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Development of Interactive Games in Plane Figure Materials With Ethnomathematics Approaches in Elementary School

Ilvia Habsah [1], Linda Indiyarti Putri [*2], Ummu Jauharin Farda [3], Nusrotus Sa'idah[4]

[1-3] *Universitas Wahid Hasyim, Indonesia*
[2] *Universitas Islam Nahdlatul 'Ulama Jepara, Indonesia*
e-mail: lindaputri@unwahas.ac.id

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ABSTRACT. The purpose of this research is to develop effective and innovative learning tools that can improve the understanding of mathematical concepts on the material of building space. This research is Research and Development by applying the Reiser and Molenda model. The final validation result of the product from the material expert is 89.4% while the media expert is 97%, so this media product is declared very feasible to use in the learning process. N-Gain was used to measure the improvement of learning outcomes. From the analysis results, the control group average was 52.3 and the experimental average was 55.90. This study also proved that there was a significant difference in the learning outcomes of the experimental group and the control group from the independent sample t-test of t = 3.74; p = 0.001; ES = 0.973. The importance of integrating innovative and contextual learning media offers educators guidance to design more engaging and effective learning strategies, as well as enriching students' learning experiences by utilizing cultural and technological elements in education.

Keywords: *Interactive Game Learning, Ethnomathematics, Elementary School*

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INTRODUCTION

Education is very influential in the development of a country. Besides that, education is also an effort to create active learning to develop an individual's potential. Education is closely related to learning. Learning is a process of a person's efforts to achieve a shift in behavior (Febriyanti & Ain, 2021). It follows Law of the Republic of Indonesia No. 20 of 2003 Chapter 1 Article 1 concerning the National Education System, which explains that education is a systematic and planned effort to develop students' potential (Aisyah M Ali, 2018). Education strives to prepare students to face all future conditions and provide them with good knowledge, skills, and attitudes (Dewi &Izzati, 2020) .

Past studies revealed that the integration of ethnomathematics approaches is of great importance in the teaching and learning of mathematics as it is believed to improve learners' understanding and achievement in mathematics. Cognisant of the benefits of using ethnomathematics approaches in teaching and learning mathematics, the Zimbabwean school syllabus recommends the adoption and integration of ethnomathematics approaches to improve the learners' performance. (Sunzuma et al., 2021). Likewise, in Iran and many other parts of the

world, teaching and learning mathematics has confronted students and teachers with many challenges such as lack of motivation and increased anxiety (Wang et al., 2020; del Valle-Ramón et al., 2020). This is of particular concern in the world of mathematics education and how to provide sustainable solutions is an urgent matter (Yetĭm Karaca & Özkaya, 2017; Cotič et al., 2015).

Although it is recognized that students who have difficulty in understanding mathematics tend to have low academic achievement, and the importance of innovation and appropriate strategies by teachers in the classroom is acknowledged, there is still a lack in literature that specifically discusses the development and application of interactive learning media, such as games, in the context of mathematics learning. Sarwoedi et al. (2018) emphasize the expectation for teachers to innovate and apply appropriate strategies, but do not explicitly explore how interactive learning media can play a role in this.

Furthermore, Hapsari & Fahmi (2021) state that the constraints faced by teachers in conveying information and limited time can be overcome with the existence of learning media. However, there is still a gap in research on how exactly interactive learning media, especially games, can be designed and implemented to improve understanding of mathematics. There is a need to explore more deeply the effectiveness of interactive games as learning media in enhancing understanding and academic achievement in mathematics, as well as how this media can be integrated into the existing curriculum and teaching strategies (Kusumaningsih et al., 2018; Indriati et al., 2022).

Therefore, this research needs to focus on the development and evaluation of the effectiveness of interactive game-based learning media in the context of mathematics learning, to fill the existing gap and provide practical guidance for teachers in implementing innovative and effective teaching strategies. This research also needs to explore the perceptions of teachers and students regarding the use of this interactive learning media, as well as its impact on student motivation and engagement in the mathematics learning process.

