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Smart Ethnomath Game: An Ethnomathematics-Based Digital Game for Improving Numeracy in Geometry

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Abstract

The background of this research is based on the low numeracy skills of students and the lack of contextual, interesting, and integrating local culture learning media in mathematics learning. The research aims to develop smart ethnomath games which is an interactive learning media based on ethnomathematics on geometry materials to improve numeracy of the students. This research uses the Research and Development (R&D) method with the ADDIE development model which includes the stages of analysis, design, development, implementation, and evaluation. The subjects of the study were fifth grade students in junior high school students consisting of 60 students. The instruments used included expert validation sheets, student response questionnaires, and numeracy tests. The results of the study show that the smart ethnomath game developed meets the valid criteria with an excellent category based on the assessment of material and media experts. In addition, this media is declared practical to be used based on the positive response of students. The effectiveness test showed that the use of Smart Ethnomath Game was able to significantly improve students' numeracy, especially in understanding geometric concepts contextually. Smart Ethnomath Game can be an innovative alternative in mathematics learning that effectively integrates local technology and culture.

Keywords: Ethnomathematics, Geometry, Numeracy, Smart Ethnomath Game

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INTRODUCTION

Numeracy is one of the most important basic competencies in 21st century mathematics learning, because it is not only related to numeracy skills, but also includes the ability to think logically, understand quantitative information, and solve contextual problems in daily life (Rahmah & Zulfadewina, 2025). Numeracy is an individual's ability to understand, use, and interpret mathematical concepts in various life contexts (Tampubolon et al., 2023). However, mathematics learning in schools is often still abstract and lacking contextual, making it difficult for students to understand concepts in depth (Bishop, 2018; Rosa et al., 2016). In practice, mathematics learning in schools, especially at the junior high school level, still tends to be oriented towards mechanistic procedures and memorization of formulas, so that students have difficulty in relating mathematical concepts to the reality of their lives (Bishop, 2018; Rosa et al., 2016). This condition has an impact on the low numeracy skills of students, especially in geometry materials that require visual and contextual understanding of concepts (Wahyuni & Mawardi, 2026; Zainovi et al., 2025). The development of digital technology has encouraged innovation in mathematics learning, especially with interactive media such as educational games (Huang et al., 2016; Radianti et al., 2020). Interactive games can increase student engagement and provide a more enjoyable and meaningful learning experience (Plass et al., 2015; Schindler et al., 2017). In the context of mathematics education, this approach is important to improve students' numeracy skills which are still relatively low (Tampubolon et al., 2023). The approaches that are considered effective to overcome this problem is ethnomathematics (Bishop, 2018; Rosa et al., 2016).

The ethnomathematical approach is present as a solution by associating the concept of mathematics with the local culture (Bishop, 2018; Rosa et al., 2016). Ethnomathematics allows students to understand mathematics through cultural experiences that are close to their lives, making learning more meaningful and contextual (Nasir et al., 2018; Setiyadi & Rusilowati, 2025). Research shows that the integration of ethnomathematics in geometry learning can improve students' understanding of concepts and numeracy skills (Wahyuni & Mawardi, 2026; Tampubolon et al., 2023; Zainovi et al., 2025). Ethnomathematics integrates mathematical concepts with local culture so that learning becomes more contextual, meaningful, and close to the student experience (Nasir et al., 2018; Rosa et al., 2016). Various studies show that the application of ethnomathematics in geometry learning can improve students' understanding of concepts, learning motivation, and critical thinking skills (Wahyuni & Mawardi, 2026; Verner et al., 2019; Zainovi et al., 2025). In addition, cultural integration in learning can also support the development of identity and student involvement in the learning process (Nasir et al., 2018). Ethnomathematics integrates mathematical concepts with local culture so that learning becomes more contextual, meaningful, and close to the student (Nasir et al., 2018; Setiyadi & Rusilowati, 2025).

