey messages to students and the community through a controller. Operated by an individual, it is designed to create an engaging impression and motivate students during the ongoing learning process (Pasandaran et al., 2021).

The digital interactive learning materials created for this instructional purpose integrate textual content, 3D visuals, and video exercise questions presented in an engaging and enjoyable manner. Appropriate instructional techniques must be developed to effectively deliver the content to students and maximize its utilization (Saputro et al., 2023).

Presently, there is a specialized Augmented Reality-based application known as "bangunAR" and a Java desktop application in the computer industry. According to data, bangunAR is considered robust as it provides valuable knowledge and understanding for the subject under study. This application also allows for room input intended for use when constructing three-dimensional structures. By utilizing a camera connected to a smartphone, this technology can be employed to create a more innovative and creative teaching method for mathematical formulas related to three-dimensional structures. Users can observe in three dimensions (3D) how an actual structure is built, and they can input their own data to derive the formulas (Parhusip et al., 2021).

In this situation, accessible student learning media, both within the classroom and at home, is highly essential. By leveraging Augmented Reality-based spatial structures learning media (bangunAR) and Java desktop applications, it is anticipated that students can learn with

confidence and easily comprehend what the teacher conveys during the instructional process (Wulandari, 2017).

II. THEORITICAL OVERVIEW

Learning is the process of interaction between students and teachers in a particular learning environment. Learning is a means given to those who want to learn more about a subject, such as mastery of skills and character, as well as fostering attitudes and trustworthiness for students. Learning, in other words, is the process of helping experienced students learn effectively. Learning that is done today often uses traditional education, where the teacher simply opens a book and starts writing on the blackboard before students read and copy the material that has just been presented. This kind of learning tends to make students unmotivated, so students are less eager to participate in learning. Students are not very confident, and they enjoy innovative and creative learning more than participating in a monotonous classroom (Abdussakir, 2009).

Magdalena et al (2021) stated that media as one of the components in the learning system has a function as a means of non-verbal communication. This means that learning media must be one of the requirements in the learning process. If one of these components does not appear, the end result of learning will not be optimal.

Munadi (2013) asserts that the main purpose of educational media is as a learning resource. Because learning resources include messages, people, materials, tools, procedures, and environments that affect student learning outcomes, educational media can replace the role of educators in this regard. Daryanto (2011) asserts that learning media functions as a messenger between teachers and students during the educational process. To encourage engagement during the learning process, media is essential. This is the process that teachers use to help students understand the messages contained in learning media. According to Sanaky (2013) the function of the media is as a learning stimulant, because it is capable:

1. Presenting actual objects and steps.
2. Create a duplication of the actual object.
3. Make abstract concepts into concrete concepts.
4. Provide a common perception.
5. Overcoming time constraints.
6. Representing information consistently
7. Providing a fun, unpressurised, relaxed and interesting learning atmosphere so as to achieve learning objectives.

According to Ronald T. Azuma (1997), augmented reality is defined as "the incorporation of real and virtual objects in the real environment", "running interactively in real and there is integration", "virtual is possible with appropriate display technology", "interactivity," "The goal of augmented reality is to improve the quality of life of users by providing information that is not only relevant to the immediate environment but also to everyone watching live streaming video in a global environment. The goal of augmented reality is to improve the quality of life of users by providing information that is not only relevant to the immediate environment but also to everyone watching live streaming video in a global environment. Augmented Reality (AR) can increase user engagement and interaction with the real world.

Augmented Reality contains an entertainment component, the use of learning materials with AR can significantly improve the learning process and students' interest in learning which, by bringing learning and play into the real world and allowing children to interact with this AR technology using their five senses, can increase their interest in both learning and playing. This is because AR has almost the same qualities and functions as learning media, namely the ability to convey information between sender and receiver or between educators and learners, to clarify how information is conveyed by educators and learners during the learning process, and to stimulate motivation and interest in learning(Elsa et al., 2022).

Java is the name of a group of technologies for developing and operating software on standalone computers or in a network context, according to (Rosa & Salahuddin, 2010). Java Virtual Machine (JVM) is a translation machine (interpreter) that supports Java. This JVM is responsible for reading the bit code (bytecode) in a program class file as a direct representation of the program's machine language. As a result, the Java programming language is referred to as a portable programming language because it can be used with various operating systems as long as they support the JVM(Gianto et al., 2018).

