Journal of Emerging Technologies in Ethnomathematics
Year 2026
Vol. 2, no 1, 2025, pp. 13-25

Development of Digital-Based Ethnomathematics E-Modules to Improve Mathematical Literacy

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Received: 21 April 2026 | Revised: 28 June | Accepted: 29 June 2026 | Published Online: 30 June 2026

Abstract

The lack of mathematical literacy skills and the importance of using e-modules in geometry learning are the background of this study. This research aims to develop a digital-based ethnomathematics e-module that is valid, practical, and effective in improving students' mathematical literacy. 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 30 junior high school students in grade VIII. The instruments used included expert validation sheets, student response questionnaires, and mathematical literacy tests. The results of the study show that the e-modules developed have a high level of validity based on the assessment of material experts and media experts. In addition, the e-module is stated to be practical based on positive student responses, as well as effective in improving mathematical literacy as shown by improving student test results categorized medium category. Thus, digital-based ethnomathematics e-modules are suitable for use as an alternative teaching material to support contextual and meaningful mathematics learning.

Keywords: Digital learning, E-modules, Ethnomathematics, Mathematical literacy

Cite: Rahayu, C., Wijayanti, P., Azizah, M., & Azhar, R. H. (2026). Development of digital-based ethnomathematics e-modules to improve mathematical literacy. *Journal of Emerging Technologies in Ethnomathematics, 2*(1), 14-26

INTRODUCTION

Mathematical literacy is one of the important competencies in 21st century learning that emphasizes students' ability to formulate, apply, and interpret mathematics in various contexts of daily life. According to the OECD (2019), mathematical literacy is not only related to the ability to calculate, but also includes the ability to think critically, solve problems, and make data-based decisions (Wahyuni et al., 2026). However, the results of the Programme for International Student Assessment (PISA) show that the mathematical literacy ability of students in Indonesia is still relatively low compared to other countries (OECD, 2019).

One of the causes of low mathematical literacy is learning that is still abstract and less contextual. Math learning is often not associated with students' real experiences, making it difficult to understand in depth. In this case, the ethnomathematics approach is one of the potential solutions because it links the concept of mathematics with local culture that is close to the lives of students. Ethnomathematics allows students to understand mathematical concepts through cultural practices, traditions, and local wisdom that exist in their environment (Bishop, 2018; d'Ambrosio, 1985; Nasir et al., 2018; Resi et al., 2025; Verner et al., 2019).

Along with technological developments, the use of digital-based teaching materials such as e-modules is also a necessity in modern learning. E-modules have advantages in terms of flexibility, interactivity, and the ability to present material in an attractive way through multimedia integration (video, animation, and simulation). Research shows that the use of e-modules can improve student motivation and learning outcomes because it provides a more independent and adaptive learning experience (Astuti et al., 2022; Gee, 2017; Khun-Inkeeree et al., 2021; Schindler et al., 2017). However, the integration between ethnomathematics and digital technology in the form of e-modules is still not optimally developed (Andang et al., 2024a).

In the context of modern learning, the integration of technology and ethnomathematics is becoming an increasingly important approach. Technology-based media such as e-learning and e-modules have been proven to be able to create more interactive, meaningful, and fun learning (Mauladaniyati et al., 2025; Rosidin et al., 2025). In fact, the development of ethnomathematics-based e-modules showed a significant increase in students' mathematical problem-solving abilities compared to conventional learning (Hamid & Rahmawati, 2024; Muzaki et al., 2022; Paramita et al., 2024). The latest study also emphasizes that learning based on local wisdom has a strategic role in improving mathematical literacy while preserving culture, but its implementation in digital teaching materials still requires further development (Munthahana et al., 2023; Tampubolon et al., 2023). Therefore, innovation is needed in the form of digital-based ethnomathematics e-modules that can bridge the needs of contextual learning and the development of current educational technology.

Recent research shows that ethnomathematics is undergoing significant development and is beginning to integrate with digital technologies and 21st century learning. Bibliometric studies

reveal a shift in focus from just cultural exploration to digital-based and contextual learning media innovation (Iffah et al., 2025; Justine et al., 2026). This is supported by several previous studies that have only focused on the development of conventional ethnomathematics-based teaching materials or the use of digital media without linking them to the local cultural context. In addition, research that specifically examines the influence of ethnomathematics e-modules on students' mathematical literacy is also still limited. In addition, various literature reviews confirm that ethnomathematics contributes to improving mathematical literacy through associating mathematical concepts with local wisdom and the real-life context of students (Ababil et al., 2025; Putra & Mahmudah, 2021). The implementation of ethnomathematics in the learning module has also been proven to be able to increase understanding of concepts, learning motivation, and love for local culture (Cahyadi et al., 2020; Noviyanti & Basir, 2025).