Various studies show that the application of ethnomathematics in geometry learning can improve students' understanding of concepts, learning motivation, and critical thinking skills (Wahyuni & Mawardi, 2026; Verner et al., 2019; Zainovi et al., 2025). First, most research still focuses on the use of media such as modules, videos, or augmented reality, while the development

of ethnomathematics-based interactive games is still relatively limited (Salsabila et al., 2025; Sudirman et al., 2020; Sunzuma et al., 2025). Second, research that simultaneously integrates three main aspects ethnomathematics, digital interactive games, and numeracy especially in geometry materials at the junior high school level, has not been widely done (Huang et al., 2016; Plass et al., 2015; Wahyuni & Mawardi, 2026). Third, previous research tends to use quasi-experimental designs with limited scope, so it is necessary to develop innovative products that are not only valid and practical but also have high potential effectiveness in improving students' numeracy contextually (Hilliyani et al., 2025; Kumala et al., 2024). In addition, studies related to the use of culturally based traditional games in the form of digital (smart games) are still rarely developed systematically in the context of modern mathematics learning (Aulya & Exacta, 2025; Tambunan et al., 2025; Zayyadi et al., 2025)

In addition, cultural integration in learning can also support the development of identity and student involvement in the learning process (Nasir et al., 2018). The ethnomathematical approach is present as a solution by associating the concept of mathematics with the local culture. Ethnomathematics allows students to understand mathematics through cultural experiences that are close to their lives, making learning more meaningful and contextual. Research shows that the integration of ethnomathematics in geometry learning can improve students' understanding of concepts and numeracy skills (Wahyuni & Mawardi, 2026; Tampubolon et al., 2023; Zainovi et al., 2025). Thus, innovation is needed in the form of the development of interactive game-based learning media that digitally integrates ethnomathematical values to answer learning needs that are contextual, interesting, and relevant to technological developments (Huang et al., 2016; Plass et al., 2015; Radianti et al., 2020). This research aims to develop Smart Ethnomath Game, which is an interactive game based on ethnomathematics on geometry materials to improve numeracy of junior high school students and analyze the effectiveness of Smart Ethnomath Game in improving students' numeracy (Hilliyani et al., 2025; Kumala et al., 2024; Tampubolon et al., 2023).

METHOD

This research was conducted in private elementary schools in Indonesia based on the need for the development of innovative mathematics learning media, especially in geometry materials that are still considered abstract by some students. In addition, the school has supporting facilities in the form of digital devices that allow the application of interactive game-based learning media. The subjects of this study are grade V elementary school students with a total of 30 students in the even semester of 2025. The selection of class V is based on the suitability of geometry materials which include the concepts of flat building, spatial building, area, volume, and the application of geometry concepts in daily life. In addition to students, this research also involves classroom teachers as informants to obtain information related to learning needs and the use of digital media, as well as material experts and media experts as validators of the developed products.

The data collection technique in this study was carried out through several methods, namely observation, interviews, questionnaires, tests, and documentation. Observations were carried out to determine student activities, involvement, and responses during the learning process using the Smart Ethnomath Game. Interviews were conducted with classroom teachers to obtain information about mathematics problems, especially students' difficulties in understanding geometry concepts and the need for more interactive learning media. The questionnaire was used to obtain validation data from material experts and media experts and to find out students' responses to the use of learning games. Furthermore, the numeracy literacy ability test is given in the form of a pre-test and post-test to measure the improvement of students' ability to understand geometry concepts, perform calculations, and solve ethnomathematics-based contextual mathematics problems. Documentation is used as supporting data in the form of photos of research activities, student work results, and learning documents.

The data analysis technique in this study uses the Research and Development (R&D) approach with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The data from expert validation results was analyzed using percentage analysis to determine the feasibility level of Smart Ethnomath Game products from the material and media aspects. Practicality data was obtained through the analysis of teacher responses, student responses, and observation results during the implementation of learning media. Meanwhile, the effectiveness of the use of Smart Ethnomath Game was analyzed through a comparison of pre-test and post-test results using a paired sample t-test statistical test to determine differences in numeracy literacy skills before and after the use of media. In addition, an analysis of improving students' abilities was carried out using the N-Gain test to determine the category of increasing students' numeracy literacy after using ethnomathematics-based interactive games. The results of the analysis are used as a basis to determine the level of validity, practicality, and effectiveness of Smart Ethnomath Game as a culture-based mathematics learning medium.

