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MOBILE LEARNING APPLICATION DESIGN BASED ON AUGMENTED REALITY GEOMETRY MATERIALS

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Abstract

Learning media is needed to facilitate students' understanding to support the learning of mathematics in the material of geometry so that it becomes concrete. Based on this, it is necessary to design an augmented reality-based mobile learning application. The steps in making a mobile learning application are adapted from the development model of Borg & Gall (2003) which consists of ten stages. The ten stages are summarized into three parts: planning, development, and evaluation. This research focuses on the first stage, namely planning. This research method is research and development (R&D). The planning section consists of two stages, namely (1) data collection in the form of needs analysis and (2) planning (planning). Data collection has been carried out based on the results of the analysis of student needs through questionnaires and needs analysis from experts based on interviews and literature studies. The results of this study get the right content and appearance to develop applications.

Keywords: application design, augmented reality, geometric, learning mathematics, mobile learning.

1 INTRODUCTION

Almost all fields of human activity have adopted easier, more effective, and more efficient methods by employing ever-improving technological advancements. The advancement of modern technology undoubtedly has a significant impact on education, particularly when it comes to the utilization of learning media. Learning media, according to Saputro & Saputra (2015), turns out to be developing in step with existing technology, including print technology, audio-visual technology, computer technology, and a mix of print technology and computer technology. The use of learning media in the teaching and learning process can also inspire students to develop new interests and wants, motivate them to learn, and even have a psychological impact on them (Azhar, 2017). The development of learning technology in Indonesia has been increasingly advanced with the existence of various learning media using computers and *mobiles*.

Mathematics, particularly geometry, is one subject that necessitates the use of learning tools. Although spatial structure has been taught in elementary school, the capacity to solve three-dimensional issues remains inadequate or low. Students may struggle to visualize a square pyramid since the shape of a square in a pyramid is typically depicted as a parallelogram. Because each sort of spatial structure has its shape and formula for area and volume, many students are disinterested in learning geometry because it is difficult, and they do not know exactly what the shape of each shape is (Djumanta & Susanti, 2008).

According to Bruner (in Wati & Purwanti, 2022), children learn mathematical concepts in three stages: *enactive, iconic*, and *symbolic*. The *enactive* stage is the learning stage in which concrete items or objects are manipulated, the economic stage is the learning stage in which pictures are used, and the *symbolic* stage is the mathematical learning stage in which symbols or symbols are manipulated. Meanwhile, Hudoyo (in Istiningsih et al., 2018) claims that learning mathematics is a process of developing or constructing concepts and principles, not merely passive and static teaching, but active and dynamic learning. This is by the constructivist view, which is a view in teaching and learning because students build their meaning from their experiences and interactions with others. Likewise, Z.P. Dienes (in Bossé *et al.*, 2021) contends that every mathematical concept or principle can only be fully comprehended if it is first provided to pupils in a concrete form that is understandable. Dienes emphasizes the importance of manipulating objects in learning mathematics.

Currently, the media utilized in spatial building learning is either a blackboard or a printed book, thus the inside and back of the part are not visible. The teacher usually uses teaching aids to visualize the form of the space, but students must take turns observing the shape of the area closely because not everyone can get all types of props with many types of shapes. Storage space for teaching aids, as well as the variety of teaching aids that must be brought into the classroom, are also obstacles.

Several research has shown that *mobile learning* can be used as a learning approach for those who learn through doing. As a result, *mobile learning* can expand options for both on-the-job and lifelong learning. This approach can save costs in terms of housing, time, and energy from the place of residence to the educational institution. In line with that, higher education institutions can also overcome the shortage of places for students and also the lack of infrastructure. This phenomenon will also help to alleviate the problem of teaching staff.

In traditional classroom learning, the learning system used to teach students to be active in the classroom is still limited. Augmented Reality (AR) technology can be utilized using many media, including desktops, mobile devices, and smartphones. This technology itself is portable and can be used in various circumstances. AR can be used to enhance traditional classroom instruction and content, additional instruction in specialized classrooms, add content to the world outside the classroom, and can be combined with other technologies to enrich applications (Antonioli *et al.*, 2014). According to students, the learning method using AR is more stimulating and interesting

than using presentation slides. This is because students prefer audio, video, and feelings when using three-dimensional objects that are transferred in the real-world (Yuen *et al*., 2011).