III. RESEARCH METODS

The research method used in this study is the ADDIE paradigm which stands for Analysis, Design, Development, Implementation, and Evaluation. By examining the intricacies related to the learning environment, the ADDIE model outlines the techniques and processes for creating development products (R.M. Branch, 2009). The ADDIE model is a very popular model because it has a high level of compatibility flexibility, making it possible to be used or adapted to the needs of solving a problem. This research belongs to the category of research and development (reseacrh and development) (Satria, Ramadhani, et al., 2023). The research method of developing learning applications based on java desktop and augmented reality using the ADDIE model can be described as follows:

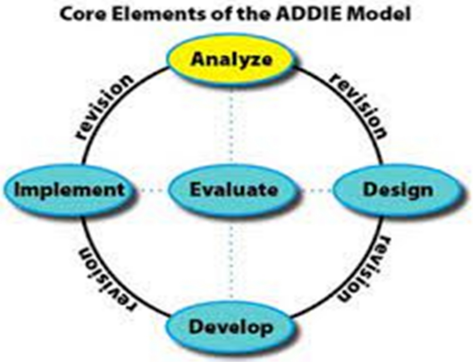

Figure 1. Stages of the ADDIE Method

The analysis stage consists of two stages, namely performance analysis and needs analysis. Design is carried out in order to prepare and design devices using: a syllabus that refers to the curriculum, as well as designing applications.

This stage of development was completed correctly. The implementation strategy for the subject is to utilise or use the media resources that have been developed in the context of a real experiment. Researchers will support students in achieving learning objectives and find solutions to the problem of learning outcomes intelligence. To assess learning outcomes (Evaluation) in students after using desktop Java-based media and Augmented Reality, teachers conduct a post-test at the end of each class period (Satria, Alvio, et al., 2023).

The focus of the research conducted is to describe the management of learning mathematics, especially building space with the use of technology such as javadesktop applications and BangunAR, the purpose of this study is to:

a. Describe the implementation of learning methods in mathematics education using augmented reality (AR) and java desktop- based technologies in an effort to improve the quality of mathematics education, especially to improve mathematics education techniques used historically by students in Indonesia.
b. Students' understanding of flat shapes and geometric shapes can be improved by using augmented reality (AR) and java desktop- based technologies to manage mathematics learning. This is due to the increased interest (attention), motivation, and role (action) of students in Indonesia in learning mathematics.

In this study, 15 grade V students and 10 subject matter experts on learning design, media, and teaching served as the test subjects of the research product. children with low, medium, and high learning achievement levels were the focus of the study. These children were selected to reflect the target demographics by looking at report cards and daily grades obtained from the class teacher. Observation, focused interviews, and questionnaires were the methods used to obtain data and information for this study. The questionnaire was the main research tool. Since alternatives to answering the questionnaire have been offered, i.e. closed-ended questionnaires. The framework of the research instruments is presented in Table 1, Table 2 and Table 3.

Table 1. Learning Content Expert Instrument Grid

No	Aspects	Indicators
1	Curriculum	1. Suitability of material with basic competencies 2. Suitability of material with indicators 3. Suitability of material with learning objectives
2	Material	1. Importance of materials 2. Material coverage 3. The material is easy to understand 4. The attractiveness of the material 5. Correctness of the material
3	Linguistics	1. Use of proper grammar 2. Language in accordance with student characteristics 3. Conformity with Indonesian language rules

Table 2. Learning Design Expert Instrument Grid

No	Aspects	Indicators
1	Destination	1. Clarity of learning objectives 2. Suitability of learning objectives with learning materials

2	Material	1. Learning Activities 2. Learning Steps 3. Material Delivery 4. Clarity of media / application instructions 5. Instructions for use are available
3	Evaluation	1. Feedback is available 2. Exercises

Table 3. Learning Media Expert Instrument Grid

No	Aspects	Indicators
1	View	1. Attractiveness of interactive media display 2. Ease of media use 3. Image Clarity 4. Attractive color
2	Material	1. The material is easy to understand 2. Clarity of material description
3	Motivation	1. There is motivation to be enthusiastic about learning
4	Operation	1. User Friendly

Quantitative descriptive analysis and qualitative descriptive analysis methods were used in the data analysis for this study. The information collected for this study was presented in the form of scores. The research scores were examined using the quantitative descriptive analysis method. This method converts information from the questionnaire into scores which are then rated on a Likert scale for analysis. The results of each subject's score were then converted into a percentage. The percentage results obtained were then converted into achievement levels using a scale of 5.

