

Development of an Ethnomathematics-Based Mobile Learning Module Integrating Banggai Yam Farming Culture for Contextual Mathematics Learning

Saipul Bachri S. Lajiba^{1,*}, Yanto Naim², & Hasman¹

¹Department of Mathematics Education, Universitas Tompotika, Indonesia

²Department of Informatics Management, AMIK Luwuk Banggai, Indonesia

*Corresponding email: bachrisaiful49@gmail.com

Received: 11 June 2026

Accepted: 31 July 2026

Published: 19 August 2026

Abstract: This study addresses the disconnection between mathematics learning and local culture in Indonesian junior high schools. Purpose: The core goal was to develop an ethnomathematics mobile learning module rooted in the yam farming culture of the Banggai Islands Regency and to verify its validity, practicality, and initial effectiveness in improving students' mathematical literacy. Method: This research and development (R&D) adapted the ADDIE model. Cultural data were collected through observations and interviews, then integrated into an Android-based module. The product was validated by two experts and one practitioner and subsequently tested on 20 eighth-grade students using a one-group pretest-posttest design. Key Findings: The module, which integrates mathematical concepts such as measurement, arithmetic, and geometry as applied in yam farming, was confirmed to be valid and practical, receiving a 95% approval rating from the practitioner and 96.88% positive feedback from students. However, the module's effectiveness in improving mathematical literacy was low, with an average N-Gain score of 0.13, falling short of the established criteria. Conclusion: The developed module demonstrates high levels of validity and practicality. However, the improvement in mathematical literacy skills remains in the low category (N-Gain = 0.13), thus failing to meet the established effectiveness criteria. Consequently, the module's effectiveness in enhancing mathematical literacy requires further refinement and testing.

Keywords: ethnomathematics, mobile learning module, banggai yams farming culture, mathematical literacy, contextual mathematics learning.

Article's DOI: <https://doi.org/10.23960/jpmipa.v27i3.pp1463-1479>

■ INTRODUCTION

Mathematics is a core, foundational discipline capable of cultivating four key types of thinking among students: logical, analytical, critical, and creative. However, current junior high school mathematics instruction focuses solely on procedural mastery and symbolic manipulation, failing to connect mathematical concepts to students' real-life experiences. This directly leads to a widespread incorrect perception among students that mathematics is abstract, hard to understand, and completely unrelated to daily life. Since its emergence, mathematics has originated from human activities aimed at solving real,

practical problems within sociocultural contexts. D'Ambrosio (2006) proposes that mathematics cannot exist independently of culture, and all cultural groups develop their own mathematical thinking.

Ethnomathematics is an alternative approach in education that can narrow the gap between school mathematics instruction and local cultures. D'Ambrosio (2006) defines it as an interdisciplinary concept that studies mathematical practices developed within specific cultural groups. Barton (2001) proposes that it helps students understand mathematics by drawing on their daily cultural experiences, with culture serving

as both an application context and a source of ideas. Rosa and Orey (2011) note that the mathematical reasoning within this framework can be transformed into meaningful learning resources.

A synthesis of conclusions from numerous prior studies in ethnomathematics reveals that learning aligned with this orientation yields threefold benefits for students. Authoritative academic literature substantiates the core value of its instructional linkages, and comparable studies corroborate the dual effects of integrating local cultural content. Nevertheless, current research on integrating digital technologies into local ethnomathematics knowledge and mobile learning modules remains very limited (Rosa & Orey, 2011).

This study opens by stating that the core challenge Indonesia faces in improving the quality of its national education is the long-standing low level of mathematical literacy among its student population. The severity of this problem is corroborated by the 2022 PISA assessment data released by the Organisation for Economic Co-operation and Development (OECD, 2023). The assessment sets Level 2 as the passing benchmark for mathematical proficiency, yet most Indonesian students fail to meet this standard, with clear deficits in their core abilities. In recent years, their test performance has also declined steadily. It is therefore imperative to advance innovation in mathematics learning models adapted to Indonesia's local educational contexts to resolve this intractable educational dilemma.