The concept of media in the teaching and learning process is interpreted as graphic, photographic, or electronic tools for capturing, processing, and reconstructing visual or verbal information (Ratnaningsih et al., 2021). Learning media is a means to improve teaching and learning activities (Rahmi et al., 2019). Learning media is used in the framework of communication and interaction between teachers and students in the learning process (Kustandi&Darmawan, 2020). Learning media has a critical role in the learning process. One of the developments of learning media is playing interactive games in learning. The existence of animations in interactive games can improve students' memory so that students can keep the materials for a longer time compared to conventional teaching methods. Interactive game learning media could make learning delightful and exciting for elementary-age children, which is not only adapted to the characteristics of students but also the characteristics of the material being taught. Accordingly, learning media can arouse enthusiasm and interest in student learning as well as increase and success of student learning outcomes (Safitri & Koeswanti, 2021).

Education and culture cannot be avoided in everyday life because culture is a complete and comprehensive unit that applies in society. In contrast, education is a basic need for every individual. Ethnomathematics is a science that has been introduced previously in Indonesia. It has been known since the introduction of mathematics itself. It is just that this discipline was conceded after several scientists introduced ethnomathematics to be part of mathematics (Putri, 2017). Ethnomathematics is a method used to study mathematics by involving activities or the local culture to make it easier for someone to understand mathematics (Putri, 2017).

The scope of ethnomathematics includes the mathematical ideas, thoughts, and practices developed by cultures as the specific ways a particular group or society uses in mathematical activity (Nasryah&Rahman, 2020; Hendriyanto et al., 2023; Kamid et al., 2021).

Ethnomathematics is also a program that aims to learn how students understand, articulate, process, and ultimately use mathematical ideas, concepts, and practices and are expected to be able to solve problems related to their daily activities. Ethnomathematics uses mathematical concepts related to various mathematical activities, including grouping, counting, measuring, designing buildings or tools, playing, determining locations, and others (Sarwoedi et al., 2018). Ethnomathematics objects are used for mathematical activities such as calculating, specifying locations, estimating, planning, and explaining a culture (Nursyeli & Puspitasari, 2021; Kamid et al., 2021).

Culture and mathematics have a close relationship because, in everyday life, they always need each other. Culture and mathematics are elements that are related to one another in life. Mathematics is used in all daily activities (Yuningsih et al., 2021). It is hoped that ethnomathematics will teach students about mathematical concepts and character building (Dewi Yuli Setyoningrum et al., 2022).

The plane figures material for grade IV of Madrasah Ibtidaiyah is studied to equip students with the ability to think logically, analytically, systematically, critically, and creatively and work together. The material presented in the media is about the definition of plane figures, understanding the types of plane figures, the properties of plane figures according to the types, and finding the circumference and the area of plane figures according to the types. In the media, exercises are also given to help students understand learning outcomes (Maksum & Zuhdi, 2022). In mathematics lessons on plane figures, the student will learn about the arithmetic concept and is expected to be able to apply it in everyday life.

The importance of this learning media development to be carried out includes first, the challenges in learning mathematics such as lack of motivation and increased anxiety among students. Second, the recognition of the importance of innovation and appropriate strategies by teachers, but there is still a lack of literature on the development and interactive learning media for flat building materials with an ethnomathematics approach. Third, the need to explore more deeply the effectiveness of interactive games as learning media in improving mathematics learning comprehension and achievement. This research also aims to fill the gap in research related to how interactive learning media, especially games, can be designed and implemented to improve mathematics understanding, as well as integrating the ethnomathematics approach which has been recognized for its importance in improving student learning performance. based on this description, this research focuses on developing game-based interactive learning media using the ethnomathematics approach to overcome student learning outcomes that have not met the minimum class target.

METHOD

This research aims to develop interactive game learning media using the ethnomathematics approach. The research method used is Research and Development (R&D) with the ADDIE development model by Reiser and Molenda, which consists of five stages, namely analysis, design, development, implementation, and evaluation.

Analysis

Based on the pre-research at MI Roudlotul Huda Gunungpati, attractive and interactive learning media were needed. MI Roudlotul Huda has implemented the 2013 curriculum, but teachers only use LKS (student worksheet) and module books provided by the Madrasah.

The product produced by the researchers was an interactive game learning media based on ethnomathematics in Mathematics on plane figure materials to provide concrete media about the material being discussed to students.

