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Augmented Reality in Case Method Learning to Improve Geometry Skills

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Abstrak

Penelitian ini bertujuan untuk mengembangkan perangkat pembelajaran Pembelajaran Case Method berbasis Augmented Reality dan etnomatematika dalam meningkatkan keterampilan mahasiswa geometri. Penelitian ini dikembangkan dengan menggunakan model pengembangan 4-D. Subjek penelitian ini adalah 39 mahasiswa Program Studi Pendidikan Matematika. Metode pengumpulan data menggunakan metode angket dan metode tes dengan instrumen lembar validasi, tes kemampuan geometri, dan angket respon siswa. Hasil analisis Validitas menunjukkan skor rata-rata lembar validasi produk sebesar 3,65. Analisis Praktikalitas menunjukkan skor rata-rata angket respon siswa sebesar 3,49 atau 87% dalam kategori sangat praktis. Hasil Paired Sample T-Test menunjukkan angka yang signifikan antara nilai pretes dan postes dengan nilai signifikansi (2-tailed) p = 0,000 < 0,05, sehingga terdapat perbedaan yang signifikan antara nilai prates dan pascates. Perbedaan tersebut terlihat dari nilai rata-rata prates sebesar 31,51 yang meningkat menjadi 45,00 pada pascates. Dapat disimpulkan bahwa produk pengembangan memenuhi kriteria valid, praktis, dan efektif dalam meningkatkan kemampuan berpikir geometri siswa.
Kata Kunci: Augmented Reality; Case method; Ethnomathematika; Keterampilan geometri

Abstract

This research aims to develop a Case Method learning tool based on Augmented Reality and Ethnomathematics to improve students' geometry skills. This study was developed by using a 4-D development model. The subjects of this study were 39 students of the Mathematics Education Study Program. The data collection method used a questionnaire method and a test method with validation sheet instruments, geometry ability tests, and student response questionnaires. Validity analysis showed an average score of the product validation sheet of 3.65. Practicality analysis showed the average score of the student response questionnaire is 3.49 or 87% in very practical category. The results of the Paired Sample T-Test showed a significant number between the pre-test and post- test values with a significance value (2-tailed) p = 0.000 < 0.05, so that there is a significant difference between the pre-test and post-test values. The difference could be seen from the average pre-test value of 31.51 which increased to 45.00 in the post-test. It could be conclude that the development product satisfied the criteria of valid, practical, and effective in improving students' geometry skills.
Keywords: Augmented Reality; Case method; Ethnomathematics; Geometric skills

I. INTRODUCTION

Recently, science and technology have been developing at an accelerated pace. On the other hand, this development should be accompanied by a growing. Students are required to have better thinking skills, especially in geometric thinking. Geometry, as a foundational domain in mathematics, often poses significant learning challenges due to its reliance on abstract reasoning and spatial visualization. Geometry is a compulsory course in the mathematics education program. In addition to mastering the concepts, students are also required to master the geometry skills used (Susanto & Mahmudi, 2021). The geometry skills referred to students' skills in learning geometry, which according to Hoffer (1981) consist of five skills: (1) visual skills, (2) descriptive skills, (3) drawing skills, (4) logical skills, and (5) applied skills. To solve problems, students are required to possess these geometry skills (Muhassanah et al., 2014; Pujiani et al., 2025).

One step that educators could take is to set a learning that is able to explore students' geometric abilities. One of them is by conducting case method learning such that students are competent to solve certain cases. Learning using the case method is considered more effective in improving learning outcomes optimally (Widiastuti et al, 2022). Case method learning requires students to solve cases in learning materials that occur in society. The use of the case method learning method is expected to be able to reduce the difference between theory and practice in learning activities.

Culture in society could be integrated into Mathematics known as ethnomathematics. History shows that mathematics emerged as a product of a culture based on human social activities. By linking mathematics and culture, learning will be more effective and meaningful (Safrida, 2021). Although culture and mathematics are two things that develop side by side, there are still many students who often have difficulty and view mathematics as a science that is difficult to learn while every daily activity involves mathematical concepts in it. Learning that uses the application of ethnomathematics is considered more effective in significantly improving students' abilities in reasoning and solving the problems given. The application of ethnomathematics could be used to help students learn about geometry. Learning with an ethnomathematics approach allows for the development of thinking skills and understanding of geometric material (Fitriza et al., 2022).

