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Development of Curved Three-Dimensional Shape Learning Media Ethnomathematics-Based Using Augmented Reality

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Abstract

A learning media is needed that can make abstract mathematics understandable and applicable in the real world where learning media currently does not interact much with technology.This study aims to develop learning media that uses Ethnomathematics-based Augmented Reality in the *Gunungan* tradition, which is valid, practical, and effective. The research subjects for the trial class are junior high school class IX students, with one class as a small class, one as a large class, and one as a control class. The learning media developed in this study is Augmented Reality (AR) assisted learning media with a combination of real and virtual objects in a real environment. Based on the results of descriptive analysis, it was found that the learning media developed had good quality because it met valid, practical, and effective criteria. The development of Augmented Reality-based spatial media can be used as a supporting medium for mathematics in grade 9 junior high school.

Keywords: *Ethnomathematics*; *learning media; Augmented Reality*

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Abstrak

Media pembelajaran diperlukan untuk membangun abstraksi agar matematika lebih mudah dipahami dan diterapkan dalam dunia nyata dimana media pembelajaran sata ini belum banyak berinteraksi dengan teknologi. Tujuan penelitian ini adalah untuk mengembangkan media pembelajaran yang menggunakan Augmented Reality berbasis Etnomatematika pada tradisi Gunungan yang valid, praktis dan efektif. Subyek penelitian untuk kelas uji coba adalah siswa kelas IX SMP, dengan satu kelas sebagai kelas kecil, satu kelas sebagai kelas besar, dan satu kelas sebagai kelas kontrol. Media pembelajaran yang dikembangkan dalam penelitian ini adalah media pembelajaran berbantuan Augmented Reality (AR) dengan perpaduan antara benda nyata dan maya dalam lingkungan nyata. Berdasarkan hasil analisis deskriptif diperoleh bahwa media pembelajaran yang dikembangkan berkualitas baik karena memenuhi kriteria valid, praktis, dan efektif. Pengembangan media augmented reality berbasis media dimensi tiga ini dapat digunakan sebagai media pendukung untuk pembelajaran matematika di kelas 9 SMP.

INTRODUCTION

Mathematics learning is often considered by students as difficult learning (Bakhrodin, Istiqomah & Abdullah 2019). This has an impact on the low achievement in learning mathematics Indonesian students. Because mathematics learning in general is still centered on the material in the book. Learning is a systematic and systemic process of teaching and learning activities. Learning is carried out to achieve learning objectives. The learning process should be interactive and communicative between the teacher and the student. But in fact, the learning process sometimes becomes communication from one direction, since students tend to be inactive and only listen to explanations from the teacher. According to Apriliyani & Mulyatna (2021), students are not interested in the learning process, especially mathematics learning. This is in line with the opinion (Nadiyah, Wijaya, Hakim, 2019) which reveals that it is undeniable that in every series of mathematics learning activities, student learning motivation is still relatively low. This can be seen from the lack of students desire to learn, and less interesting learning activities because students tend to be passive and rarely ask questions.

Therefore, a learning medium is needed that can make abstract mathematics understandable and applicable in the real world. Meanwhile, it is necessary to balance learning between concepts in schools and traditional culture in realizing contextual learning that is following the expectations of the 2013 curriculum (Lin, Chen & Liu 2017). To be able to create an atmosphere of learning mathematics that is closely meaningful as in everyday life (Herlina, 2020). So that a teacher has an important role in carrying out culture-based mathematics learning so that learning can be more easily accepted and does not seem to be something far from real life (Abdullah, 2016).

Based on these conditions, it is necessary to have learning related to daily problems, one of which is through culture. Therefore, learning innovations that use a cultural approach is needed by connecting teaching materials with daily life. The mathematics connected with the local culture is called Ethnomathematics (Khomah, 2020). Through ethnomathematics, students can learn mathematics through real activities so that they can construct and understand abstract mathematical concepts (Anjarwati, 2022; Nursyahidah and Albab, 2021). Noto, Firmasari & Fatchurrohman (2018) state that the application of ethnomathematics to learning approaches is an alternative to conveying mathematics more interestingly and overcoming saturation. In addition, culture-based mathematics learning is an interesting and innovative alternative because it encourages the emergence of contextual meanings based on student

experiences in the life of cultural societies (Fajriyah, 2018). In addition, learning using ethnomathematics can stimulate students' problem-solving abilities (Nursyahidah, Saputro, and Robowo, 2018).