At this stage, theoretical and practical analysis was carried out, which aimed to obtain information to what extent this development media was needed to optimize the implementation of learning activities.

Planning (Design)

After knowing the needs of the educators and the students for interactive game learning media based on ethnomathematics in Mathematics on plane figure materials at MI Roudlotul Huda Gunungpati, the design was made following theoretical and practical studies. The result of this stage was a new product complete with specifications.

Development

At this stage, all elements of interactive game learning media that will be made were collected and designed, such as animation, text, audio, video, questions, and answers. It was according to the ethnomathematics-based interactive game learning media design in Mathematics on plane figure materials at MI Roudlotul Huda Gunungpati.

The next step was testing and assessing the developing learning media to the media and material experts regarding material and language to find its strengths and weaknesses.

Implementation

The activity at this stage tested the ethnomathematics-based interactive game learning media by involving grade IV students at MI Roudlotul Huda Gunungpati.

Evaluation

The evaluation phase was conducted after the four initial stages had been carried out. This stage could be done by providing an evaluation in the form of pre-test and post-test questions to determine the increasing learning outcomes of the students.

In this research article, we apply quantitative methods to test the effectiveness of learning with a focus on t-test to evaluate and compare the effectiveness of two or more groups (treatment group and control group). Next, normality and homogeneity of variance distribution tests are used to fulfill the initial assumption test and determine the type of t-test analysis. Finally, a statistical test is applied to determine whether there is a significant difference between the study groups. The t-test used was independent sample t-tests using jamovi software .

Table 1. Media and Material Eligibility Criteria (Suharsimi Arikunto, 2020)

No	Score in percentage (%)	Eligibility Category
1	< 21 %	Very Inadequate
2	21 – 40 %	Inadequate
3	41 – 60 %	Decent Enough
4	61 – 80 %	Eligible
5	81 – 100 %	Very Eligible

Result percentage formula = $\frac{total\ score\ obtained}{maximum\ score}$ x 100%

Qualitative descriptive data from the average score of students' test results will be analyzed to see the level of achievement of students' learning outcomes in class. To test individually

whether the designed interactive game learning media has effectiveness or not on the learning outcomes of each student, a comparison was made between the results of the pre-test and the post-test using (N-gain) as follows:

This test was used to analyze the pre-test and post-test score data (Hake, R. R).

$$N\langle gain\rangle = \frac{\textit{Post-test scores} - \textit{Pre-test scores}}{\textit{Maximum score} - \textit{Pre-test scores}}$$

The category or interpretation of the N Gain Score value can use the N Gain value directly or in percentage.

Table 2. Gain Score Distribution (Direct N Gain)

N-gain Value	Category
> 0,7	High
0,3 ≥ g ≥ 0,7	Moderate
< 0,3	Low

Table 3. Category Effectiveness N Gain (Munawarah et al., 2021)

Percentage (%)	Enterpretation
76	ffective
6 - 75	oderately Effective
0 - 55	ess Effective
40	ot Effective

RESULT AND DISCUSSION

The development of interactive game learning media with an ethnomathematics approach to plane figure materials in this research follows the ADDIE Research and Development model: Analysis, Design, Development, Implementation, and Evaluation. The following describes the stages in developing interactive game learning media with an ethnomathematics approach to plane figure materials that can be used in mathematics learning according to the ADDIE stages.

1. Needs Analysis (Analysis Stage)

Based on interviews with mathematics teachers at MI Roudlotul Huda Gunungpati, the teacher used training methods and assignments in online learning. The media used were books and WhatsApp. Explaining the learning materials via streaming video required a lot of internet quota, so teachers used WhatsApp more often. In addition, based on the results of interviews with the students, they were less interested in knowing Indonesian culture. Student knowledge

about Indonesian culture still needs to be improved. They considered Indonesian culture ancient and were more interested in contemporary things.

Learning media can then be implemented in schools in learning activities and at home as learning materials for students to study ethnomathematics-based plane figure materials. After applying the material that the media would be made, the researcher then analyzed the characteristics of the material based on the purpose of the plane figure materials. The plane figure material was taken from grade IV at the Madrasah Ibtidaiyah level with competency standards, basic competencies, and indicators according to the needs at MI Roudlotul Huda Gunungpati.