IV. Result and Discussion

RESULT

The results of this study are summarised in two main points: (1) the design and construction of interactive media, and (2) the feasibility of producing interactive media based on product validation findings. Images, texts, music, and videos are all included in the multimedia design for the creation of interactive learning materials. Many software, including Unity 3D, Blender, Vuforia SDK, Corel Draw, Adobe Photoshop, Android Studio, Netbeans and other supporters, are used in the creation of interactive learning materials. The main screen, media identity, menu, instructions for use, selection of flat and spatial shapes, area and volume formula calculation menu from the flat and spatial shapes menu, markers to display 3D of flat/spatial shapes from smartphones. Interactive learning media components based on augmented reality and Java Desktop. In developing this interactive learning media using the ADDIE model which consists of 5 stages.

The analysis stage is the first. In the analysis stage, the activities carried out are analysis of student characteristics and needs, material analysis. Students were observed, interviewed, and questionnaires were sent to analyse students' needs and characteristics.

Based on the results of observations and interviews with grade V homeroom teachers, information was obtained that the learning media usually given to students is only a textbook, so that the learning media provided is sometimes boring and one-way. In addition, it is known that grade V students are more active in learning activities when using different learning resources provided by the teacher based on the results of a survey of grade V students. If during the learning process the teacher's media does not match the information contained in the student book, the majority of students also have difficulty in understanding the material. In the material analysis, the selection of material is carried out in accordance with the learning media developed and adjusted to the results of the needs analysis and student characteristics. The results of the analysis lead to the selection of information about the mathematical form and attributes of the shape of the building space for this interactive learning media. Based on the material analysis, basic competency criteria and indicators of spatial material are implemented in grade V mathematics subjects.

Design is the next stage. Selecting the necessary hardware and software, creating flowcharts and storyboards, designing interactive media elements such as display design, and creating curriculum-based materials are all steps in the product design process. Tripods and mobile phones were used as hardware to create this interactive media. Software such as Unity 3D, Blender, Vuforia SDK, Corel Draw, Adobe Photoshop, Android Studio, and Netbeans were used to create this interactive media.

The third stage is development. At this stage, the operation starts to produce media in accordance with the flowchart and storyboard layout that has been made previously using Microsoft Power Point 2013 software. then continue by publishing using Unity 3D, Vuforia SDK, Android Studio, and Netbeans. As a result, this media develops into interactive media that can be used in accordance with product specifications during the learning process. After that, activities were carried out with product validation by experts and individual product trials and small group trials.

The fourth stage is implementation. At this stage the product that has been designed and tested is applied to learning activities at school directly to students. Learning activities are carried out conventionally at school. The product was tested by conducting a trial involving 15 students. Students are assisted in using learning media then students are also directed to try all the features that are on this learning media.

The fifth and final stage is evaluation. At this stage, the evaluation used is formative evaluation. Formative evaluation is carried out during the product development process. At the analysis stage, data collection was carried out using a structured interview method and giving questionnaires and feedback forms to students which aimed to find out the needs and characteristics of students and the benefits of this application to the learning process of students at school.

The results of the product validity study conducted by a team of experts, as well as product trials conducted in groups of 15 students, determine the feasibility of building interactive media products. By giving questionnaires to a team of experts and students, the validity of the product was evaluated. Before being used in the classroom, this validity test tries to ensure the feasibility and validity of the product. The results of product validity include (a) learning content expert review results, (b) learning media expert review results, (c) learning design review results, (d) group test results. The detailed product validity test

results are presented in Table 4.

Table 4. Product Development Validity Results

No	Test Subject	Validity Result (%)	Description
1	Learning Content Expert Test	84,1 %	Very Good
2	Learning Design Expert Test	80 %	Very Good
3	Learning Media Expert Test	81,5 %	Very Good
4	Group Trial	86,7%	Very Good

Based on Table 4, it is clear that augmented reality and Java Desktop-based interactive learning media products achieve excellent validity overall. Therefore, it can be stated that Augmented Reality and Java Desktop-based interactive learning media are practical and valid for use in classroom learning based on the findings of the product validity test that has been conducted. In addition, suggestions from experts and test subjects on the product can be taken into consideration and used as material for improving the product being developed during the validity test.

The following is an application resulting from the development of geometry learning media with Java.