Thus, students can cultivate a sense of love and cultural ownership when learning mathematics which can certainly help students not to get bored and not to feel lazy (Rizki & Frentika, 2021). In general, mathematics learning is still rare and integrates various local cultures that can be related to mathematics, one of which is *the Gunungan* Tradition. Central Java has a variety of local cultures, one of which is the *Gunungan* Tradition. In *the Gunungan* tradition, students can relate to geometric material that is still abstract.

Geometry is included in one of the branches of mathematics that is the subject of learning mathematics at various levels. Learning cannot only be done by knowledge transfer but must also be done by forming concepts through a series carried out directly by students (Nurhasanah et al. in Fauzi & Arisetyawan, 2020). Thus over time, the development of information technology is increasingly advanced which certainly affects human life (Mustaqim et al, 2017). Therefore, in facing the learning and development of 21st-century technology, one of them is by utilizing *Augmented Reality* technology (Rampengan, 2015). Augmented Reality is an application that combines the real world with the virtual world in two-dimensional and three-dimensional forms projected in a real environment simultaneously (Mustika & Sanjaya 2015). With the use of technology associated with Ethnomathematics, it is hoped that mathematics learning will no longer be boring. This learning media aims to increase students' understanding of the material to build space so that it is expected to help students more easily understand the material.

Based on the above problems, this study aims to describe the development of android-based mathematics learning media using augmented reality technology with an ethnomathematics approach at the junior high school level. The development of this learning media aims to invite students to build mathematical concepts from the real world, using their smartphones with an ethnomathematical approach (Richardo, et al., 2019). The real-world context used in this study is the cultural context which is a *mountain* tradition. While smartphones act as a bridge between cultural contexts and mathematical concepts, which in this case use applications based on augmented reality.

Based on the background stated, the purpose of this study is to develop an ethnomathematics-based curved three-dimensional shape learning media using Augmented Reality.

METHODS

The method used in this study is ADDIE (Branch, 2009) which is arranged into 5 stages, namely: analysis, design, development, implementation, and evaluation. The method can be seen in figure 1.

Stage 1: Analysis (analysis*),* which consists of an early-end analysis. The stage of activity carried out is to identify the problems encountered in the learning process to build a curved side room. In addition, a study of the availability of mathematics learning media was also carried out. The results of this analysis will be used as the basis for the development of mathematics learning media; student analysis. Activities are carried out to find information from the teacher to obtain the characteristics of students of class ix, the background of academic abilities, as

