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The Effectiveness of Augmented Reality-Based Learning Media Integrating Toraja Carving Etnomathematics in Improving Junior High School Students' Productive Disposition in Palopo

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Abstract

The advancement of digital technology has driven innovation in mathematics education, one of which is the utilization of Augmented Reality (AR) that provides interactive and contextual learning experiences. The integration of AR with ethnomathematics, particularly Toraja carvings that are rich in cultural values and geometric patterns, is believed to enhance students' productive disposition. This study aims to examine the effectiveness of AR-based learning media grounded in Toraja carving ethnomathematics in improving the productive disposition of junior high school students in Palopo. This research employed a quantitative approach with a quasi-experimental design. The population comprised junior high school students in Palopo, with a sample of 150 students drawn from six schools selected through purposive and random sampling techniques. The research instrument used was a productive disposition questionnaire. Data were analyzed using the Wilcoxon Signed Rank Test, as the data were not normally distributed. The results indicate that AR-based learning media incorporating Toraja carving ethnomathematics are effective in enhancing students' productive disposition. This is evidenced by a significant difference between pre-test and post-test results, as well as an increase in the average scores of productive disposition in five out of six measured indicators.

Keywords: augmented reality; ethnomathematics; productive disposition

1. Introduction

The advancement of digital technology has brought significant transformations in the field of education, including mathematics learning. One emerging innovation increasingly utilized in educational contexts is Augmented Reality (AR), a technology capable of integrating virtual objects into the real world in real-time. AR provides an interactive, contextual, and immersive learning experience that can enhance students' motivation and engagement in the learning process [1][2]. In the context of mathematics education, AR has the potential to assist students in understanding abstract concepts [3], particularly through the integration of learning media with local cultural elements [4][5].

Ethnomathematics, as an approach that emphasizes the relationship between mathematics, culture, and practices of a community, provides significant opportunities to create more meaningful learning experiences [6]. By integrating cultural values, students do not merely learn mathematics as a formal discipline but also connect it with identity, tradition, and local wisdom [7][8]. In Palopo, which has a diverse social structure, one form of cultural richness that can be highlighted is Toraja carvings, which are rich in philosophical values as well as geometric patterns [7]. Toraja carving motifs, such as *pa'tedong*, *pa'dadu*, *pa'kapu' baka*, and *ne' limbongan*, not only carry symbolic meanings in community life but also embody mathematical concepts, particularly geometric transformations.

In learning the concept of geometric transformations through the introduction of Toraja carving motifs commonly found in daily life—such as on traditional Tongkonan houses, woven fabrics, and decorative objects—the learning process becomes more contextualized and meaningful. With the support of AR technology, these Toraja carving motifs can be visualized interactively, allowing students to directly explore the connections between cultural elements and mathematical concepts. This approach is believed not only to strengthen cognitive skills but also to foster cultural pride [9], learning motivation [10], and students' productive disposition toward mathematics [11].

Productive disposition refers to a tendency to view mathematics as logical, useful, and beneficial for life [12]. Indicators of productive disposition include perseverance, self-confidence, curiosity, learning enthusiasm, willingness to share knowledge, and a love for mathematics [13]. Various studies have shown that students' success in mathematics is determined not only by cognitive abilities but also by affective aspects [14]. Unfortunately, mathematics instruction in schools still tends to focus predominantly on cognitive skills, paying insufficient attention to affective dimensions such as productive disposition. Therefore, there is a need for innovative learning media capable of stimulating students' affective aspects, one of which is ethnomathematics-based AR.

Several previous studies have confirmed the effectiveness of using AR in learning [15][16]. AR can enhance conceptual understanding, motivation, and active student engagement in the learning process [17][18]. In Indonesia, some prior research has demonstrated the effectiveness of ethnomathematics-based learning in fostering students' appreciation and competence in mathematics [19][20]. However, studies that specifically integrate AR with ethnomathematics, focusing on improving the productive disposition of junior high school students, remain very limited.

Based on the above discussion, this study specifically aims to examine the effectiveness of Augmented Reality (AR) learning media based on Toraja carving ethnomathematics in enhancing the productive disposition of junior high school students in Palopo City. The integration of AR with ethnomathematics is considered an innovation that is not only relevant to the characteristics of students in the digital era but also contextualized with local culture that is closely connected to their daily lives. This study is significant in strengthening the affective aspects of students, particularly productive disposition, which has received limited attention in mathematics education. In addition, the research presents a learning model that links modern technology with local cultural values. Therefore, the findings of this study are expected to enrich the academic literature, provide practical recommendations for teachers in developing innovative learning, and support educational policies that emphasize character and cultural development through technology-based learning.