The cultural heritage presented in the case study method is the tobacco house. The tobacco house, also known as the "atag house," is a cultural heritage of our nation, dating back to 1850 and is still preserved to this day, particularly in Jember Regency. Jember is a regency in East Java that produces tobacco, and tobacco is a leading commodity. Tobacco houses are generally located in the middle of rice fields, with their unique shape aiding the drying process by utilizing temperature and wind.

In order to present ethnomathematics in learning, educators could take advantage of the increasingly rapid development of technology. One technology that could support geometry learning activities is Augmented Reality (AR). In recent years, AR

has emerged as a promising educational technology that bridges the gap between abstract geometric ideas and concrete visualization. AR enables the overlay of interactive 3D models onto the physical environment, allowing learners to manipulate, explore, and engage with geometric shapes in real time (Ibáñez & Delgado-Kloos, 2018; Saputro et al., 2024). This direct manipulation supports spatial reasoning by making invisible or intangible mathematical relationships visible and tangible, thereby addressing a key limitation of traditional instruction. AR helps in displaying 3D virtual objects that are around so that the use of this technology could help the sustainability of geometry learning activities (Kartini et al., 2020; Rahman, 2025).

Geometry learning requires the use of media because mathematics does not just present something that seems passive and static, but learning must be active and dynamic (Sarjana et al., 2020; Yulia & Nasution, 2024). The use of AR as a learning media is innovations produced with visualize object real. It could explore students' mindset in thinking critically about problems that occur around them students, because augmented reality could visualize abstract concepts for understanding and the structure of an object model so that AR is a more effective media (Nistrina, 2021; Mustaqim, 2016). The presence of AR-based learning media could change the teaching and learning process from abstract and difficult to understand to interesting material that is easier for students to understand. The use of AR as a learning media inspires educational media not only using real objects, but also using visual objects in conveying information. In addition, it could correspondingly stimulate students' mindsets to think critically about a case and event that occurs in everyday life, because augmented reality could visualize abstract concepts for understanding and the structure of an object model as a result, allowing augmented reality to become a more effective media in line with the objectives of learning media.

Moreover, when embedded within case method learning, AR offers an opportunity to ground abstract concepts in authentic, problem-based scenarios. Case method learning emphasizes student-centered inquiry, collaboration, and contextualized problem-solving—aligning well with the constructivist principles underlying AR-based learning environments (Kim et al., 2020). Through this synergy, learners are not only exposed to more immersive and meaningful tasks but are also encouraged to construct their own understanding, test hypotheses, and apply geometry in real-life decision-making situations.

The background that has been described shows that it is necessary to conduct research related to ethnomathematics-based case method learning assisted by augmented reality. The innovation carried out in Geometry learning is implementing a case method model based on ethnomathematics assisted by augmented reality as a learning media to improve students' geometric thinking skills. This research aims to develop a case method learning tool based on Augmented Reality and ethnomathematics to improve students' geometry skills.

II. METHOD

This research is Research and Development (R&D) used the 4-D development model by Thiagarajan. The research subject was 39 students of Mathematics Education Study Program. Method tests using questionnaire method and tests methods test with validation sheet, geometry test, and students' questionnaires response. Validation sheet used for validity test, students' questionnaires response used for practicality test, and geometry test used for effectiveness test. Validity tests involve content, language, and construct aspects. The response questionnaire contains aspects of student responses after conducting ethnomathematics-based case method learning and using AR-assisted media. Geometry test divided into two types, pretest and posttest. Pretest was given before learning and posttest was given after learning. Geometry tests are arranged based on geometry skill indicators including visual skills, descriptive skills, drawing skills, logical skills, and applied skills. Research instruments and products are validated before being tested.

Procedure study consists of on four stage development (4D), namely Define, Design, Develop, and Disseminate. In the define stage , there are five stages, namely: (a) initial and final analysis, namely by conducting observations in the classroom in the form of observations to find out the learning system in the classroom; (b) student analysis, by observing how the characteristics of students; (c) task analysis, namely identifying tasks to be carried out by students and adjusting objectives to the skills in geometry; (d) concept analysis, namely compiling indicators based on skills in geometry and learning outcome; (e) objective specification, namely this research was carried out to develop augmented reality in case method learning to improve skills in geometry such as Semester Learning Plans (RPS), Student Assignment Plans (RTM), Student Worksheets (LKM), and assessment instruments.

The design stage consists of four stages, namely: (a) preparation of test criteria, determining the content, design the learning tools, and research instrument; (b) media selection, determining the augmented reality based on media using Assemblr Edu and Geogebra 3D Calculator; (c) format selection, the learning plans, student worksheet, media, and assessment developed pay attention to characteristics in the form of content, construct, and language; (d) initial design, namely designing media using Assembr Edu before the trial is carried out.