The rapid development of digital technologies, especially mobile devices, has created the conditions for building flexible, interactive, context-specific learning experiences. Consistent with the definition set out by Crompton (2013), mobile learning enables students to access educational content via portable devices anytime, anywhere, and can integrate media formats such as text, images, and video to boost learner

engagement. However, existing research on the development of ethnomathematics-oriented mobile learning modules that use Banggai's yam-planting culture as a core resource remains extremely scarce.

Building on the preceding review of existing global and local practices in technology-enabled mathematics education, current academic research still faces a core gap: local cultural practices cannot be systematically integrated into technology-supported teaching scenarios. This study proposes a targeted solution to address this gap and constructs a full-process research framework centered on two core modules: cultural embedding and technological adaptation. Its key innovation lies in breaking away from the past positioning that treated culture merely as a supplementary add-on to classroom teaching. Instead, it transforms local culture into implementable, tiered carriers for mathematical inquiry. The core goal of this study is to develop and test the initial feasibility of an ethnomathematics-based mobile learning module that integrates the culture of Banggai yam cultivation as a contextual resource for mathematics learning for junior high school students. At the same time, it also delivers dual academic and practical value: it improves local mathematics education resources, and expands the boundaries of technology-enabled education.

Specifically, this study seeks to answer the following research questions: 1. How can the ethnomathematical concepts within the Banggai yam farming culture be developed into a mobile learning module for junior high school students? 2. To what extent is the developed ethnomathematics mobile learning module valid and practical for classroom use according to experts, teachers, and students? 3. What is the initial effectiveness of the module in improving students' mathematical literacy as measured by N-Gain scores?

■ METHOD

Research Design

This research used a Research and Development (R&D) approach, adapting the ADDIE model developed by Molenda (2003). The ADDIE model was chosen because it provides a systematic and flexible framework for developing technology-based learning products and has been widely used in educational development research (Branch, 2009). This model consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation.

This study adapted the ADDIE model within an ethnomathematical context. The Analysis phase encompasses not only an assessment of learning needs, student characteristics, and the curriculum, but also the exploration of Banggai sweet potato farming culture and an ethnomathematical analysis to identify the mathematical concepts embedded in these cultural activities. This approach was adopted because the primary source material for the developed product stems from local cultural practices that require in-depth exploration and analysis before being transformed into a digital learning module. This aligned with the perspective that the development of ethnomathematics-based learning should begin with identifying and interpreting cultural practices that embody mathematical ideas (Rosa & Orey, 2011).

Therefore, this research was conducted in five stages. The first stage (Analysis) included exploration of Banggai sweet potato farming culture, ethnomathematics analysis, learning needs analysis, curriculum analysis, and student characteristics analysis. The second stage (Design) included the development of module structure, material design, learning activities, evaluation instruments, and mobile learning design. The third stage (Development) involved the development of an ethnomathematics-based mobile learning module and its expert validation. The fourth stage (Implementation) involved a

limited field trial to assess the product's practicality and effectiveness for students. The fifth stage (Evaluation) was conducted formatively and summatively through analysis of validation results, user feedback, and implementation results to refine the developed product.

Development Procedure

Analysis

The analysis phase of this study established two core analytical modules: cultural exploration and ethnomathematical analysis. This cultural exploration, set against the backdrop of sweet potato cultivation in Banggai, employed a method that combined field observation and in-depth interviews to collect data across six core categories. The informants included farmers, community leaders, and relevant stakeholders.

An ethnomathematical analysis was then conducted to identify the mathematical concepts embedded in these cultural practices. This analysis resulted in an ethnomathematical concept map that links Banggai sweet potato farming culture to junior high school mathematics materials. The ethnomathematical analysis encompassed three main dimensions: (a) Banggai sweet potato farming culture, including local varieties, planting and harvesting seasons, traditional farming systems, and agricultural tools and technologies; (b) agricultural activities, including land preparation, planting patterns and crop rotation, the local agricultural calendar, land measurement, harvest yield calculations, and storage and distribution systems; and (c) cultural values which include reciprocal cooperation in the cultivation process, cooperation in observing the weather and environment, socio-economic values of sweet potato cultivation, as well as beliefs and traditions which are still practiced by the community.

Design

Based on the analysis results, an ethnomathematics-based mobile learning module

was designed. This stage included developing learning outcomes, mapping mathematics material within the local cultural context, developing a learning flow, designing learning activities, developing assessment instruments, and designing the user interface (UI) and user experience (UX). The result of this stage was a blueprint or initial design of the mobile learning module.

