ETHNOMATHEMATICS APPROACH IN THE DESIGN OF *AUGMENTED REALITY-BASED MOBILE LEARNING* OF TWO-DIMENSIONAL AND THREE-DIMENSIONAL SHAPE MATERIALS AT THE ELEMENTARY SCHOOL LEVEL

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Abstract

Teachers need instructional media to make students' understanding concrete to support mathematics learning on the elementary school's two-dimensional and three-dimensional shapes materials. Based on this, designing a mobile learning application based on augmented reality is necessary. The steps in making mobile learning applications are adapted from the Borg & Gall (2003) development model, which consists of ten stages. The ten stages are summarized into three parts, namely design, development, and evaluation. This research focuses on the first stage, namely design. 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. Data collection was carried out based on the results of a needs analysis by the teacher through distributing questionnaires and analyzing the needs of experts based on interviews and literature studies. The results of this study obtained an application design in the form of appropriate content and features in developing mobile learning based on augmented reality material on the two-dimensional and three-dimensional shapes in mathematics learning with an ethnomathematics approach. One of the cultural products raised in this application is the Lengkong Traditional House from West Java, so through this application, culture can be known while learning about two-dimensional and three-dimensional shapes.

Keywords: Application Design, Mobile Learning, Augmented Reality, Learning Media, Two-Dimensional and Three-Dimensional Shapes, Ethnomathematics Approaches.

1 INTRODUCTION

The era of technology 4.0 requires students to be ready for the ever-evolving digital media. Graduates today must be able to optimize digital media widely used as a source of knowledge. Teachers are no longer considered the only source of knowledge because the presence of new media currently complements it as a source of knowledge (Reginasari & Annisa, 2018).

An educator or teacher needs media to make it easier to communicate subject matter to students in the hope that the learning process goes well so that the material can be understood. Therefore,

the role of media is vital in the learning process because the use of media can make it easier for students to understand the material presented by a teacher. However, a teacher must also be able to choose, design, and display media following the development of students and can make children feel comfortable when participating in the learning process. For the elementary school level, learning media is made as attractive as possible so that students can focus on the learning process (Abdurrohim, 2020).

The learning process can utilize technological developments, such as *mobile learning*. Mobile learning is a learning media that uses *mobile* phones or *tablet* computers to support the learning process. (Mehdipour & Zerehkafi, 2013). In addition, *mobile learning* uses wireless mobile technology devices to access information and learning materials anytime and anywhere. Learners can determine the time that suits their learning readiness, so *mobile learning* provides learning alternatives (Ally, 2009).

Mathematics is a subject that requires innovative learning media so that students can learn the material quickly (Djumanta & Susanti, 2008). Mathematics material can be understood easily if it is delivered to students in a concrete form so that they can manipulate objects in learning mathematics. One of them is the use of *augmented reality* (AR). AR has advantages, namely providing deep experience and understanding of the introduction subject. This research is expected to add references to the use of fun and interactive learning media to support the meaningful learning process for students. This *mobile learning* development also uses an ethnopedagogical approach that can make learning more contextual. AR itself can improve the spatial ability of learners (Nurhasah et al., 2019).

Research that has been done on AR states that AR makes learning more effective, and children are more excited. It is known from research conducted by Khotimah and Satiti (2019), who utilized *augmented reality* learning media. According to the study, students have a very positive response to *augmented reality-based* learning media because the learning media is considered practical and effective to use as learning media. It follows the research of Sungkur, Panchoo, and Bhoyroo (2016), which states that *mobile learning augmented reality* can be used to understand complex concepts in mathematics material so that students have no difficulty understanding the learning material. Through *augmented reality*, students can easily visualize the material they learn. Other research conducted by Nurhasanah (2019) shows that AR can positively impact students' understanding of science concepts. A *non-equivalent control group*

design shows differences between classes that use AR media and classes that do not use AR media in the science learning process. Thus, there are advantages to using AR as a learning medium for understanding material.

Nowadays, teachers still need to develop their own culture so that learning can be contextualized. One way to do this is by using cultural products in mathematics learning, known as the ethnomathematics approach. Ethnomathematics in the mathematics learning process is an approach to motivate students to learn mathematics by connecting the mathematical material taught with existing local culture or cultural practices (Marsigit, Setiana, & Hardiarti, 2018). Ethnomathematics uses concepts related to mathematical activities, including classifying, counting, measuring, and designing buildings in daily activities or using cultures rooted in students' Fields(Yuliasari, 2017). The ethnomathematics in this study identify spatial shapes found in West Javanese culture, namely the Lengkong Traditional House.