The develop stage consists of two stages, namely: (a) expert validation, this activity is carried out by experts (validators) to validate the learning tools and media before being tested. The results of this validation are used to make initial product revisions; (b) product trial, this activity consists of two stages. The first is a limited trial by non-subjects to test the readability of student worksheet and geometry test. The second stage is a field trial to determine the practicality and effectiveness of learning tools (prototype).

At the dissemination stage, the products were declared valid, practical, and effective. This dissemination was carried out by presenting in colloquiums and published articles. In addition, the developed products

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are shared with the lecturers of the Geometry course team.

The development procedure flow is presented in Figure 1 below.

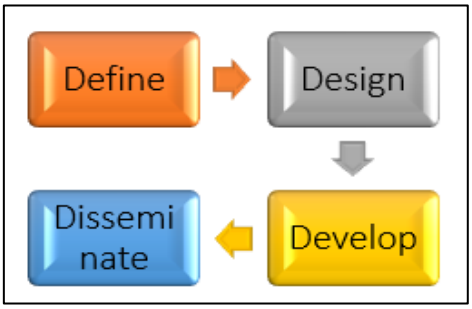

Figure 1. Learning Tools

Category validity based on the table following criteria on Table 1.

Table 1.
Validity Criteria

No	Mark V_a	Category
1.	$3 \leq V_a \leq 4$	Valid
2.	$2 \leq V_a < 3$	Less Valid
3.	$1 \leq V_a < 2$	Invalid

Products and instruments were said to be valid if fulfil valid criteria with interval $3 \leq Va \leq 4$. Analysis practicality product done with count percentage average questionnaire score response students. Category practicality product based on the following Table 2.

Table 2.
Practicality Criteria

No.	Percentage (P)	Category
1.	$85 < P \leq 100$	Very practical
2.	$70 < P \leq 85$	Practical
3.	$55 < P \leq 70$	Enough Practical
4.	$40 < P \leq 55$	No Practical
5.	$0 \leq P \leq 40$	Very No Practical

Products and instruments were said to be practical if fulfil minimal practical category or at intervals $70 < P \leq 100$. Analysis of product effectiveness is carried out using parametric tests. use Paired Until T-Test if Paired Sample T-Test results show significant numbers between pre-test and post-test scores with value significance <0.05 then H0 rejected and H1 accepted where there is significant difference between pre-test and post-test scores. Before conducting the paired sample t-test, homogeneity and normality tests were carried out.

III. Result and Discussion

At the defining stage, the researcher conducted a study related to students' geometric thinking skills. In addition, the researcher showed a literature study on learning that is able to explore students' geometric thinking skills. The results of the literature study indicate that the geometric abilities of new students in the Mathematics Education study program are immobile. Furthermore, based on the results of the literature study, it is known that one of the learning methods that could train students to solve certain cases is case method learning.

In the design stage, the researcher designed the integration of augmented reality in ethnomathematics- based case method learning to improve geometry skills. The products developed are learning devices consisting of Semester Learning Plans (RPS), Student Assignment Plans (RTM), Student Worksheets (LKM), and assessment instruments. Moreover, the design of learning devices that implement ethnomathematics-based case method learning with augmented reality is carried out to improve students' geometry skills.

At the development stage, researchers developed learning devices using the case method assisted by augmented reality and instruments that are able to explore

students' geometric thinking skills. The learning plans that have been developed presented in Figure 2.

Figure 2. Learning Tools

The lesson plan (RPS) is also equipped with student worksheets (LKM) and assessments. Ethnomathematics-based case method learning is presented through the tobacco house problem. Students are asked to solve the problems in the LKM presented in Figure 3.

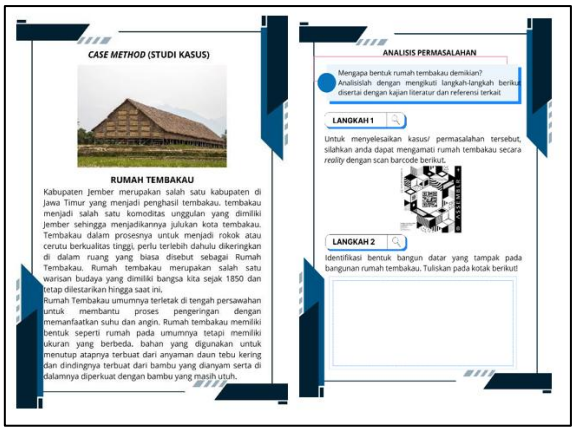

Figure 3. Student Worksheet (LKM)

Visualization of the tobacco house problem uses augmented reality, presented through Assembly Edu by scanning the provided barcode. The visualization of the tobacco house (Atag house) present in the following Figure 4.