AR technology is applied to mathematics subjects in the spatial building based on this. This material was chosen based on the difficulty of educators employing the appropriate media to teach the material. Previously, AR research on mathematics subjects had been conducted, with a discussion on the introduction of geometry formulas. These features are presented via *smartphones* camera (Subagyo *et al.*, 2015). The addition of nets in the form of animation and a space calculator to compute volume distinguishes it from previous research. AR was created by merging these distinct features to make mathematics more engaging for students. This will have a significant impact and will encourage them to learn and teach geometry.

2 METHODOLOGY

Research and development (R&D) is the research methodology utilized in this research. Development research is a type of research methodology used to create a specific product and evaluate its efficacy. To be able to produce particular products needs analysis research must be conducted (Sugiyono, 2017). The result of this research is a mobile learning application based on *Augmented Reality* that serves as a learning resource and is intended to increase student comprehension.

Data was collected by distributing needs analysis questionnaires to students and conducting interviews with experts. Questionnaires are a set of questions given to respondents for data collection techniques. The data analysis technique used in this research is descriptive quantitative analysis. The results of data analysis are used to identify things that must exist in the learning of spatial construction materials as a reference in designing *mobile learning* media.

3 FINDINGS AND DISCUSSION

The result of this research is a *mobile learning* application called "ABRAR: *Augmented Reality* Building Application," which can be accessed via a smartphone running the Android operating system. This media's content includes AR simulations, resources, learning videos, quizzes, spatial calculators, and information based on the results of a student needs analysis.

The steps for creating a mobile learning application are based on Borg & Gall's (2003) development model, which consists of ten stages. The ten stages are summarized into three parts: planning, development, and evaluation. This research took two years to complete. The planning and development section will be completed in the first year, 2022. The evaluation section will be

completed the following year. The following is an explanation of the research process that will be carried out throughout the first year, with a focus on the design part.

The planning section consists of two stages: (1) data collecting in the form of a needs analysis and (2) *planning*. Data was collected based on the outcomes of an analysis of student needs via questionnaires and needs analysis from experts via interviews. The outcomes of data collecting in the form of a needs analysis are used for the next stage, which is planning. In addition, this first stage included a literature review. This is meant to find theoretical notions to determine the proper steps in constructing these products (Sukmadinata, 2006). The activity of needs analysis is explained further below.

3.1 Analysis of Student Needs

This stage of analyzing student needs was carried out on 36 students from the PGSD FKIP UT Study Program who filled out a questionnaire and had previously taken the Mathematics Education II course. The data gathering step took place between 11 and 24 April 2022 in *online* tutorial classes (Tuton) and webinar tutorials (Tuweb). According to the requirements analysis results, pupils are still relatively proficient in learning the subject because only 60% of students comprehend the material well. This is supported by the results of other needs analysis which shows that as many as 38% of students do not know the various shapes of flat and curved planes and as many as 59% of students do not understand the properties related to shapes, such as sides, ribs, side-space diagonals, and the nets they have learned.

Based on the needs analysis data, students have difficulty in learning the material of geometry due to 58% of students having difficulty imagining the shape of the space, 5% of the material is a lot, 21% of learning is less interesting, and 53% of the absence of alternative learning media. Physical objects can help students make connections between their visual understanding and their sense of taste, including relating spatial abilities and helping students focus their attention (Billinghurst *in* Ibili *et al.*, 2019). In addition, the learning method used by the tutor to teach the material of the spatial structure is dominated by discussion (79%) and practice questions (63%). The large percentage of discussion and practice questions that are monotonous is one of the factors that make it difficult for students to visualize the material and feel that learning becomes less interesting.

To overcome the problem of visualizing building materials, 88% of students want 3D modeling of geometric shapes, 58% want learning videos to boost their understanding of building materials,

28% want to use *smartphones* as a learning resource, and 26% want to reproduce exercises. Learning mathematics is a process of reconstructing concepts and principles; the learning process must be active and dynamic, rather than static and passive (Rusnandi *et al.*, 2016).

As revealed by Turmudi (2008) views that mathematics learning so far does not involve students actively. In addition, he stated that mathematics learning so far has been conveyed in an informative manner, meaning that students only get information from the teacher so the degree of "attachment" can also be said to be low. With this kind of learning, students as learning subjects are less involved in finding the learning concepts that must be mastered. This causes the concepts given not to make a sharp impression in the memory of students so that they are easy to forget and often confused in solving a problem that is different from the one exemplified by the teacher. Therefore, it is important to provide and prepare teaching materials that can facilitate students to involve themselves actively and dynamically in learning and understanding mathematical concepts so that they can see the relationship between mathematics and other concepts.