2. Media Design (Design Stage)

This interactive game of plane figure materials with an ethnomathematics approach was designed to make learning media that is educative, acceptable, good quality, attractive, easy to access and make students more enthusiastic about learning. This ethnomathematics-based interactive game facilitates learning activities, especially mathematics, by utilizing technological capabilities that construct learning media into an interactive game that can be accessed anywhere and anytime and does not require a large quota. Learning becomes more flexible and enjoyable. Learning materials were made according to the needs of students, and the material in this interactive game was taken from various sources, such as several mathematics textbooks for grade IV MI. At the design stage, the researcher designed learning materials for plane figures using an ethnomathematics approach by inserting illustrations of Indonesian culture that can be found in everyday life.

The results of creating learning media designs in the form of Ethnomatematics-Based Interactive Games in this study are shown in the following figure.

Figure 1. Contains the home screen of the Ethnomatematics-Based Interactive Game

Figure 2. Contains the home screen of the Ethnomatematics-Based Interactive Game

Figure 3. Contains a description of what plane figures and ethnomathematics are

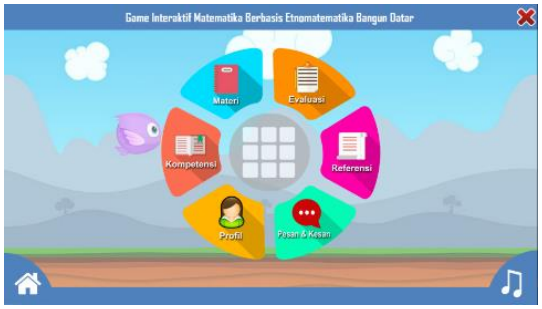

Figure 4. Contains the appearance of the Interactive Game homepage, such as Competency, Material, Evaluation, Reference, Profile, and Messages & Impressions

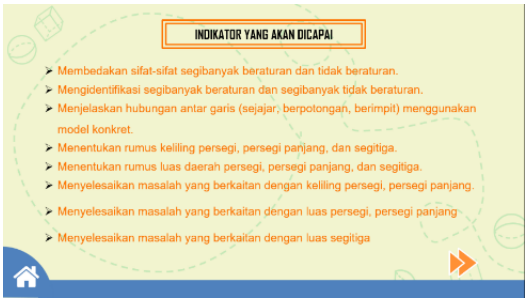

Figure 5. Contains the indicators that students will achieve

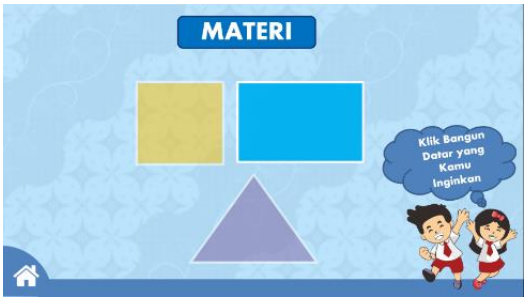

Figure 6. Contains the display on the plane figure material menu

Figure 7. Contains ethnomathematics-based plane figure material, and there is a menu that includes Definitions, Properties, Formulas, and Example Questions