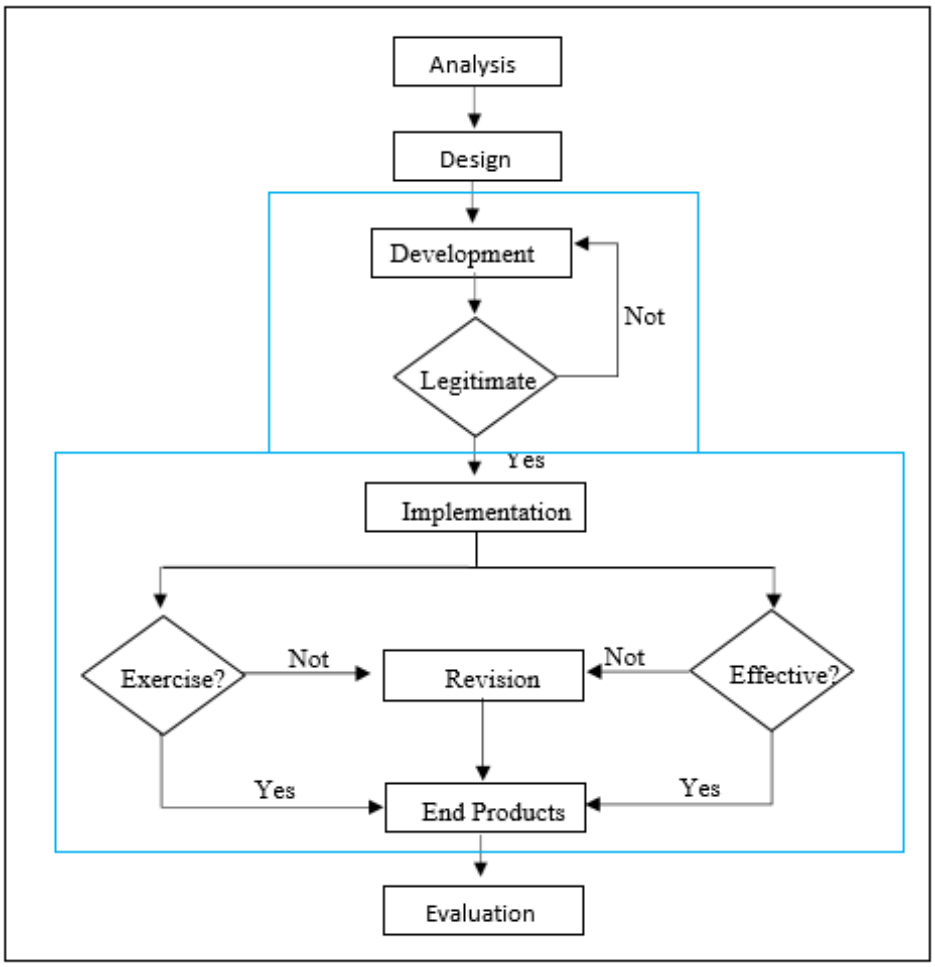

Figure 1. Development Procedure with the ADDIE Model (Branch, 2009)

well as the background of skills. The results of the analysis are used as instructional information to design learning media to build curved side rooms. and material analysis. Material analysis is carried out to mark, summarize, structure, and arrange mathematical objects such as facts, concepts, and procedures on the material to build curved side rooms that students will study. The material for the curved 3D shapes taught refers to the curriculum applicable in the high school that is the research site, and the teacher's book and student book used are books issued by the Ministry of Education and Culture.

Stage 2: Design, consisting of the following steps: creating a learning path. This stage creates a learning flow where the arrangement in the media is following the order of learning that corresponds to what is applied in the school according to the results at the analysis stage; drawing up the content of the substrate. At this stage, the media is compiled and designed its contents according to the created plot and according to the material resulting from the analysis, and the creation of a display design. At this stage, the media is designed to look in such a way that the appearance of the media can increase the attractiveness of the use of the media to be created later.

Stage 3: Development, consisting of stages: media creation. After all the previous stages are completed, the creation of design media 1 is carried out, the media is made according to the design that has been designed. Media creation using *blender, unity, and vuforia* software; preparation instructions for use. After the

design of 1 substrate is completed, then make instructions for use. The goal at this stage is for students to easily operate the learning media. At this stage, the media produced according to design 1 is corrected or recreated according to the assessment, correction, and input of the validator. Validation by media expert validator Mr. M. Prayito S.Pd., M.Pd. Conducted to obtain assessments, inputs, or comments from experts regarding the format, content, and illustrations of learning media, the beauty of design on AR media, and application systems. Validation by material expert validator Dr. Ida Dwijayanti, M.Pd is carried out to obtain assessments, inputs, or comments from experts regarding aspects of language, material suitability, and media uniqueness. So that after validation and it has been declared valid, a draft media 2 is obtained; and trials. At this stage, after design 2 is obtained, it is tested limited to a few students in the teaching and learning process. Before the teaching and learning process takes place, students are given *a pre-test*. At the second meeting, students were given treatment that was carried out in groups, and each student's activities were observed and recorded. At the last meeting, students were given *a post-test.* After all the complete data that has been obtained from the results of *the pre-test, post-test,* and observation are analyzed.