2. Methodology

This study employed a quantitative approach with a quasi-experimental design. This approach aims to measure the effectiveness of AR-based learning media grounded in ethnomathematics in enhancing students' productive disposition. The variables examined include the use of the learning media as the treatment variable and productive disposition as

the dependent variable, which was measured using a questionnaire instrument. The study focused on analyzing the differences in students' productive disposition scores before and after using the learning media.

The population of this study comprised all junior high school (SMP) students in Palopo City. From this population, a sample of 150 students was selected from six different schools. The selection of schools was conducted using purposive sampling, taking into account the availability of facilities, school readiness, and curriculum compatibility. Subsequently, within each selected school, students were chosen using random sampling, ensuring that every student had an equal chance of being included as a research participant.

The data analysis technique in this study employed the Wilcoxon Signed Rank Test as a nonparametric alternative, considering that the research data were not normally distributed. This test was chosen because it is appropriate for comparing students' productive disposition scores before and after the treatment within the same group. The analysis was conducted with the assistance of statistical software to ensure that the results were accurate, reliable, and accountable. Through this test, it is expected to obtain an objective overview of the effectiveness of AR-based learning media grounded in ethnomathematics in enhancing the productive disposition of junior high school students in Palopo City.

3. Result and Discussion

3.1. Result

This study involved 150 students from six junior high schools (SMP) in Palopo City. The research activities began with the distribution of a productive disposition questionnaire to the students prior to the implementation of the learning. The questionnaire data were used to test the validity and reliability of the instrument, as well as to obtain an initial overview of the students' productive disposition levels before the learning intervention.

Table 1. Results of Validity and Reliability Test

Item No-	r-calculated	Interpretation	Cronbach's Alpha	Interpretation
1	0,400	Valid	0,810	Reliable
2	0,331	Valid		
3	0,543	Valid		
4	0,543	Valid		
5	0,545	Valid		
6	0,660	Valid		
7	0,656	Valid		
8	0,660	Valid		
9	0,646	Valid		
10	0,531	Valid		
11	0,669	Valid		
12	0,621	Valid		

Based on Table 1, the calculated r-value for each questionnaire item was greater than the r-table value (0.159) at a 5% significance level. In addition, the Cronbach's Alpha was 0.810, which is higher than 0.60. Therefore, the questionnaire is considered valid and reliable for measuring students' productive disposition.

There are six indicators measured under the aspect of productive disposition, with each indicator developed into two statements. Students' perceptions of each productive disposition indicator before the learning intervention are presented in the following table.

Table 2. Students' Perceptions of Each Indicator

No	Indicator	Score	Category
1	Perseverance	78	Very Good
2	Self-confidence in abilities	67	Good
3	High curiosity	76	Very Good
4	Enthusiasm in learning	66	Good
5	Willingness to share knowledge	71	Good
6	Enjoyment of mathematics	67	Good

Based on Table 2, the indicators *perseverance* and *high curiosity* fall into the very good category, indicating that students demonstrate strong persistence and curiosity in learning mathematics. Meanwhile, the indicators *self-confidence in abilities*, *enthusiasm in learning*, *willingness to share knowledge*, and *enjoyment of mathematics* are categorized as good. These results suggest that, in general, students' productive disposition is at a positive level, with perseverance and curiosity serving as key strengths that should be maintained. However, aspects such as learning enthusiasm and appreciation for mathematics still need to be improved, for example, through more engaging and contextual learning strategies.

Overall, students' productive disposition before the learning intervention is presented in the following table.

Table 3. Productive Disposition Before Learning

Categori	Percentage
Very Good	31,33%
Good	63,33%
Low	5,33%
Very Low	0%

Table 3 shows that the majority of students (63.33%) fall into the good category. This indicates that most students already possess a positive attitude toward learning mathematics, such as self-confidence, enthusiasm for learning, and a willingness to share knowledge. Meanwhile, 31.33% of students are in the very good category, reflecting a group with highly developed productive dispositions characterized by strong perseverance and curiosity in learning. Only 5.33% of students fall into the low category, and none are categorized as very low. Overall, these results illustrate that the productive disposition of junior high school

students in Palopo City is generally at a positive level, although a small portion of students still require further support to strengthen their productive disposition in mathematics learning.