Based on this review, it is necessary to research to design an *augmented reality-based mobile learning* application to teach two-dimensional and three-dimensional shapes material at the elementary level. The research question is how to design *mobile learning* with *augmented reality* technology on two-dimensional and three-dimensional shapes with an ethnomathematics approach. According to users and experts, this research aims to design *mobile learning* media as an open learning resource. As a novelty, the *mobile learning* design can support students' understanding of recognizing culture through West Java traditional houses while learning the two-dimensional and three-dimensional shapes through an ethnomathematics approach so that it is expected to improve students' spatial abilities in a concrete form.

2 METHODOLOGY

The research method used in this study is development research or *Research and Development* (R&D). Development research is a research method used to produce specific products and test the effectiveness of these products. This research starts by analyzing the needs that need to be done to be able to produce specific products (Sugiyono, 2017). The product produced in this study is a learning resource in the form of *augmented reality-based mobile learning* that is expected to improve learners' understanding of the material in chemistry learning. Data was collected by distributing needs analysis questionnaires to teachers, interviews with experts in May-June 2023, and literature studies. The needs analysis data was used for the next stage,

namely development. The data analysis technique used in this research was quantitative descriptive analysis. The results of data analysis were used to identify things that must exist in learning the two-dimensional and three-dimensional shape materials as a reference in designing *mobile learning* media. It aims to find theoretical concepts to find the proper steps in developing these products (Sukmadinata, 2006).

3 FINDINGS AND DISCUSSION

This study designs a mathematics learning media application on the material of two-dimensional and three-dimensional shapes at the elementary level. The steps in making this *mobile learning* application were adapted from the Borg & Gall development model (2003), which consists of ten stages. The ten stages were summarized into three parts: design, development, and evaluation. This study lasted for two years. In 2023, the design and development part were conducted. In the following year, the evaluation part will be carried out. The following explains the research process carried out in the first year focusing on the design part. The design part consists of two stages, namely (1) the preliminary stage in the form of needs analysis and (2) *planning*. The following is an explanation of the application design activities.

3.1 Preliminary Stage

The preliminary stage consisted of *research and information* collection, and *planning*. The research and data collection stage was carried out by distributing a needs analysis questionnaire to elementary school teachers' respondents. The questionnaire was filled in between June 1st—14th, 2023, through a *Google form* link. The questionnaire contains questions about the respondents' experiences and opinions regarding learning the two-dimensional and three-dimensional shapes that have been carried out. In addition, this stage also conducted interviews with experts so that the features and content needed in the learning process could be identified. The results of the questionnaires and interviews were used for the development stage. The following is the explanation.

3.1.1 Teacher Needs Analysis

Based on the answers from the questionnaires that have been distributed, elementary school teachers have a good understanding of the two-dimensional and three-dimensional shapes materials at 95.1%. Through this, the difficulties that arise during learning the material from

the teacher's perspective can be investigated. The results showed that 34.1% of the respondents felt that the concept of the material of the two-dimensional and three-dimensional shapes was abstract, and 31.7% stated that they found it challenging to learn the material of the two-dimensional and three-dimensional shapes because there was no learning media that helped in understanding the material. 26.8% of teacher respondents also stated that the lack of practice questions was the cause of teaching difficulties. In addition, the learning methods used needed to be more varied, with almost 68.3% of respondents teaching the two-dimensional and three-dimensional shapes materials only through question exercises and discussions, 51.2% through lectures, and 46.3% through presentations. Teaching becomes monotonous also due to the need for more application of technological innovation in learning. It is evidenced by almost 61% of respondents stating that they have yet to use technology-based learning media in learning the two-dimensional and three-dimensional shapes materials.

Only a little exploration has been done using learning media for the two-dimensional and three-dimensional shapes. From the questionnaire, 80.5% of respondents still used blackboards and markers to explain the two-dimensional and three-dimensional shapes materials, and only 34.1% used simple PPT/ICT. Some teachers still have to use concrete objects in teaching. Therefore, 70.7% of respondents agreed that to overcome the problem of students' difficulties in understanding the material of the two-dimensional and three-dimensional shapes, it is necessary to make 3D modeling media from chemical bonds or the two-dimensional and three-dimensional shapes and practice questions. A total of 53.7% of respondents from teachers also agreed to use learning videos as a solution to explain two-dimensional and three-dimensional shapes materials. Teachers also agreed to utilize *smartphones* as an alternative learning source for understanding the material, with a percentage in the questionnaire of 39%.

Regarding *mobile learning* knowledge, 56.1% of respondents have known about mobile learning but from all respondents' responses. They rarely use mobile learning in the learning process or even never at all. In this modern era, learning using technological media significantly impacts learning (Sakat et al., 2012). Therefore, advanced technology can be utilized to develop more creative and innovative learning media. *Mobile learning* media is one of the options that can be used in the learning process. More than 90% of respondents agree and are interested in *mobile learning being* used as a learning media for two-dimensional and three-dimensional shape materials with additional features of learning videos and practice questions. In addition, respondents also think that students' understanding can be improved by

practicing 3D shapes to make them more attractive. Innovative *mobile learning* media makes learning more accessible, exciting, and practical (Huang et al., 2016).