Furthermore, other research has also shown that digital ethnomathematics-based learning can significantly improve students' creative thinking skills and learning outcomes (Bintoro et al., 2021; Supriyadi et al., 2023). This is reinforced by systematic review studies that confirm that the integration of local cultures in mathematics learning is able to increase the relevance of learning and student engagement (Ababil et al., 2025; d'Ambrosio, 1985). However, a number of studies reveal that ethnomathematical studies still tend to focus on the exploration of cultural concepts (e.g. geometry in traditional houses, batik, and cultural artifacts) (Dhema et al., 2025; Pradana et al., 2022; Supriyadi et al., 2023), while the development of innovative digital media is still limited (Andang et al., 2024b; Lita & Mustika, 2024). In addition, the integration of ethnomathematics with technologies such as augmented reality and interactive e-modules is still in the early stages of development (Mauladaniyati et al., 2025; Radianti et al., 2020). This shows that there is a research gap in the development of innovative teaching materials that can integrate cultural and technological aspects simultaneously to improve mathematical literacy.

Based on this description, this research aims to develop a digital-based ethnomathematics e-module that is valid, practical, and effective in improving students' mathematical literacy. In addition, this research also aims to test the feasibility and effectiveness of e-modules as innovative teaching materials that integrate local cultural values with digital technology in mathematics learning.

METHOD

Research Subject

The subjects in this study are junior high school students who are learning mathematics, especially in geometry materials. Students are chosen because they are at a stage of cognitive development that makes it possible to develop numeracy literacy skills through ethnomathematics-based contextual learning.

The subjects of the study were students in grade VIII of junior high school as many as ±30–35 students in one class. The sampling technique used in this study is *urposive sampling where sample selection is carried out deliberately by considering certain criteria, namely students have a relatively low level of numeracy literacy, schools have not used ethnomathematics-based learning media, teachers are willing to cooperate in the implementation of research, and students have access to digital learning tools.

Research Design

This study uses the ADDIE model described in Figure 1.