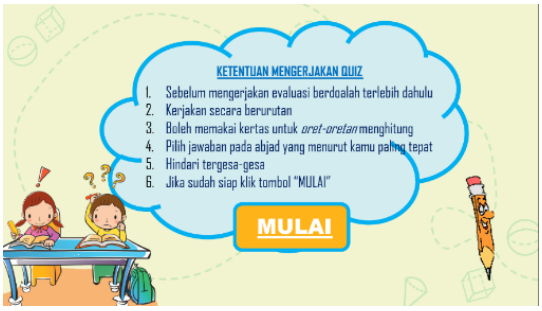

Figure 8. Contains views on evaluations or quizzes

Figure 9. Contains ethnomathematics-based interactive game evaluation questions

Figure 10. Displays the value of the evaluation or quiz results

Figure 11. Contains the profile display

Figure 12. Contains the display on the reference menu

Figure 13. Contains the display on the impressions and messages menu

3. Media Development (Development Stage)

Firstly, design validation was a process to assess products through learning media. Validation can be done by inviting media and material experts to assess learning media. The media expert helped assess the media's feasibility regarding display design and program running. Meanwhile, the material expert was to evaluate the material contained in the media. (1) Design revisions were made after the media and material experts suggested learning media for Ethnomatematics-Based Interactive Games. (2) Revision from Media Experts, the results of the validation of media experts found that the learning media was included in the "Very Good" criteria for use. (3) Revision from Material Expert, material expert revisions were taken after material experts validated learning media product design. From the validation results, it was known that learning media had entered the "Very Eligible" criteria for implementation but still needed improvement following the suggestions given by material experts.

Secondly, the result of the revision at the end of the product validation was at MI Roudlotul Huda Gunungpati. After going through various stages of validation and practicality, the ethnomathematics-based interactive game learning media with plane figure material contains Basic Competencies, Indicators, Ethnomatematics-based Material, evaluation questions, messages and impressions, and profiles.

Implementation (Implementation Stage), program implementation is the stage of displaying interactive games based on ethnomathematics in the experimental group. This game was tested involving grade IV students. After being given treatment, post-test data was taken. Next is Evaluation (Evaluation Stage), this stage was a phase to determine whether the product produced, in this case, Ethnomatematics-Based Interactive Game learning media for mathematics on plane figure materials for grade IV. The technique to determine whether interactive game learning media based on ethnomathematics can improve learning outcomes was done by calculating the pre-test and post-test methods. This method was carried out by providing pre-test questions before applying ethnomathematics-based interactive game-learning media. After that, these values were compared with the post-test scores where students had used ethnomathematics-based interactive game learning media. These results obtained the validity and effectiveness of interactive game learning media based on ethnomathematics.

Media and material experts carried out media validation tests. Improvements will be made based on their comments and suggestions. Following are the results of the first stage validation questionnaire recapitulation.

Table 4. Recapitulation Results of the First Phase of the Validation Questionnaire

No.	Expert	Total Average Score	Maximum Score	Percentage	Criteria
1.	Media Expert	4,7	5	93,7%	Very eligible to use
2.	Material Expert	3,7	5	75,3%	Eligible to use

Material and media validation was conducted in two stages. The first stage met the criteria and was suitable for use but needed to be revised. The validation results from material experts on the development of Ethnomatematics-Based Interactive Game learning media can be concluded that the two aspects, after being summed and looking for the average, were classified in the category of "Very Eligible to use". Meanwhile, for the second stage of validation, the percentage results are as follows:

Table 5. Recapitulation Results of the Second Phase of the Validation Questionnaire

No.	Expert	Total Average Score	Maximum Score	Percentage	Criteria
1.	Media Expert	4,8	5	97%	Very eligible to use
2.	Material Expert	4,47	5	89,4%	Very eligible to use

The output of the N-Gain score test showed that the mean N-Gain scores were: 1.) The control class was 52.3 or 52.3%, included in the category of less effective. 2.) The experimental class was 55.90 or 55.9%, included in the category of moderately effective. It means there was a difference in the number of means in the two classes. The average obtained by the experimental class was more significant than the control class. It proved that learning using interactive learning media based on ethnomathematics was effectively applied in grade IV.

Table 6. Average N Gain Score

No	The Score Obtained	Experimental Class	Control Class
1	N Gain Max	100,00	100,00
2	N Gain Min	0,00	0,00
3	Average	55,90	52,3
4	Categories	Moderately Effective	Less Effective

The next stage is statistical testing to determine the effectiveness of learning using interactive game media based on ethnomathematics critical steps to ensure that the analysis results are valid, accurate, and reliable (Parmin & Peniati, 2012; Alika & Radia, 2021; Nurdyansyah et al., 2020). Before the difference test, the researcher conducted an assumption test first. Normality and homogeneity tests on data to decide the next step of analysis.

Table 7. Normality distribution calculation results

Normality Test (Shapiro-Wilk)

	W	p
post test	0.968	0.181

Note. A low p-value suggests a violation of the assumption of normality

Next, the researcher conducted a statistical analysis of the assumption test as the first step in determining the difference test. by using the Shapiro-Wilk test and a confidence level of 5%,

the resulting p value = 0.181. This shows that the data is assumed to be normally distributed. Then in the homogeneity variance test between groups, researchers used Levene's test with a confidence level of 5%, resulting in a p value = 0.708. this can prove that the data obtained has a similar variance, so it can be continued in the t-test.