Along with the rapid development of technology, it is not surprising that many students already have personal smartphones. This is supported by the results of data analysis which states that 100% of students have personal smartphones. Nearly 86% of students utilize the internet as a learning tool to understand the material displayed in lectures. In addition, there are now many *platforms* that provide alternative learning resources. However, just 65% of students use *smartphones* for academic purposes, whereas 84% of students use them for non-academic purposes. Learning in the modern era is significantly influenced by the use of technology and media (Sakat *et al.*, 2012). Therefore, advanced technology can be used to develop more creative and innovative learning media.

Mathematics is deemed dull by the majority of students. This is because mathematics, like more abstract learning, tends to be abstract. Educators must be able to make mathematics learning enjoyable and engage students in active, creative, and innovative learning activities. The learning media factor is one of the factors that can make mathematics pleasant and fascinating. *Mobile learning* media is a learning media that can be utilized in the classroom. According to the findings of the needs analysis questionnaire, 100% of students agree that *mobile learning* on spatial materials is utilized as an alternative learning method, and 81% are interested in adopting *Augmented Reality*-based mobile learning in the learning process. Innovative *mobile learning* media makes the learning process easier and more interesting so that it is effective for learning (Huang *et al.*, 2016). In addition, the material contained in *mobile learning* can be adapted to

learning needs. The needs analysis that has been carried out provides information that 89% of students want a summary of material and practice questions, and 100% of students agree that in *mobile learning* there is a learning video feature that can help understand learning material.

Based on the problems and needs of students, the researchers concluded that a learning application that can be accessed via *smartphones* is required as an alternative learning resource for students. If *smartphones* are used properly in the learning process, their presence among students can be positive. This is reinforced by 95% of students who are already familiar with *mobile learning* and 86% of students who have used *mobile learning* in the classroom learning process. Tutors' ability to use technology-based learning media in learning building materials is also good because the dominant tutor employs *Powerpoint* media while teaching these subjects. This is evidenced by more than 80% of student answers supporting this and as many as 74% of students are interested in learning about building materials using smartphones. The content presented in *mobile learning* is made by considering the wishes of students. As many as 100% of students agree that in *mobile learning* there is a learning video feature to explain the material, then as many as 89% of students want a summary of the material and practice questions and their discussions. In addition, it is proven by 86% of students agree that *mobile learning*-based learning media can make it easier to understand the material. Overall, as many as 93% of students are interested in learning building materials using *mobile learning*.

3.2 Expert Needs Analysis

According to expert interviews, learning spatial material is seen to be incredibly difficult because it depends on factors like spatial ability and the use of learning media.

> *"Learning the material of geometry is a learning that is quite difficult to achieve the learning objectives because there are several factors that hinder students from understanding the material. Among them are the different spatial abilities of students, even the spatial abilities of teachers also influence the teaching style of this material. Another factor is the media, where the introductory media for building material which is learning about three-dimensional objects is taught through two-dimensional objects such as images on paper, blackboards, or screens."*

According to several studies, students have difficulty in geometry because of their weak geometric concepts, their inability to solve geometrical problems, and their low geometric object reasoning (Budiarto & Artiono, 2019; Subaidah et al., 2017). Therefore, we need effective learning media

in understanding the material of geometry. The use of learning media in the teaching and learning process can also encourage students to develop new interests and wants, motivate them to learn, and even have a psychological influence on them (Azhar, 2017).

According to expert information, the things needed in studying the material of spatial structure are spatial abilities and literacy skills in dealing with the problems given.

> *"Good spatial skills are needed in studying spatial material, as well as literacy skills are also needed in dealing with the questions provided. This is because the material of spatial structure also includes calculations and measurements involving unknown variables such as volume and surface area."*

Because it can aid students in comprehending geometric concepts and in being familiar with and interacting with their surroundings, spatial literacy is crucial for students. Spatial literacy can also be applied in the disciplines of *Science, Technology, Engineering, and Mathematics* (STEM) and is one of the factors needed in various types of work so spatial literacy skills are needed by students to excel in various fields and be able to compete globally. The *Program for International Student Assessment* (PISA) (Lane et al., 2019), which is part of the *space and shape* content in mathematical literacy, is one of the international standards that can test or evaluate spatial literacy (Yusmin, 2016). The ability of students in the context of *space and shape* is still low. The average achievement score of Indonesian students in the *space and shape* category is 383 while the average score for the Organization for Economic Co-operation and Development (OECD) is 490, as seen in the PISA data (Piacentini & Monticone, 2016).