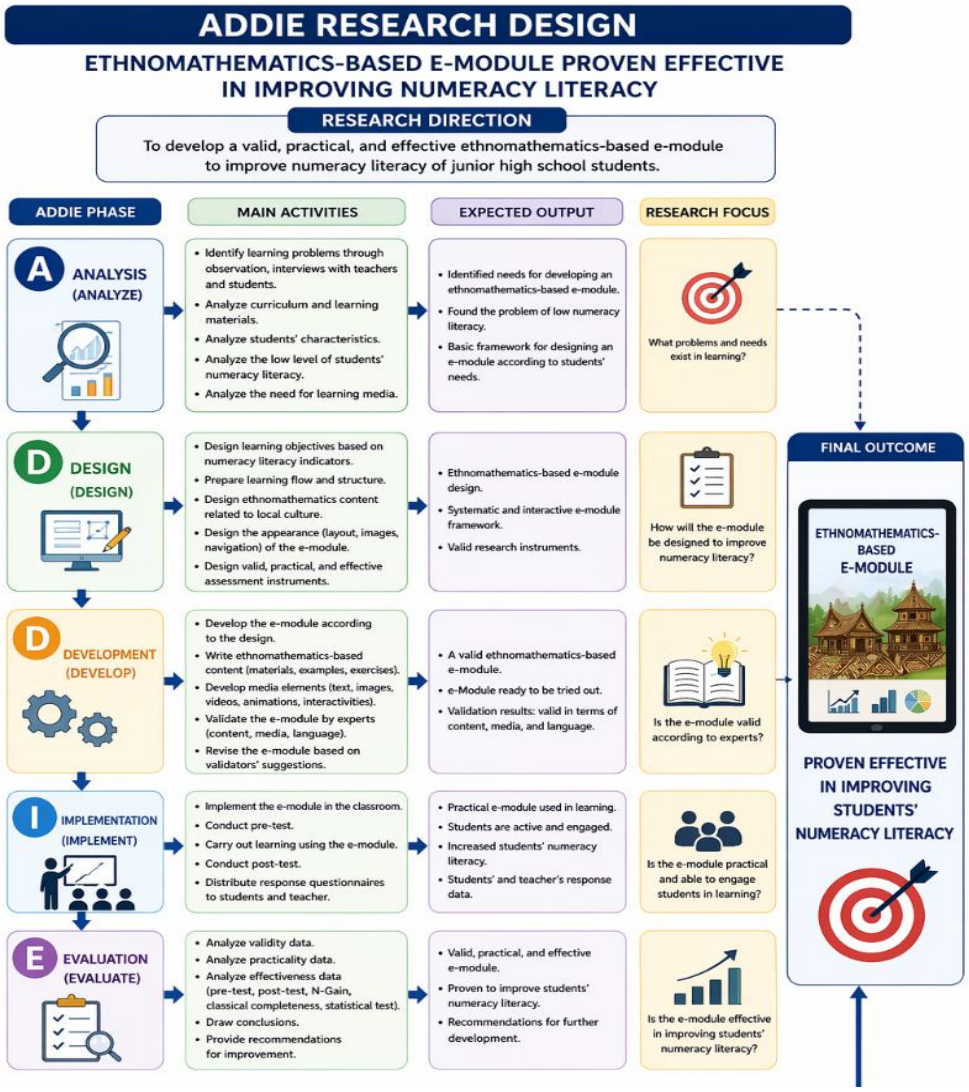

Figure 1. ADDIE Model

The data collection technique in this study was carried out through several methods, namely observation, interviews, questionnaires, tests, and documentation. Observation is used to determine the initial condition of mathematics learning in the classroom, especially related to student activities and involvement as well as difficulties in understanding geometry concepts. Interviews were conducted in a semi-structured manner for teachers and students to identify learning needs and problems related to low numeracy literacy. Indicators of numeracy literacy include numerical information interpretation, mathematical representation, calculation and application of concepts, mathematical reasoning, contextual problem solving, and data-driven decision-making

Furthermore, the questionnaire was used to obtain data on the practicality of e-modules and the responses of students and teachers to the use of learning media, using a Likert scale of 1–4. Tests are given in the form of pre-tests and post-tests to measure students' numeracy literacy skills before and after the use of ethnomathematics-based e-modules. In addition, documentation is used to complement research data in the form of photos of activities, results of student work, and other supporting data.

The data analysis techniques in this study were carried out qualitatively and quantitatively. Qualitative analysis is used to process data from observations, interviews, and suggestions from validators through the stages of data reduction, data presentation, and conclusion drawn. Meanwhile, quantitative analysis is used to measure the validity, practicality, and effectiveness of e-modules. Validity and practicality are analyzed using the percentage of scores obtained compared to the maximum score, then categorized based on specific criteria described in Table 1.

Table 1. The Criteria of Validity and Practicality

Percentage Score	Kriteria Kevalidan	Practicality Criteria
85,01% – 100%	Highly Valid	Very Practical
70,01% – 85%	Valid	Practical
50,01% – 70%	Less Valid	Less Practical
01,00% – 50%	Invalid	Impractical

The effectiveness of the e-module was analyzed through improving student learning outcomes using the N-Gain test obtained from the difference in pre-test and post-test scores and supported by classical learning completeness analysis. The categorization of effectiveness described in Table 2.

Table 2. The Criteria of Effectiveness

N-Gain Percentage	Effectiveness Criteria
> 76%	Highly Effective
56% – 75%	Effective
40% – 55%	Quite Effective
< 40%	Less Effective

In addition, statistical tests such as normality tests and t-tests can be used to find out significant differences between pre- and post-treatment outcomes. Thus, data analysis was carried out comprehensively to determine the feasibility and effectiveness of ethnomathematics-based e-modules in improving students' numeracy literacy.

RESULT AND DISCUSSION

Result

This research uses the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. This model is widely used in the development of technology-based learning media.

1. Analysis Stage

Conducting needs analysis through observation and interviews related to students' difficulties in understanding mathematical concepts and the limitations of contextual teaching materials. At the analysis stage, observations and interviews were conducted to identify learning problems.

The results obtained are that most students have difficulty in understanding the concept of geometry and its application in daily life. Students' numeracy literacy skills are relatively low, especially in solving contextual problems, learning is still abstract and less associated with local culture, and students show high interest in technology-based learning media. This is the basis for the need for learning media in the form of ethnomathematics-based e-modules that integrate local culture, present contextual problems, and support the improvement of numeracy literacy.