Stage 4: *Implementation.* At the implementation stage, learning is carried out using learning media to 34 students in large classes, and students in control classes carry out learning as usual. The results of the implementation stages determine whether there are significant differences in android-based learning media if applied in learning and also the results of completing classical learning for students who take part in learning using android-based augmented reality media. Stage 5: Evaluation, at this stage, the results of the data obtained during the implementation are analyzed. After the data analysis of was is completed, the media is evaluated. Whether the media is effective or not.

RESULTS AND DISCUSSION

Results

The process of developing android-based learning media that is feasible for learning materials to build curved side rooms is to use the ADDIE development model, namely: *Analysis (Analysis).* Results at this stage are 1) The background of students' abilities and students' creative thinking skills. Students' ability to understand curved 3D shapes materials is still relatively low, judged by pretest results that show a classical average score below KKM; 2) The background of the student's learning experience. The learning experience of students using android media is still small because students more often follow learning with conventional learning. Design. The results at this stage are in the form of learning media design which includes: 1) Learning flow. The results of the learning flow design used in the design of learning media are learning paths that have been discussed with teachers who teach mathematics subjects in schools according to Figure 2.

At the beginning of the lesson, students will be reminded again of the previous material, which is the material for 3D shapes by asking questions about the material. Then students orient the problem by using the illustrations that are in groups. After students understand the existing problems, students and their groups solve the problems that have been presented in the worksheet by collecting data related to the material. When the data and problems have been solved, students present the results of their analysis in front of the class. In the findings of this study, it is hoped that students can learn the material