Then there are several evaluations of the learning process on the building material that has been done. As stated by the expert:

> *"The major evaluation is that most learning is still driven by printed books and lecture methods... Since there has been pressure from learning to be held online, an evaluation of the learning process of building materials has been developed. Some teachers have been seeking ways to adjust when they are unable to use the blackboard in class due to students no longer learning in class, but learning from home."*

The material in the printed book is deemed less than optimal since understanding the material for spatial construction requires tangible visualization, for which text and images are not enough. Books as media and AR technology supplements can assist teachers to deliver material using 3D visualization in printed books, making it more interesting and easier to absorb the

material (Abdillah et al., 2020). To overcome this problem, AR technology has great potential to assist learning activities in education and improve learning quality throughout the process by combining the actual and virtual worlds (Nincarean et al., 2013).

In the interview process conducted by the informants (experts), they gave their opinions related to learning interesting spatial materials, namely the exploration process to reduce learning saturation.

> *"Learning about building materials will be more engaging if students are also invited to explore the basics of understanding geometry, geometry, and real objects surrounding it so that students are not bored because they just struggle with counting and formulas."*

The concept of meaningful learning in mathematics learning is consistent with the constructivist viewpoint because students are said to understand if they construct meaning from their experiences by making cognitive connections between new experiences and their previous understanding of mathematics, rather than simply memorizing formulas/propositions (Gazali, 2016). Likewise, Z.P. Dienes (in Bossé et al., 2021) contends that every mathematical notion or principle can only be fully comprehended if it is first provided to students in a concrete form that is understandable. Dienes emphasizes the importance of manipulating objects in learning mathematics.

In addition, informants (experts) argue that further consideration is needed for some students who are not familiar with technological sophistication in the use of *mobile learning.*

> *"It may be interactive for some students who are accustomed to technological sophistication, and these students will easily adapt to learning. On the other hand, it may be possible to find a percentage of students who are unfamiliar with technology, making it difficult for some of these students, but this can be a challenge in and of itself, as the teacher in one class must take a different approach in delivering this latest technology-based learning to students. students who are used to, but are yet unfamiliar with, this sophisticated technology."*

In *mobile learning*, good visualization features are required to study geometric material.

> *"Good visualization features will be highly helpful in learning and understanding students, that are easy to understand, and supportive designs will also pique their interest in using them."*

The examples in the form of space, according to Zodik & Zaslavsky, are highly dependent on visualization. This *Augmented Reality* method has the advantage of an appealing visual display because it may show 3D objects as though they exist in a real setting (Amir, 2017). Learning will be more engaging because an *android smartphone* can show a virtual three-dimensional form of the desired object in the real world.

After carrying out the data collection stage in the form of needs analysis from students and experts proceed to the planning stage. The planning stage shows that a *mobile learning* application is needed for *Augmented Reality*-based building materials to support learning so that it can improve students' spatial abilities and can provide convenience in exploring abstract objects projected in 3D.

3.3 Planning for Making Augmented Reality-Based *Mobile Learning* Applications

The *Augmented Reality*-based *mobile learning* media, which will take the form of an application, will be developed. Students can pick the right time according to their readiness to learn. This is in line with the principle of fun learning, meaning that *mobile learning* provides an alternative time and place to learn without any pressure from external parties. This is an advantage of *mobile learning* in terms of time and place, allowing students to access materials and information at any time and anywhere (Ally, 2009).

Researchers want to develop *Augmented Reality*-based *mobile learning* on spatial materials. This is because *mobile learning* is one of the learning media that uses technology to allow student participants to quickly access information and learning materials at any time and anywhere. According to Buchori (2017), Android learning media that can be selected based on spatial structure characteristics are *Augmented Reality* media. *Augmented Reality* is a technology that blends two-dimensional and three-dimensional virtual objects in our environment and projected virtual objects in real-time with Android phones (Azuma in Gybas et al., 2019). According to Saputro & Saputra (2015), AR technology is the integrity of digital elements that are added to the real world directly (real-world data) and follow environmental conditions that exist in the real world and can be applied to *mobile* devices. The *Augmented Reality*-based *mobile learning* media that was developed is expected to be learning support that can improve students' spatial abilities in building materials so that it can provide convenience in exploring abstract objects projected in 3D.

4 CONCLUSION

Based on the problems and the findings of the needs analysis of students and professionals, the researchers formulated that mobile learning media, which can be accessed via *smartphones*, is required as an alternate learning source for students studying building materials. Because it is based on *Augmented Reality*, the developed *mobile learning* media is expected to improve students' spatial abilities. Because it can display 3D objects as though they were in a real environment, this *Augmented Reality* approach has an appealing visual display.

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