2. Design Stage

This stage focuses on designing the structure and content of the e-module. The module contains numeracy-literacy-based learning flows, materials related to the local cultural context (ethnomathematics), module components and display designs that are made interesting and interactive. Designing ethnomathematics-based e-modules by containing contextual materials based on local culture, interactive activities, and mathematical literacy questions.

The learning flow based on numeracy literacy includes understanding contextual problems, analyzing data, solving problems, and interpreting results. The components of the e-module include an introduction (culture-based perception), core material, examples of contextual problems, numeracy-based exercises, interactive evaluations. The ethnomathematical e-module design is described in Figure 1.

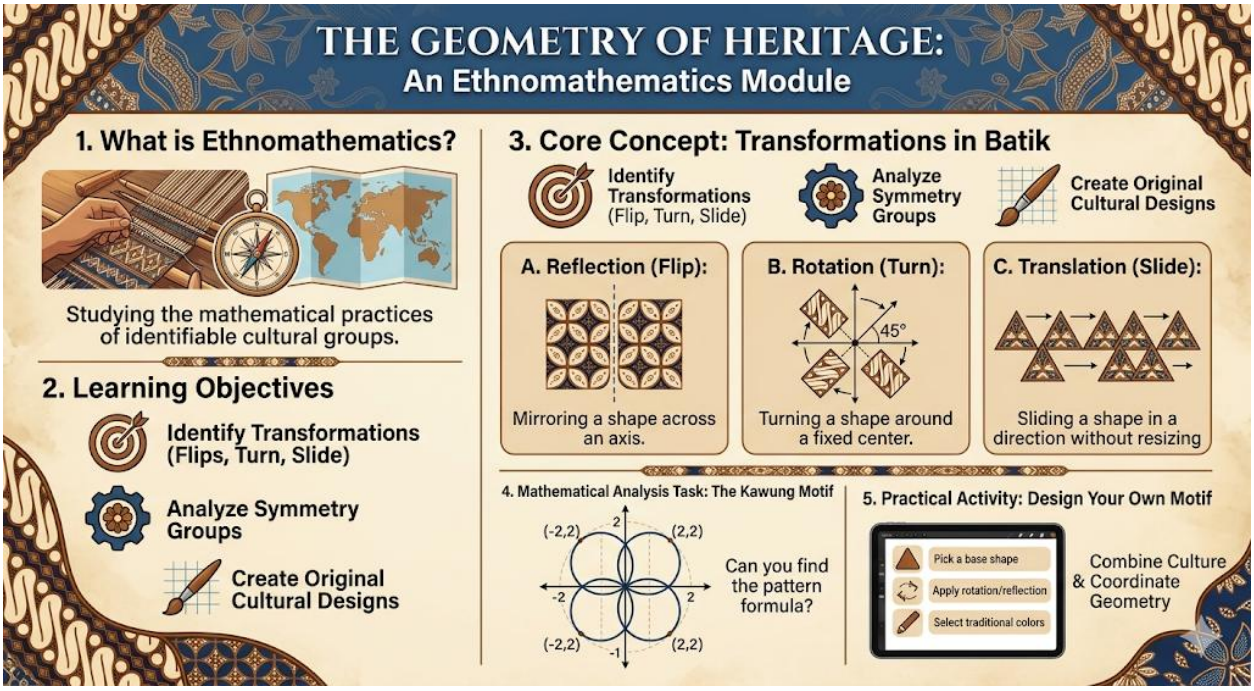

Figure 1. The Ethnomathematical E-Module

3. Development Stage

Develop e-module products using digital platforms (e.g. HTML5/Flipbook). Validation is carried out by material, media, and language experts. The e-module was validated by subject matter experts and media experts using the Likert scale described in Table 3.

Table 3. The Result of Expert Review

Expert	Average Score	Percentage
Expert of material	4,45	89% (highly valid)
Expert of media	4,30	86% (highly valid)
Expert of language	4,40	88% (highly valid)

Based on Table 1, it is concluded that the ethnomathematics e-module meets the criteria of content feasibility, conformity with numeracy literacy, and display and interactivity. The ethnomathematics e-module is highly valid and worth using without major revisions.

4. Implementation Stage

Trials were carried out on students to determine the practicality and effectiveness of using e-modules. Practical results based on student responses and teacher responses are described in Table 4.