To practice 3D shapes, *mobile learning* is equipped with *Augmented Reality* technology. As many as 63.4% of respondents do not know *Augmented Reality* technology, and 80.5% have never used Augmented *Reality* technology in the learning process. From the advantages of *Augmented Reality*, 97.6% of respondents agreed that mobile learning based on *Augmented Reality* can facilitate understanding of the material and is suitable for use in learning two-dimensional and three-dimensional shapes. It is in line with the results of research by Iordache et al. (2012), states that by using *augmented reality,* students understand more and learn chemistry quickly. Mustaqim (2016) also said that using *augmented reality* is very useful for interactive and authentic learning media directed by students.

Based on respondents' answers regarding the ethnomathematics approach, 61% of respondents needed help understanding the approach, and 65.9% had never held a learning process with an ethnomathematics approach. Implementing the current curriculum directs teachers to develop learning approaches to be more effective and preserve their culture. In this study, ethnomathematics focuses on West Javanese culture with the result that 65.9% of respondents are familiar with West Javanese culture, such as the Lengkong Traditional House. Learners' cultural background significantly affects the educational process if incorporated into classroom learning (Sumarni, 2016). It is because learners have spent their time in an environment influenced by community culture rather than formal education theory. More than 92% of respondents agreed if the material in the *mobile learning of* the two-dimensional and three-dimensional shapes is integrated with West Java culture so that learners can be interested in understanding learning contextually.

3.1.2 Expert Needs Analysis

Based on interviews conducted with experts, learning on two-dimensional and three-dimensional shapes materials is problematic because it depends on using learning media.

"The material in the two-dimensional and three-dimensional shapes chapter is quite difficult because it requires a lot of concrete examples so that students can imagine the shapes being taught. Therefore, the right media is needed. However, many teachers lack creativity in teaching this material. All of them only refer to practice questions and give homework. Thus,

students lack understanding of the characteristics and concepts of existing shapes." (Expert Interview, June 1, 2023)

Some studies that show students' difficulties in learning two-dimensional and three-dimensional shapes include weak geometry concepts, difficulty in solving problems, and low students' reasoning in geometry objects (Budiarto & Artiono, 2019; Subaidah et al., 2017). Therefore, effective learning media is needed to understand the material of two-dimensional and three-dimensional shapes. Using learning media in the teaching and learning process can also arouse new desires and Interests in students, arouse learning motivation, and even psychologically influence students (Azhar, 2017).

According to expert testimony, the things needed to learn two-dimensional and three-dimensional shape materials are recognizing a shape, drawing, calculating, and having spatial abilities to deal with the questions given.

"The abilities that are often needed to learn elementary level shapes are... the ability of students to recognize a shape from the characteristics given or its characteristics, the ability to draw will certainly also contribute to explaining the scope of students' understanding, and counting because it is the core of mathematics, and spatial abilities needed in learning the material. It is because the two-dimensional and three-dimensional shape's *materials also include calculations and measurements involving unknown variables such as area and volume."* (Expert Interview, June 1, 2023)

Spatial literacy is very important for students because it can help them understand geometry material and help them better recognize and interact with the surrounding environment. One of the international standards that can measure or evaluate spatial literacy is the *Program for International Student Assessment* (PISA) (Lane et al., 2019) which is included in the *space and shape* content of the mathematical literacy (Yusmin, 2016). The ability of students to *space and shape content* still needs to improve. It can be seen in the PISA data because the average score of Indonesian students' achievement in the *space and shape* category is 383, with the average score of the *Organization for Economic Co-operation and Development* (OECD) 490 (Piacentini & Monticone, 2016).

Then, several evaluations of the learning process on the material have been done. As stated by the expert:

"The reality is that the learning process is still guided by printed books, students' worksheets, and the lecture method. Sometimes, the teacher only explains through the blackboard. It will certainly make students bored easily. Educational innovations or learning media must often be done so that students are not bored learning math." (Expert Interview, June 1, 2023)

The material in the printed book is considered less than optimal because concrete visualization is needed in understanding the material of three-dimensional shape, which is more than just text and images alone. Media in the form of books as media and supplements with *augmented reality* technology can help teachers convey material with 3D visualization in printed books so that it is exciting and makes it easier to understand the material (Abdillah et al., 2020). To overcome these problems, combining the real world with the virtual world in *augmented reality* technology is excellent potential as a support for learning activities in education and improving the quality of learning during the process. (Nincarean et al., 2013).