Table 8. Homogeneity test analysis results

Homogeneity of Variances Test (Levene's)

	F	df	df2	p
post test	0.142	1	49	0.708

Note. A low p-value suggests a violation of the assumption of equal variances

The research data has been declared normal and homogeneous so that it can be continued with parametric statistical analysis using the independent sample t test because the samples obtained are post-test results from two unrelated or independent groups (experimental group and control group) (Tamur et al., 2020).

Table 9. independent sample t-test results

Independent Samples T-Test

		Statistic	df	p		Effect Size
post test	Student's t	3.47	49.0	0.001	Cohen's d	0.973

Note. H_a $\mu_{experimen\ group} \neq \mu_{control\ group}$

The t-test analyzed using Jamovi is shown in table 8 the value of t = 3.74; p = 0.001 the decision taken is to reject H0. This proves that there is a significant difference in student learning outcomes between the experimental group and the control group. Student learning outcomes in the treated class showed higher learning outcomes than the untreated class. So it is proven that the use of interactive math games with an ethnomathematics approach provides a high impact size of 0.973.

Pembahasan

The conclusions of this study are consistent with prior research that highlights the efficacy of ethnomathematics in improving students' comprehension of mathematical principles. By incorporating cultural aspects into the learning process, ethnomathematics enhances the relevance and engagement of the material for students (Putri, 2017; Nasryah & Rahman, 2020). The present work findings reveal that the implementation of interactive games based on ethnomathematics resulted in notable enhancements in learning outcomes, as evidenced by the post-test scores and N-Gain values. The findings of Wang et al. (2020) and Sunzuma et al. (2021) support the notion that using culturally contextualized learning methods can effectively decrease students' anxiety and enhance their motivation in the field of mathematics education.

The notable disparity observed between the control and experimental groups in this study aligns with the results of preceding studies that underscore the significance of interactive learning media in enhancing educational achievements (Hapsari & Fahmi, 2021; Sarwoedi et al., 2018). The robust effect size (0.973) indicates that the interactive games not only enhanced students' involvement but also facilitated more profound cognitive comprehending of the subject matter.

The findings align with the theoretical framework of constructivism, which suggests that students acquire knowledge more effectively when they actively participate in practical, situationally appropriate activities (Tamur et al., 2020). The integration of games into the educational process offered pupils a more interactive and engaging setting, therefore enhancing their ability to remember and comprehend mathematical principles.

Nevertheless, the study was constrained by its small sample size and the narrow scope of its implementation, as it only examined fourth-grade pupils inside a particular educational environment. Kusumaningsih et al. (2018) emphasised the need of conducting extensive investigations with larger and more diverse samples in order to comprehensively assess the generalizability of ethnomathematics-based techniques. Furthermore, future study should investigate the performance of these interactive games among various age groups, educational levels, and cultural settings to guarantee a more thorough comprehension of their efficacy. This would offer more definitive data to substantiate the incorporation of ethnomathematics into conventional education strategies.

CONCLUSION

Key results from the construction of interactive game learning media based on ethnomathematics were as follows: material validation achieved 89.4% and media validation reached 97%, both falling into the very valid bracket. The post-test measures revealed a notable enhancement, as the experimental group achieved an average score of 88.7, in contrast to the control group's average score of 75.2. The experimental group achieved an N-Gain value of 55.90, indicating a fairly effective learning outcome. In contrast, the control group scored 52.3, indicating a less effective learning outcome. This difference in learning outcomes was statistically significant ($t = 3.74$; $p = 0.001$) with a substantial effect size of 0.973. The key discovery was the substantial efficacy of interactive games based on ethnomathematics in enhancing learning results, verified only by experimentation. Nevertheless, the study was constrained by its low sample size and concentration on a particular grade level, therefore limiting its applicability to a broader population. Further investigation using larger and more varied research samples and a wider range of instances is necessary to get more profound understanding and guide the development of more comprehensive educational programs.

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