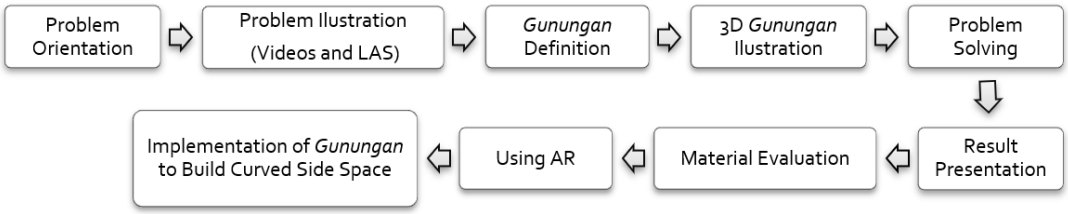

Figure 2. Learning Path

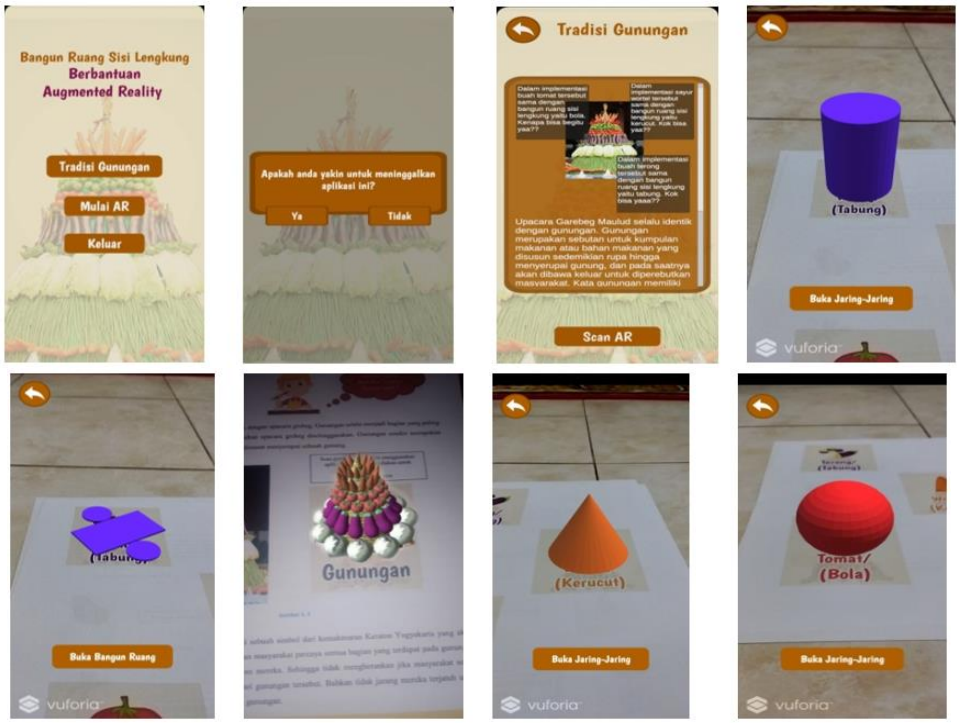

Figure 3 Screen Design

of curved 3D shapes easily using ethnomathematics-based Augmented Reality media, which helps students imagine the shape of curved 3D shapes concretely and makes classroom learning less monotonous. In addition to learning with media that support learning, students are also still taught to get to know Indonesian culture.

After the presentation of the results and analysis is complete, it is continued with the evaluation and strengthening of the material using *Augmented Reality (AR)* media. 2) The content of the media. The content of the learning media is the understanding of the mountain tradition based on its implementation of the curved 3D shapes that have been discussed with the teacher who teaches mathematics subjects, and 3) Display design. The display design drawings can be seen in Figure 3.

Development. Activities at this stage are 1) Media creation. The result is learning media created using *Blender, Unity, and Vuforia* by design software; 2) *Validation*. The media created and the instruments that have been compiled are validated by material experts and design experts to obtain validation. Revisions are made based on suggestions from validators. The revision is done by fixing *AR* Media by adding background music as per validator instructions. The results of the revisions are carried out continuously following the suggestions of the validators

Table 1. Results of Teacher Observations in Managing Learning

No.	Teacher Activities	Valuation
Introduction		
1	The teacher's ability to focus students' attention at the time of learning initiation	4
2	Ability to motivate and arouse student interest	4
3	Ability to convey learning objectives and learning steps	4
4	The ability to alert prerequisite materials	4
Core Activities		
1	Ability to make presentations/demonstrations using *smartphone* media	3
2	Ability to assist students who have difficulty using *smartphones*	4
3	Ability to provide feedback on students' understanding of the material *contained in smartphones*	4
4	Ability to motivate students to work and study using *smartphones*	4
Cover		
1	Ability to infer learning that has been discussed in *smartphone* media	4
2	Ability to close learning	4
3	Ability to condition the classroom atmosphere, including the enthusiasm of students and teachers	4
Mood		4

and the final result is stated that the media and instruments are valid; 3) Trials. Media and instruments are tested in small classes and show results that media and instruments are worth using.

Implementation. Media and learning instruments from the results of the development stage were then implemented in 34 students in large classes. Data from the results of the implementation are collected and analyzed.

Evaluation. The results of this stage are an evaluation of the results of data analysis in the previous stage, which shows that the final results of android-based learning media curved 3D shapes have met the categories of valid, practical, and effective. The implementation of the learning media trial was carried out in class IX SMP N 11 Semarang.

The data that have been obtained in the research process of developing android-based learning media for learning to build curved side rooms are analyzed and explained as seen in Table 1.

Observation of the teacher's activities in managing learning is carried out by one of the observers. The assessment of each observation criterion of teacher activity is successfully studied following the predetermined assessment criteria and is contained in each observation sheet. Based on the results of the analysis of teacher activities, managing learning to build curved side rooms to improve student understanding when learning lasts until the end of learning meets the criteria of "Excellent".

The teacher's activity in managing learning at the trial stage is observed with the results in Table 1 The results of data analysis show that the scores of each aspect of assessment in learning are 3 and 4 or can be said to be "Good" and "Excellent" with mode 4. This kind of value indicates that the teacher's activity in managing learning is categorized as "Excellent" in learning activities. The implementation of learning using this media is only as a facilitator to direct and guide as necessary, as well as encourage students to understand and solve problems according to their respective abilities. This is in line with (Lin, Chen, Liu, 2017) that teachers in conventional classrooms are transformed into different settings where ICT media are involved in the learning process. Where the role of the teacher who was originally purely providing information turns into a facilitator where students are

directed to find more information and determine the truth of the information.