During the interview, the expert expressed his interest in the advantage of learning materials, namely the exploration process, to reduce learning boredom.

"The learning of the material of the two-dimensional and three-dimensional shape will be interesting when students are also invited to explore the basics of understanding two-dimensional shapes, geometry, and real objects around them so that students do not become bored because they struggle to calculate and formulas." (Expert Interview, June 1, 2023)

In mathematics learning, meaningful learning is consistent with the constructivist view. Learners are said to understand if they build meaning from their experiences by making cognitive connections between new experiences and their previous mathematical understanding, not just memorizing formulas/arguments. (Gazali, 2016). Similarly, Z.P. Dienes (in Bossé et al.) argued that any mathematical concept or principle can be understood perfectly only if first presented to learners in concrete form, so, understandably, Z. P. Dienes emphasized the importance of manipulating objects in learning mathematics.

In addition, informants (experts) argue that further consideration is needed for some learners unfamiliar with technology's sophistication in *mobile learning.*

"For some students who are used to using smartphones, it is easy to adapt to the interactive nature of smartphones. However, some students are still not too familiar with the sophistication of technology, making it difficult in the learning process. Of course, technology development

in each region is different, so we must understand. However, we must also teach it slowly so students can understand and adapt." (Expert Interview, June 1, 2023)

Experts also agreed if the ethnopedagogical approach is used in creating *mobile learning* content. Learners' cultural background has a more significant effect on the educational process if incorporated into the classroom learning process. (Sumarni et al., 2016). It is because learners have spent their time in an environment that is created/influenced by the culture of the community rather than formal education theory.

"Agree" to recognize the region's characteristics and culture being occupied. In addition, it can also add insight to students because it is in the context of life so that learning becomes meaningful." (Expert Interview, June 1, 2023)

The features that are needed to learn three-dimensional shapes material in *mobile learning* are good visualization features.

"Light but clear material, knowledge games about the two-dimensional and three-dimensional shapes*, cultural games, interesting info about ethnomathematics, colorful visualization of AR, a sound that is easy to hear and menus that are easy to understand and design that supports can also attract students' interest in using it."* (Expert Interview, June 1, 2023)

Zodik & Zaslavsky suggested that examples in the three-dimensional shape are very dependent on visualization. The advantage of this *Augmented Reality* method is an attractive visual display because it can display 3D objects in the natural environment. (Amir, 2017). Learning will be more interesting because it can display the 3-dimensional virtual form of the desired object in the real world through an *Android smartphone*.

After conducting the data collection stage through needs analysis from teachers and experts, the next stage is planning. The planning stage shows that a *mobile learning* application on the material of the two-dimensional and three-dimensional shape based on *augmented reality and an* ethnomathematics approach is needed to support learning to increase the ease of exploring abstract objects projected in 3D and add cultural insights through contextual learning.

3.2 Planning Stage

The *mobile learning* media using the ethnomathematics approach to used six main menus, namely the implementation of *Augmented Reality* technology, material about the two-

dimensional and three-dimensional shapes, learning videos, exercise questions, an introduction to West Java cultural elements through ethnomathematics articles, and information related to *mobile learning*. The material described consists of text, images, shapes, characteristics of shapes, and real examples that can be found every day. Hilton & Nichols (2011) found that if learners increase their representation competence, their understanding of chemical concepts will also increase. If learners find it easy to understand the two-dimensional and three-dimensional shapes using several representations, it will be easier to understand and visualize the material. Moreover, applying the ethnomathematics approach can be contextualized learning so that students easily understand it.

The characteristics of the product to be developed in this research and development are as follows:

1. The product developed is a mobile learning media using an ethnomathematics approach in the form of an application that can be accessed with a smartphone equipped with the Android operating system.
2. The material covered in this developed product is the characteristics of two-dimensional shapes and the introduction of three-dimensional shapes for the elementary school level.

4 CONCLUSION

Based on the needs analysis from elementary school teachers and experts, *mobile learning* media is needed as a supporting learning resource for students that can be accessed via *smartphones* in learning two-dimensional and three-dimensional shapes materials. The designed *mobile learning* media is expected to improve students' spatial ability because it is based on *augmented reality*. The advantage of this *augmented reality* method is an attractive visual display because it can display 3D objects that seem to exist in a natural environment using one of the cultural products from West Java, namely the Lengkong Traditional House. This research resulted in designing a *mobile learning* application that can be accessed using a *smartphone* with an *Android* operating system. The content contained in this media consists of AR simulations, material, learning videos, quizzes, culture (containing an explanation of the Lengkong traditional house, which is associated with the material of the two-dimensional and three-dimensional shape), and information following the results of the analysis of student and expert needs. The results of the design stage are used for the next stage, namely application development.

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