This research uses the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) (Mayer, 2020) model described in Figure 1.

1. Analysis

At this stage, the developer identifies learning objectives and user needs, relevant ethnomathematics content (local culture, mathematical concepts) and characteristics of target users (e.g., students' level, learning styles). The goal was ensuring the game is meaningful, culturally relevant, and aligned with learning outcomes (Nasir et al., 2018; Rosa et al., 2016). Need analysis was carried out through observation and interviews to identify students' difficulties in understanding geometry concepts and low numeracy.

2. Design

This stage focuses on planning the structure of the game designing game flow and storyline based on ethnomathematics, creating levels, challenges, and game mechanics, and developing storyboards and initial UI/UX design (Huang et al., 2016; Plass et al., 2015). The goal was building

a clear blueprint before development begins. Designing an ethnomath-based interactive game that contains local cultural context Geometry Concepts with Numeracy Questions

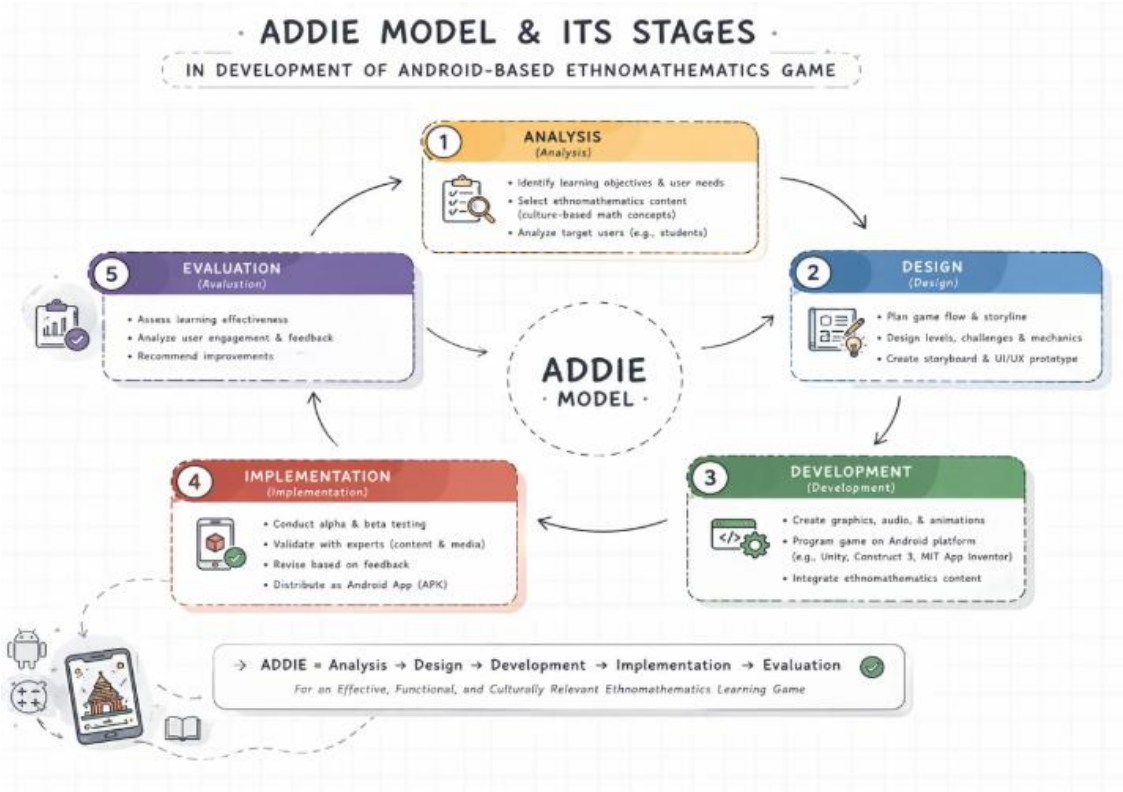

Figure 1. ADDIE Model and Its Stages

3. Development

The actual creation of the game takes place developing game assets (graphics, audio, animations), programming the game using Android platforms (e.g., Unity, Construct 3, MIT App Inventor), and integrating ethnomathematical content into gameplay (Huang et al., 2016; Plass et al., 2015). The goal was Produce a functional and interactive learning game. The game is developed using a digital platform (Unity/Construct). Validation is carried out by material, media, and language experts (Kumala et al., 2024).

4. Implementation

The game is tested and applied conducting alpha and beta testing, validating content with experts (media and subject matter experts), revising based on feedback, and distributing the game (APK) to users (Schindler et al., 2017). The goal was ensuring the game works well and is ready for real users. The trial was carried out on junior high school students with a pretest-posttest design (Hilliyani et al., 2025).

5. Evaluation