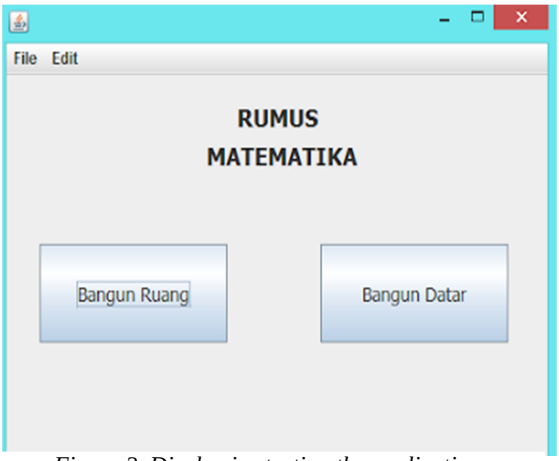

Figure 2. Display in starting the application

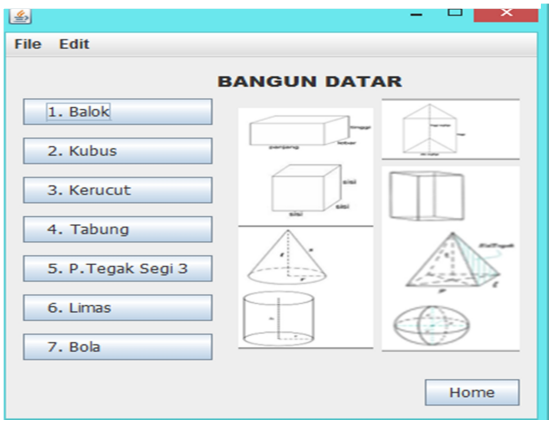

Figure 3. Display of geometries building

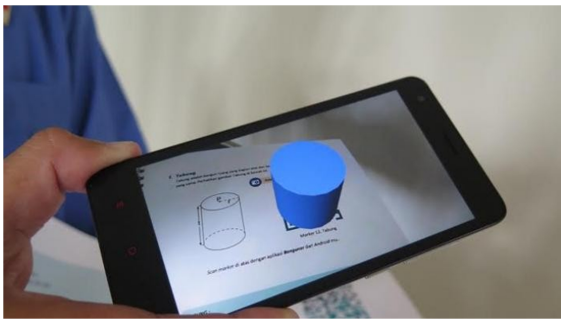

Figure 4. AR display of the geometry building with a smartphone

In Figure 4 is a 3D visualisation of the image of the building space. The 3D display can be seen after students scan the marker that has been provided in the system using a smartphone. So students not only imagine the shape of the building but can see directly in 3D.

DISCUSSION

To minimise Indonesian students becoming disinterested in their academic learning process, especially in learning mathematics due to the traditional nature of educators' teaching methods. So new innovations and creativity must be introduced because of the development of technology that is increasingly advanced and can be utilised by all teachers in Indonesia.

Students' interests, talents and motivation to learn will all change due to the use of increasingly sophisticated technology, such as computers and the internet. Facts and field observations show students' lack of interest in mathematics. This occurs as a result of the similarity of instructional strategies, overexposure of students to the idea of learning from practice problems, and other factors. In order to improve students' knowledge of the meaning of learning mathematics, especially geometry, it is interesting to study, research, and discuss the management of technology-based mathematics learning.

This application can calculate the formulas of spatial and flat buildings, students just need to choose a spatial building such as a cube, block, triangle, cone, tube, pyramid, ball and others. then enter the required value and select calculate then the final result will be displayed immediately along with the formula. With this application, it is expected to be able to help students in learning and remembering and implementing the formulas of space/flat buildings according to their respective formulas.

This application is also equipped with Augmented Reality which is able to display 3D shapes of flat / spatial shapes. So that students can not only learn formulas easily but also be able to capture lessons with the material of building space faster. Because students can see directly the building space in 3D view through a smartphone and calculate the outside and volume of flat and space buildings.

Interactive learning media based on augmented reality and Java Desktop received a percentage of 84.1% and was in the very good category based on the

results of material expert validation. This is due to the material text and content, the application of KD, indications, and learning objectives, as well as the use of appropriate terminology.

The result of this research is an augmented reality and java desktop-based learning application that is able to improve students' understanding of building space. When presented in 3D, learners learn faster. Students are also able to learn, remember and implement the formula quickly and precisely according to the formula of each space.

The use of augmented reality technology in this buildAR application works well and according to the original plan, which involves combining 3D objects with the actual location. Users can operate this programme more easily by interacting with the buttons offered. It is important to pay attention to the quality and detail of the marker obtained by the smartphone camera when recognising the marker pattern.

The results of this study can be utilised as teaching materials by teachers to describe the physical characteristics of flat space buildings. The findings of this research can be used as a guide when developing interesting learning media for students. This learning media is also able to introduce to students in 3D the shape and appearance of both spatial and flat shapes. This learning media is also able to make it easy for students to remember the formulas of area and volume of both spatial and flat shapes.

The study conclusion has practical applications, including interactive learning materials with spatial properties based on augmented reality and desktop Java that can trigger students' interest in learning and are useful for use in the classroom because they have excellent qualifications from the results of the pilot test and individual trial following the use of the developed media in groups.

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