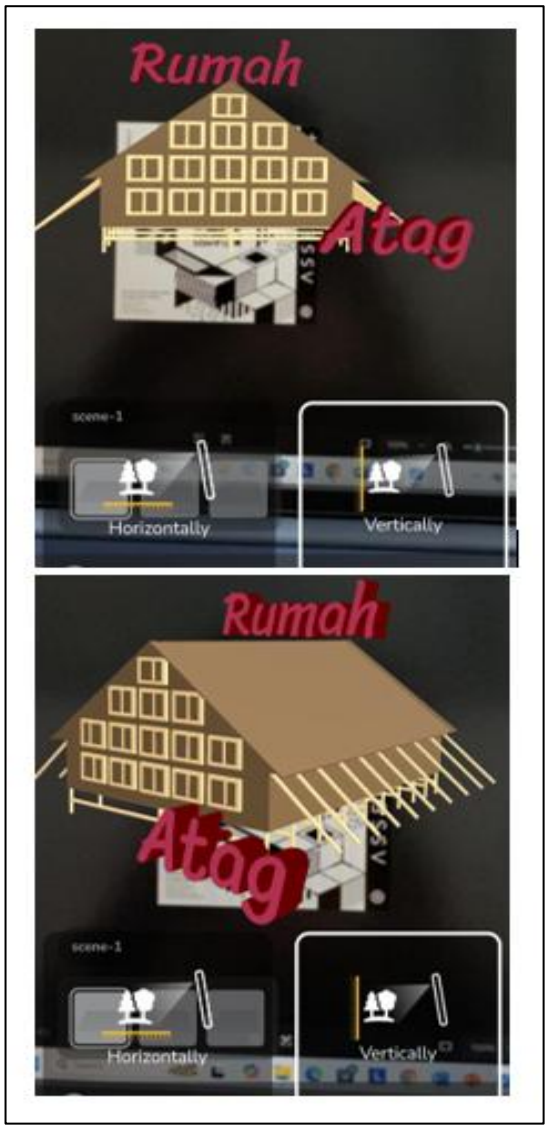

Figure 4. Visualisation of Tobacco House using Assemblr Edu

Furthermore, in addition to developing a prototype of the learning device, an instrument was also prepared to measure the validity, practicality, and effectiveness of the product. The validity instrument was in the form of a validation sheet, the practicality instrument was in the form of a learning implementation sheet and a student response questionnaire, and the effectiveness instrument was in the form of a geometry ability test. The prototype of the product and the resulting instrument were validated to test the validity on two

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validators who were lecturers of the Mathematics Education Study Program.

The results of the Validity analysis showed the average validation score was 3.65, meeting valid category (Table 1). The learning device that has been validated becomes Prototype II. Furthermore, prototype II is tested to test its practicality and effectiveness. The practicality and effectiveness test are carried out by conducting a trial by conducting learning and giving pretests and posttests. The results of the analysis of the student response questionnaire are presented in Figure 5 below.

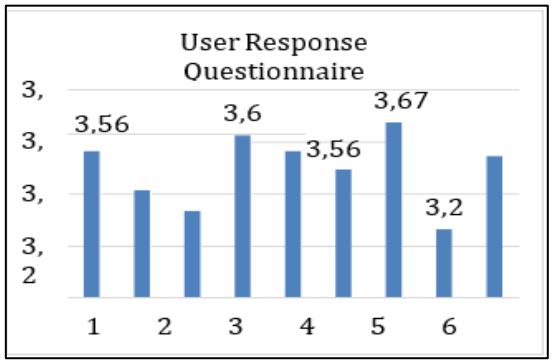

Figure 5. Questionnaire Results

The student's response questionnaire yielded an average score of 3.49 or 87%, categorized as very practical (Tabel 2). The effectiveness analysis begins with a normality test of the pretest and posttest results shown in Table 3.

Table 3.
Normality Test

Test	Kolmogorov-Smirnov[a]			Shapiro Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Pre-test	.127	39	.111	.956	39	.135
Post-test	.113	39	.200	.975	39	.529

Based on the results of the Shapiro-Wilk normality test, the pre-test significance value was 0.135 and the post-test was 0.529. Both significance values are greater than 0.05, indicating that the pre-test and post-test data are normally distributed, so the normality assumption has been met. Furthermore, the pretest and posttest data were continued with parametric tests using the Paired Sample T-Test to determine the differences between the pre-test and post-test values shown in Table 4.