Final assessment and improvement evaluating learning outcomes and user responses, analyzing effectiveness and engagement, and making improvements for future versions (Mayer, 2020). The goal was measuring success and refine the product. The analysis was carried out using: N-Gain T test effect size (Cohen's d) (Hilliyani et al., 2025).

RESULT AND DISCUSSION

Result

1. Analysis

Data analysis using observations and interviews conducted with teachers and students. Based on observations in class, the following findings were obtained in Figure 2.

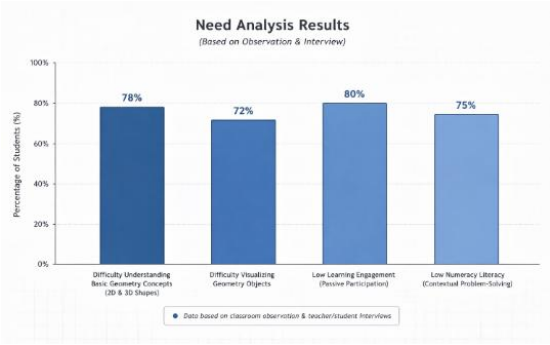

Figure 2. Need Analysis Based on Observation

Based on Figure 2, it can be concluded that the condition of mathematics learning, especially in geometry materials, is currently facing a significant crisis in understanding and engagement. The results of interviews with teachers and students are described in Figure 3.

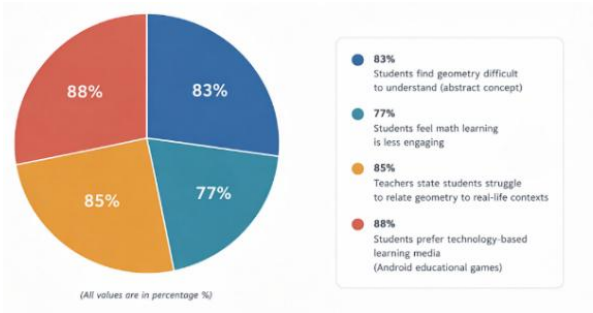

Figure 3. Interview Results

Figure 3 described the difficulty in understanding the concept of geometry because the material was considered abstract. As many as 83% of students stated that geometry is difficult to understand, especially when it comes to imagining shapes, properties, and relationships between geometric concepts. In addition, as many as 77% of students feel that mathematics learning is still not interesting, so there is a need for learning media innovations that are more interactive and able

to increase student involvement in the learning process. From a teacher's perspective, 85% stated that students have difficulty connecting geometry concepts to real-life contexts, so experiential and culture-based learning is important to help students understand the application of mathematics.

Meanwhile, as many as 88% of students showed a preference for the use of technology-based learning media, especially Android-based educational games, because they were considered more interesting, interactive, and in accordance with current technological developments. It can be concluded that the development of Android-based educational games with an ethnomathematical approach is needed to improve students' understanding of concepts and numeracy.