Judging from the teacher's activities during the learning process, it shows that the learning media created has fulfilled its objectives, namely as a support for learning in understanding the material, and improving the quality of learning meetings as conveyed by (Branch, 2009) this is in line with the opinion (Branch, 2009; Sari, 2018) that the media can expand the ability of teachers in teaching, and offering opportunities to strengthen learning without being seen repeatedly for students.

Based on the observation of the results of student activities during learning to build a curved side room using android-based learning media, then at the time limit, 1 meeting is faster than learning time without using media. Thus, it can be said that students build curved side rooms using android-based learning media during learning activities to improve students' understanding of meeting active criteria. Students' responses to learning using media can be seen in table 2.

Based on the results of the analysis of student responses in Table 2, most students gave positive responses to the material being taught, how the teacher taught and each learning component received a positive response from students. This proves that student responses to the use of android-based media in learning activities to increase student understanding fall into the "Positive" category. This shows that students feel happy and interested in learning curved side shapes using Android-based media.

In Table 2, the responses of students who chose the happy category for the use of media in learning activities averaged 96% with a 100% mode in the student response questionnaire. This shows that students' responses tend to be happy or interested in participating in learning activities on curved side shapes using Android-based media.

Table 2. Results of Student Response Questionnaire to Media Used

Statement	Answer	
I feel good about the following learning components	Happy	Not
Learning material is good	100%	0%
How teachers teach is interesting	100%	0%
I can clearly understand the language used in smartphone learning media	100%	0%
The display (writing and illustrations/images) in *smartphone learning media* is very interesting	100%	0%
With smartphone-assisted math learning, it becomes easier to understand the material for curved 3D shapes	Yes 80%	Not 20%

Completion of Classical Learning

To see the completion of learning can be seen in Table 3 and Table 4.

Table 2. Pre-test and Post-test Results

Initial name	Pre-test	Posted	n-again	Learning Completion
C.S.A	56,5	85,5	0,666	Complete
E.R.F	56,5	85,5	0,666	Complete
F.D.S	64	90	0,722	Complete
F.A.A	64	90	0,722	Complete
M.J.M	75,5	100	1	Complete
Y.C	75,5	100	1	Complete
Middle	65,333	91,833	0,796	
0,764 N-high gain				

Table 4. Post-test Results of Experimental Class and Control Class Students

Control Class	Experimental Class
50	77,5
50	82,5
50	85
50	85
60	92,5
65	92,5
65	92,5
65	92,5
65	92,5
65	92,5
65	92,5

Table 3 Test Results- T

Test Paired Samples

		Paired Differences					t	Df	Sig. (2-tail)
		Mean	Std. Deviations	Std. Error Means	95% Confidence Interval of Difference Lower	Above			
Pair 1	Pretest - Post	-31,76471	22,50866	3,86020	-39,61835	-23,91106	8,229	33	,000

Based on the results of the table, it was obtained that the completion of individual student learning in experimental classes and experimental classes was achieved by 100%. All students completed learning with a KKM score of 75, because all students in the trial class and experimental class had the lowest score of 77.5 and the highest score of 100, so it was categorized that all students from the trial class and experimental class "Complete Learning". In addition, the data obtained from the pre-test and post-test in the form of tests have been validated by expert validators. Each question item given has been declared valid so that each question item in the pre-test and post-test has been declared suitable for use as a source of data collection.

Improvement in student comprehension based on the descriptive statistical analysis in table 3 was obtained and the increase in student comprehension is categorized as "High". The n-gain results from the pre-test and post-test showed a score of 0.764, or it can be called > 0.7 so it is included in the category of high comprehension improvement. In addition, the data obtained from the pre-test and post-test in the form of tests have been validated by expert validators. Each question item given has been declared valid so that each question item in the pre-test and post-test has been declared suitable for use as a source of data collection in the results of the analysis in the trial class described in the previous section, it can be stated that: 1) The test results to improve students' understanding of the experimental class are classically complete. This can be seen in Table 4 which describes the post-test results in the experimental class and control class.