Subsequently, the learning process was carried out using AR-based learning media integrating Toraja carving ethnomathematics on the topic of geometric transformations. After the learning activities were completed, students were again given the productive disposition questionnaire to measure changes in their attitudes. The questionnaire was developed based on six indicators of productive disposition, expanded into twelve statement items. The results of the validity and reliability tests of the questionnaire are presented in the following table.

Table 4. Results of Validity and Reliability Test

Item No-	r-calculated	Interpretation	Cronbach's Alpha	Interpretation
1	0,246	Valid	0,844	Reliable
2	0,187	Valid		
3	0,207	Valid		
4	0,222	Valid		
5	0,406	Valid		
6	0,261	Valid		
7	0,411	Valid		
8	0,352	Valid		
9	0,274	Valid		
10	0,214	Valid		
11	0,381	Valid		
12	0,565	Valid		

Based on Table 4, the calculated *r*-values for each statement in the questionnaire are greater than the *r*-table value (0.159) at a 5% significance level. In addition, the Cronbach's Alpha value obtained is 0.844, which is higher than 0.60. Therefore, the questionnaire is declared valid and reliable for measuring students' productive disposition.

Students' perceptions of each productive disposition indicator after the learning process are presented in the following table.

Table 5. Students' Perceptions of Each Indicator

No	Indicator	Score	Category
1	Perseverance	78	Very Good
2	Self-confidence in abilities	71	Good
3	High curiosity	74	Good
4	Enthusiasm in learning	75	Good
5	Willingness to share knowledge	76	Very Good
6	Enjoyment of mathematics	76	Very Good

Based on Table 5, students' perceptions of each productive disposition indicator after the learning process show positive results. Three indicators—perseverance, willingness to share knowledge, and enjoyment of mathematics—fall into the *very good* category. This indicates that students demonstrate high persistence in facing learning challenges, enthusiasm in sharing ideas with peers, and a growing interest in mathematics. Meanwhile, the other three indicators—self-confidence in abilities, curiosity, and enthusiasm for learning—are categorized as *good*. This suggests that students have developed a fairly strong sense of confidence and motivation to learn, although these aspects can still be enhanced through more interactive and contextual learning approaches.

Overall, students' productive disposition after the learning process is presented in the following table.

Table 6. Productive Disposition After Learning

Categori	Percentage
Very Good	41,33%
Good	57,33%
Low	1,33%
Very Low	0%

Based on Table 6, the level of students' productive disposition after learning with the AR-based ethnomathematics media featuring Toraja carvings increased compared to before the learning process. The percentage of students in the *very good* category rose to 41.33% from the previous 31.33%. Meanwhile, the percentage of students in the *good* category remained dominant at 57.33%. In contrast, the proportion of students with a *low* productive disposition decreased to 1.33%, and there were no students in the *very low* category. These results indicate that most students maintained or even improved their positive attitudes toward learning mathematics through the use of AR-based ethnomathematics media incorporating Toraja carvings. Thus, this learning media proved effective in enhancing students' productive disposition.

Furthermore, statistical analysis was conducted to determine whether there was a significant difference between students' productive dispositions before and after learning with the AR-based ethnomathematics media. Prior to hypothesis testing, a normality test was performed using SPSS to determine the appropriate statistical analysis technique.

Table 7. Results of the Normality Test

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Pra	0,087	150	0,007
Post	0,137	150	0,000

Based on the results of the normality test using the Kolmogorov–Smirnov technique, the significance values for the productive disposition data before and after learning were 0.007

and 0.000, respectively. Both significance values are less than 0.05 (at the 5% significance level), indicating that the productive disposition data are not normally distributed. Therefore, the analysis technique used was the nonparametric Wilcoxon Signed Rank Test.

Table 8. Results of Wilcoxon Test

Test Statistics[a]	
	Post – Pra
Z	-4,577[b]
Asymp. Sig. (2-tailed)	0,000

Based on the results of the hypothesis test in Table 8, a significance value of 0.000 was obtained, which is less than 0.05 (at the 5% significance level). This indicates that there is a significant difference between students' productive disposition before and after learning using the ethnomathematics-based Augmented Reality (AR) learning media featuring Toraja carvings. Therefore, it can be concluded that the Augmented Reality-based learning media integrating Toraja carving ethnomathematics is effective in improving junior high school students' productive disposition in Palopo.