2. Design

The design of this adventure-based ethnomathematics game uses android technology equipped with interesting audio and visuals. Not only that, but this game is also designed with interesting and interactive material content and questions like Figure 4.

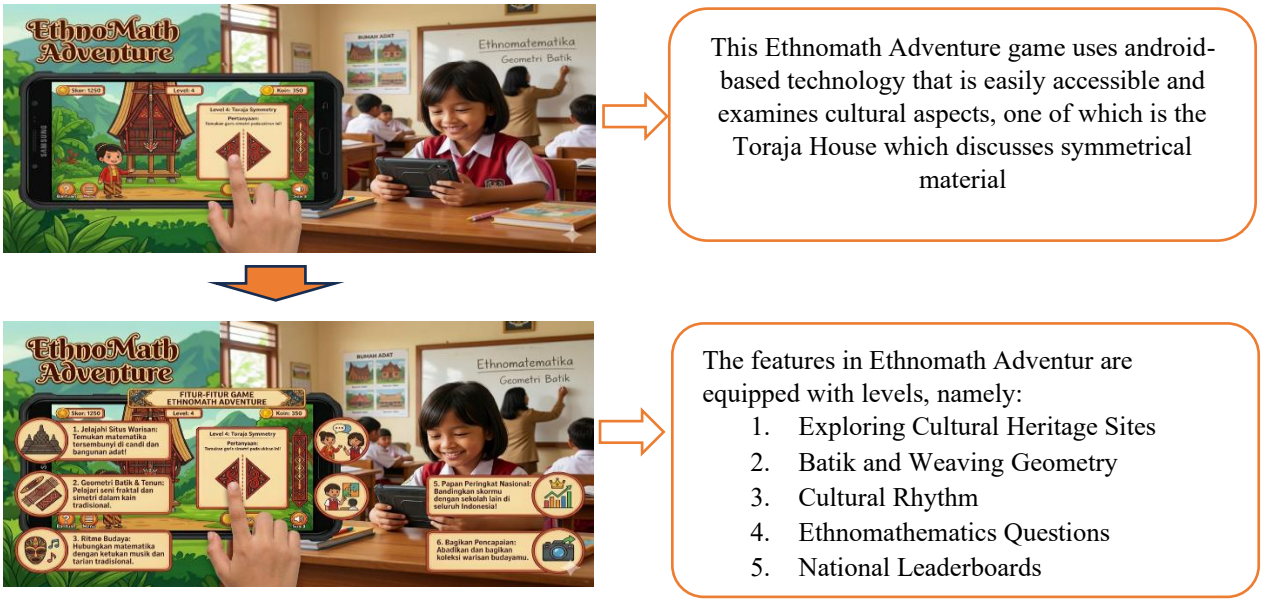

Figure 4. Ethnomath Adventure Game

3. Develop

Validation is carried out by three experts (material, media, and language). The average validation score obtained is as follows: Subject matter score was 92.5% (highly valid). Media experts score was 90.8% (highly valid), linguists score was 91.2% (highly valid). Overall, the average validity reached 91.5%, so the media was declared very suitable for use without major revisions.

4. Implementation

Practicality was measured through a student response questionnaire after the use of the game. The results show: Average student response: 88.6% (very practical) The highest indicators are found in the aspects: Ease of use (90.2%) Attractiveness of the display (89.8%) Game interactivity (88.5%) This shows that students find games easy to use, engaging, and supportive of the independent learning process.

5. Evaluation

Pretest and posttest scores average pretest was 58.4 with average posttest was 85.7. There was an increase of 27.3 points, which shows an increase in students' numeracy skills after the use of games. N-Gain results an average N-Gain value of 0.80 was obtained, which is in the high category. This shows that the improvement of students' abilities is at a significant level. T-test results were of the paired sample t-test showed: t count = 11.87 p-value = 0.000 < 0.05, this means that there is a significant difference between the results of the pretest and posttest. The effect size (Cohen's d) Cohen's value d = 1.10 was obtained, which is in the large effect category. This shows that the influence of game use on increasing numeracy is very strong.