In Table 5, it can be seen that the post-test results of each student in the experimental class have the lowest score of 77.5 while the highest score is 92.5. Since the lowest score is 77.5 and when compared with KKM 75, then the score of 77.5 can be said to be complete so it can be said that the student's comprehension test results are classically complete; 2) A significant influence on students' learning comprehension by using learning media.

This can be seen from Table 5 which explains the results of the T-test on the pretest and post-test data in the experimental class. In the table, it can be seen that the signification value (2-tailed) in the T-test is 0.000 < 0.05, so it can be said that learning media has a significant effect on students' understanding of curved 3D shapes materials. It can be stated that the learning media developed can be declared effective

Based on the descriptive statistical analysis in table 3 it is obtained that the improvement in student experience is categorized as "High". The n-gain results from the pre-test and post-test showed a score of 0.764, or it can be called > 0.7 so it is included in the category of high comprehension improvement. In addition, the data obtained from the pre-test and post-test in the form of tests have been validated by expert validators. Each item of the question given has been declared valid so that each item of the question in the

pre-test and post-test, it has been declared feasible to be used as a source of data collection.

Discussion

After being analyzed using the application, the results of the analysis of student learning outcomes data are shown in table 5. Table 5 describes the T-test results against post-test result data in the experimental class and control class. In the table, it can be seen that the signification value (2-tailed) in the T-test is 0.00 or it can be said to be <0.05, so it can be said that the development of learning media has a significant effect on students' learning about curved 3D shapes materials. This is following the results of previous research that the use of technology as a learning medium in the classroom can increase understanding so that students can learn more effectively (Eyyan & Yaratan, 2014; Hennessy & Dunham, 2002; and Lin, Chen, Liu, 2017).

To find out the effectiveness of learning media to build android-based curved 3D shapes, it is implemented and declared effective if it meets the following aspects: 1) Test results to improve student understanding are completed classically. Provided that the aspects of learning completion are met; 2)There is a significant influence on understanding. This study has important theoretical implications for the literature on AR namely, that these two modalities have different cognitive demands on users. However, the cognitive demands of such immersive experiences can make AR a more effective medium for conveying auditory (or other nonvisual) information. When designing an AR experience, it may be best to communicate relevant information in a hearing format.

Implication

The development of Augmented Reality-based spatial media can be used as a supporting medium for mathematics in grade 9 junior high school to improve creative thinking skills, to be a medium to support the creation of a good atmosphere in class, and to be a medium to support students in constructing geometric shapes abstract into 3D forms which are explored through the *Gunungan ethnomathematics context.*

Limitation

This study has various limitations. The limitations of this study are as follows: (1) This research is focused on the development of media using AR on curved 3D shapes; (2) The time required for this research is quite short so that media development can be carried out in a more complete and sophisticated manner so that it can have a greater effect on the development of student's creative thinking skills and can be improved to support students' HOTS abilities.

CONCLUSION

The results of the development of learning media using the ADDIE model that has been described, *ethnomathematics-based Augmented Reality-assisted learning* media are said to be valid with validation results from material experts and media experts of 90% with valid and very good criteria used, said to be practical as shown by the results of student response questionnaire analysis by 80%, and effective for improving creative thinking ability the students are shown by analyzing the post-test results of each student in the experimental class has the lowest score of 77.5 and when compared to KKM 75, a score of 77.5 can be said to be complete so that it can be said that the student's post-test results are classically complete. In addition,

the use of Ethnomatematics-based Augmented Reality technology can increase students' interest in curved side geometric material, students can associate *gunungan* context with the characteristics, volume, and surface area of the material they are studying, and students can solve problems related to volume and area problems. the surface of tubes, cones, and balls.

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