Table 4.
Paired Sample T-Test Results

Test	n	Statistics descriptive	Paired Sample T-Test		
		M (Std. *D*)	*t*	*f*	Sig. (2-tailed)
Pre-test	39	31.51 (9.78)	-8,804	38	.000
Post-test	39	45.00 (9.92)			

The results of the Paired Sample T-Test showed a significant number between the pre-test and post- test values with a significance value (2-tailed) $p = 0.000 < 0.05$, so that H0 was rejected and H1 was accepted. This shows that there is a significant difference between the pre-test and post-test values. The difference could be seen from the average pre-test value of 31.51 which increased to 45.00 in the post-test. An increase of 13.49 shows that case method learning with Augmented Reality based on ethnomathematics is effective in improving students' geometric thinking skills. At this stage, dissemination is carried out, researchers disseminate the products produced in colloquiums and published

articles. In addition, the developed products are shared with the lecturers of the Geometry course team.

Products developed in integrate Augmented reality in case method learning based on ethnomathematics for increase ability think geometry in the form of learning tool. Devices learning is a collection of media or means used by teachers and participants educate in activity classroom learning (Hidayatni and Fathani , 2023) . Developed products has fulfil valid, practical and effective criteria. As for the device developed learning consists of on Plan Semester Learning (RPS), Student Assignment Plan (RTM), Student Worksheets (LKM), and test's ability geometry. Learning tool implement Integrated augmented reality in learning case method based on ethnomathematics.

Learning case method based Ethnomathematics serve related issues with ethnomathematics in the district Jember namely the Tobacco Warehouse or what is called as House atag. Regency Jember is area exporter tobacco. Tobacco that has been harvested through the drying process. Tobacco dried in a special place to maximize the drying process. Tobacco warehouse or House tobacco is designed building special to organize new tobaccos harvested and dried with method smoking so that the drying process maximum (Apriyono, 2021). Tobacco warehouse resemble get up space and shape flat in geometry namely prism and rectangle. Through ethnomathematics at Tobacco Warehouse, students given a problem Why Tobacco Warehouse formed. Problems the as implementation of learning models case method. Case method is a learning model that is carried out based on breakdown case (Harahap & Yusra, 2022). Implementation learning case method expected could explore ability think geometry so that quality graduate of become more good and has an impact on the waiting period which is relatively short (Andayani et al., 2022).

Student requested for identify Tobacco Warehouse form through augmented reality that could visualize it in a way real time through the assemblr.edu platform. AR is an application that combines real-world elements with the virtual world into a form two dimensions and three dimensions simultaneously in a real environment (Mustaqim, 2017). AR is a technology that combines the real world and virtual world. AR uses the real world as a reference basic and add some technology so that the understanding obtained becomes increasingly clear. Marker based tracking is a technique in AR that recognizes markers and identify the pattern of the marker to insert the virtual object into in real environment (Satria , B & Prihandoko, P; 2018). Furthermore, student identify characteristics shape and space by visible space in the tobacco warehouse via AR by scanning the barcode. Next, students could visualize get up flat and also room in a way independent through assisted AR Geogebra 3D calculator. This principle of Augmented Reality could make it easier participant educate in learn draft dimensions three with method participant educate No need draw in form two dimensions or imagine again, but could see in a way directly in the real world so that learning become interactive and effective (Herman et al., 2023).

Furthermore, AR's capability to simulate 3D geometric models from different

perspectives enhances spatial thinking, which is fundamental to geometry proficiency. Studies have shown that AR-based instruction leads to significant improvements in spatial visualization, geometric reasoning, and conceptual understanding, especially when compared to traditional methods (Cai et al., 2021). By enabling students to manipulate virtual objects, rotate figures, and explore cross-sections, AR empowers learners to grasp complex geometric relationships that are otherwise difficult to internalize.

IV. CONCLUSION

The devices' developed learning has fulfilled valid, practical and effective criteria. The result showed that learning tool is effective in integrating AR in learning case method ethnomathematics. As well as the learning tool was found practical, as student could easily use LKM which contains problems and AR with easy. Learning tool was effective, as statistical tests confirmation a significant increase student's geometry skill's. This study provides an alternative AR-assisted ethnomathematics-based case method learning tool in Geometry courses to help students prove theorems based on visual geometric shapes. For further research, it can explore the use of AR with various applications, study other ethnomathematics in geometry, and visualize other geometric shapes.

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