Discussion

The results of the study show that Smart Ethnomath Game can significantly increase students' numeracy. The results of the study show that Smart Ethnomath Game has high effectiveness in improving students' numeracy in geometry materials. The significant increase shown through the N-Gain value (0.80), t-test ($p < 0.05$), and effect size (1.10) indicates that this game-based learning intervention has a strong pedagogical impact (Hilliyani et al., 2025; Kumala et al., 2024). This effectiveness is influenced by several key factors. First, the integration of ethnomathematics in games allows students to understand geometric concepts through familiar cultural contexts (Nasir et al., 2018; Rosa et al., 2016). Concepts such as building space, symmetry, and patterns are visualized through cultural objects, so that students not only memorize formulas, but also understand the meaning of concepts contextually. This is in line with the research findings that the ethnomathematics approach can improve students' conceptual understanding and mathematical literacy (Wahyuni & Mawardi, 2026; Tampubolon et al., 2023; Zainovi et al., 2025).

Second, the use of interactive games increases student engagement and motivation to learn. Features such as exploration, challenges, and immediate feedback encourage students to be active in the learning process (Plass et al., 2015). This interactivity allows active learning to occur which contributes to improving learning outcomes (Huang et al., 2016). Third, game design based on digital learning provides a more interesting and flexible learning experience. Students can learn independently and repeatedly, thus strengthening their understanding of geometry concepts (Mayer, 2020; Radianti et al., 2020). It is also supported by constructivist learning theory that

emphasizes that students build knowledge through hands-on experience (Gee, 2017). In addition, the large effect size value shows that the use of games is not only statistically significant, but also has a strong practical impact on learning (Hilliyani et al., 2025; Kumala et al., 2024).

This is due to the integration between local culture and digital technology, which makes learning more contextual and engaging (Sudirman et al., 2020; Sunzuma et al., 2025). Ethnomathematics allows students to understand geometric concepts through real-life experiences in their culture (Nasir et al., 2018; Rosa et al., 2016). Various studies show that geometric concepts such as two-dimensional shapes, three-dimensional shapes, and symmetry are widely found in local culture and traditional games (Aulya & Exacta, 2025; Ayuningsih et al., 2025; Hakim & Soebagyo, 2025; Sholikhah et al., 2025). Additionally, the use of interactive games increases student motivation and engagement. Games provide an active and fun learning experience, making it easier for students to understand math concepts (Huang et al., 2016; Plass et al., 2015). These findings are in line with previous research showing that ethnomathematics and technology-based learning can improve students' understanding of concepts and thinking abilities (Azhar et al., 2025; Kumala et al., 2024; Meilina & Marsigit, 2025; Salsabila et al., 2025). Thus, the integration of ethnomathematics and digital games is an effective learning innovation in improving students' numeracy in geometry materials (Tampubolon et al., 2023; Zainovi et al., 2025).

Thus, the game is not only academically effective, but also relevant for implementation in the classroom (Hilliyani et al., 2025; Kumala et al., 2024). However, there are some limitations in this study, such as the limited number of samples and the use of specific cultural contexts that may not be representative of cultural diversity at large (Verner et al., 2019). Therefore, further research is recommended to develop games with more diverse cultural contexts and conduct trials on a larger scale (Supriyadi et al., 2023; Zayyadi et al., 2025).

CONCLUSIONS

This research resulted in a Smart Ethnomath Game that: Valid Practical Highly effective This game has been proven to be able to significantly increase students' numeracy. Therefore, the use of ethnomathematics-based games is recommended as a mathematics learning innovation in the digital era.

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reference list, and remove any references not cited. We recommend that authors explore the Journal of Emerging Technologies in Ethnomathematics archives to identify connections with previous publications and build upon existing research.

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