Table 4. Responses of Implementation Stage

Responses	Average Score	Percentage	Categorization
Students' Response	4.40	88%	Very practical
Teachers' Response	4.50	90%	Very practical

Student activity increased from 65% to 85% which means that student activity is included in the category of high activity level. Student learning outcomes increased from a pretest score of 62.00 to a posttest score of 82.00 This means that there is an increase of 20 points.

5. Evaluation Stage

Evaluation is carried out through N-Gain test, T-test, and student responses. Classical learning completeness of 87% of students is complete. Increasing numeracy literacy can be seen from the improvement of the ability to understand problems, analyze data, solve problems, and interpret results.

$$g = \frac{82 - 62}{100 - 62} = 0.53$$

The N-Gain calculation was obtained with a score of 0.53 which means it reached 53% with the category of quite effectiveness. The e-modules are easy to use (practical), increase student engagement, and improve numeracy skills. Practical and effective e-modules are used in real learning.

Discussion

The results of the study show that digital-based ethnomathematics e-modules have high effectiveness in improving students' mathematical literacy. This is due to the integration between digital technology and cultural contexts that make learning more meaningful. The ethnomathematical approach helps students understand mathematical concepts through real-life experiences. In addition, the use of digital media increases student engagement in learning. Previous research has also shown that technology-based media such as virtual reality and ethnomathematics-based digital modules are able to improve students' understanding and learning motivation. In addition, research trends show that the development of ethnomathematics-based media is increasing, especially in the learning of geometry and local cultural contexts. Thus, the integration of ethnomathematics and digital technology is an innovative approach that is relevant to 21st-century learning and supports the strengthening of students' mathematical literacy.

These findings show that the developed e-modules are effective in improving students' mathematical literacy. These results are in line with previous research that showed the effectiveness of ethnomathematics modules in mathematics learning. The results of the study show that ethnomathematics-based e-modules have proven to be effective in improving students' numeracy literacy. This effectiveness can be seen from the increase in learning outcome scores,

N-Gain scores in the medium category, and increased student involvement during learning. Conceptually, the increase in numeracy literacy occurs because e-modules integrate the local cultural context (ethnomathematics) into the learning material. This approach makes mathematical concepts that were originally abstract more concrete and meaningful, making it easier for students to understand, interpret, and apply concepts in their daily lives. This finding is in line with the view of Ubiratan D'Ambrosio who emphasized that mathematics is inseparable from culture, and Alan J. Bishop who stated that learning mathematics is a process of enculturation.

In addition, the use of e-modules in digital format provides flexibility for students to study independently. It strengthens numeracy literacy skills, especially in understanding contextual problems, analyzing numerical information, solving problems, and interpreting results. These findings are also supported by the digital literacy theory from James Paul Gee which states that technology-based learning can increase student engagement and understanding.

From the pedagogical side, ethnomathematics-based e-modules encourage contextual learning, because they are based on local culture, student-centered, because students actively explore, and are meaningful, because they are related to real life. This has a direct impact on increasing student engagement, which is one of the important factors in the success of mathematics learning. Students not only memorize formulas but can understand the meaning behind mathematical concepts.

This research strengthens the theory that ethnomathematics can be an effective approach in mathematics learning, the integration of local culture can improve numeracy literacy, and digital media (e-modules) play an important role in 21st century learning. Thus, this research contributes to the development of ethnomathematical studies based on digital technology.

CONCLUSIONS

This research produces a digital-based ethnomathematics e-module that valid based on expert judgment, practical based on student responses highly effective and based on N-Gain, t-test effect size. The e-modules developed have been proven to be able to significantly improve students' mathematical literacy. This e-module is suitable for use as a cultural and technology-based mathematics learning innovation.

The implication of this research is that ethnomathematics e-modules can be used as an alternative innovative learning media to improve students' numeracy literacy, help students understand mathematics more easily, interestingly, and relevant to their lives, support the implementation of technology-based learning and strengthen numeracy literacy according to the curriculum, support national numeracy literacy programs, and encourage integration local wisdom in learning.

Therefore, the integration of ethnomathematics and digital technology is recommended as an innovation in mathematics learning. The limitation of the researcherlies in the fact that the e-module is only developed on certain subjects, namely geometry and does not cover all mathematics topics

Acknowledgments

The author expresses his deepest gratitude to the school, especially the principal, mathematics subject teachers, and grade VIII students in one of the schools in Indonesia who have provided support, opportunities, and participation during the process of implementing this research. Hopefully the results of this research can make a positive contribution to the development of mathematics learning, especially in improving students' numeracy skills.

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