3.2. Discussion

The results of this study indicate that the Augmented Reality-based learning media integrating Toraja carving ethnomathematics is effective in improving junior high school students' productive disposition in Palopo. This effectiveness is evidenced by the results of the Wilcoxon Signed Rank Test, which produced a significance value of 0.000 < 0.05, indicating a significant difference between students' productive disposition before and after learning. These findings demonstrate that the application of ethnomathematics-based AR learning media has a positive impact on students' affective aspects, particularly in terms of perseverance, self-confidence, learning enthusiasm, and a love for mathematics.

The improvement in students' productive disposition is also reflected in the descriptive data, which show an increase in both scores and categories across most indicators. After the use of the learning media, 41.33% of students were categorized as having a very good productive disposition—an increase from 31.33% before the learning phase. This improvement indicates that the ethnomathematics-based AR media successfully created a more engaging, meaningful, and relevant learning experience for students, thereby fostering positive changes in their attitudes and dispositions toward mathematics.

One of the factors contributing to this improvement is the interactive and contextual nature of the ethnomathematics-based AR learning media. Through AR technology, students can directly observe geometric transformation patterns—such as reflection, translation, rotation, and dilation—found in Toraja carvings, visualized in attractive three-dimensional forms. This feature makes abstract mathematical concepts more concrete and easier for students to comprehend. Such learning experiences promote both cognitive and emotional engagement, thereby strengthening students' motivation and curiosity in learning mathematics.

Moreover, the integration of Toraja carvings serves as an essential cultural element that adds significant value to mathematics learning. The motifs of *pa'tedong*, *pa'dadu*, *pa'kapu' baka*, and *ne' limbongan* not only represent the aesthetic richness of Toraja culture but also embody authentic mathematical principles. When students learn through a cultural context, the learning process becomes more connected to real-life experiences and fosters a sense of pride in their local identity. This aligns with D'Ambrosio's perspective that ethnomathematics plays a crucial role in bridging formal mathematical knowledge with cultural practices embedded in society [21].

These findings are consistent with previous studies. For example, research by Carolina [1] and Farika [22] demonstrated that AR-based learning media can enhance students' motivation and positive attitudes toward mathematics by offering a more immersive and exploratory learning experience. Similarly, Ardiansyah [11] and Paulia [23] reported that the application of ethnomathematics enhances students' mathematical dispositions through more contextual and meaningful learning. Therefore, the results of this study not only align with prior research but also provide a new contribution by integrating two approaches—AR technology and ethnomathematics—into a unified and innovative learning model.

From an affective perspective, the improvement in students' productive disposition shows that the use of ethnomathematics-based AR media promotes the development of positive attitudes toward learning mathematics. The significant increase in indicators such as perseverance, willingness to share knowledge, and enjoyment of mathematics suggests that this learning media effectively fosters a collaborative learning attitude among students. The exploration within the AR media enables students to work together in understanding Toraja carving motifs, discussing their relationships with geometric transformation concepts, and helping one another solve problems. Such interactions build confidence and satisfaction in learning, which in turn strengthens students' productive disposition.

The results of this study underscore the importance of developing culturally based learning media in the digital era. The integration of technology and culture not only enriches the learning experience but also serves as a strategy for preserving local wisdom in the face of technological advancement. Thus, the ethnomathematics-based AR media featuring Toraja carvings is not only pedagogically effective but also holds significant educational and cultural value. The findings provide empirical evidence that innovative learning combining interactive technology with local culture can serve as an effective solution to address students' low productive disposition toward mathematics.

This study contributes to the body of literature on the use of learning media oriented toward strengthening students' character and positive attitudes toward mathematics. It not only demonstrates the effectiveness of ethnomathematics-based AR media in enhancing students' productive disposition but also emphasizes the importance of a holistic approach to mathematics learning that integrates cognitive, affective, and cultural dimensions. Such an approach is expected to serve as an innovative alternative for 21st-century education—an education that harmoniously blends technology, culture, and character in shaping a generation of learners who are critical, creative, and rooted in local values.

4. Conclusion

The Augmented Reality (AR)-based learning media integrating Toraja carving ethnomathematics has been proven effective in improving junior high school students' productive disposition in Palopo. The integration of AR technology with Toraja carvings creates interactive and contextual learning experiences, encouraging students to be more confident, enthusiastic, and develop positive attitudes toward mathematics. Therefore, it is recommended that future research expand the application of ethnomathematics-based AR media to different topics and educational levels, as well as explore its impact on critical thinking skills, mathematical communication, and student character, in order to enrich the findings on the effects of culture and technology-based learning

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