Development

This mobile learning development project, built on the completed design plan, completed five development tasks and ultimately produced a prototype of an Android-based mobile learning module that integrates elements of ethnic mathematics.

This study's prototype will be validated by domain, media, and cultural experts, as well as education practitioners. Validation aims to assess the appropriateness of the content, the accuracy of ethnomathematics integration, the quality of learning, the interface design, ease of use, and the application's technical aspects. Validation data is collected using validation sheets and teacher response questionnaires. Validation results are used as the basis for product revisions before implementation.

Implementation

The revised module was piloted on a limited basis with junior high school students. The implementation phase aimed to gather information on the module's practicality and effectiveness, as well as its potential to support students' mathematical literacy. During the pilot, students used the module in learning activities and participated in pre- and post-tests. Additionally, student and teacher responses to the module were collected via a questionnaire to gather feedback on their experiences with the product.

Evaluation

The evaluation phase is conducted formatively and summatively throughout the

development process. Formative evaluation is conducted at each stage through review of analysis results, expert validation, and product revision. Meanwhile, summative evaluation is conducted based on implementation results, including analyses of improvements in learning outcomes, the module's practicality, and user responses. Evaluation results are used to refine the final product to produce a valid, practical, and suitable ethnomathematics-based mobile learning module for use in junior high school mathematics instruction.

Participants and Research Site

This field study was conducted over six months in the Banggai Islands Regency, Central Sulawesi Province, Indonesia. The primary reason for selecting this research site is that yam cultivation is one of the local community's primary economic and cultural activities. During the cultural exploration phase of this study, specific research villages were selected. Purposive sampling rules were applied to screen participants; the scope of research subjects was clearly demarcated; the core rationale for subject selection was explicitly explained; all implementation details were transparent and traceable; and the entire research process complied with the academic norms for field research.

This study conducted a limited field test at SMP Negeri 2 Buko Selatan in Kambani Village. The research site was selected because the local community predominantly grows yams, aligning with the study's contextual learning approach. The participants included 20 eighth-grade students and one mathematics teacher. The intervention protocol was implemented across four sessions, each lasting 80 minutes (2×40 minutes). During these sessions, the teacher acted as a facilitator, guiding students in understanding the ethnomathematical context, directing group discussions, and providing scaffolding when difficulties arose. Formative assessment was conducted through observation, oral questioning,

and feedback. While students engaged with the module and completed tests and questionnaires, the teacher also formally assessed the module's practicality and usability. It is important to acknowledge the methodological limitations inherent in the One-Group Pretest-Posttest design used for this limited field test. This design is susceptible to internal validity threats, such as maturation, history, and testing effects. Consequently, the observed increase in mathematical literacy scores cannot be definitively attributed solely to the module's intervention. These findings on effectiveness are therefore interpreted with appropriate caution.

In the expert validation phase of this study, the total number of participants was first clarified, the reviewing experts were categorized into two groups with distinct qualifications, 6 evaluation dimensions that cover all core research directions were established, and it was ensured that all parameters were clearly defined, thereby meeting the requirements for research reproducibility.

Data Collection Instruments

This study used a total of six categories of tools to cover the full research process: First, the observation sheet for cultural practices of yam cultivation, which was used to collect field data, and the semi-structured interview guide, which was used to gather ethnographic data from core informants; Next, the expert validation form that conducted module quality reviews and adopted a 5-point Likert scale ranging from 1 (extremely poor) to 5 (excellent), plus two types of questionnaires to collect feedback from teachers and students; Finally, the mathematics literacy test administered before and after the module trial. Students' mathematical literacy was measured using a researcher-developed test consisting of 15 multiple-choice items based on contexts related to Banggai sweet potato cultivation. This instrument was designed to assess key mathematical literacy competencies adapted from

the PISA framework, including: (1) formulating mathematical situations from contextual problems, (2) using mathematical concepts, procedures, and reasoning to solve problems, and (3) interpreting and evaluating mathematical results in relation to their original context. Each item was scored using an analytical rubric, and the total score was converted to a 0–100 scale for pre-test and post-test analysis. Prior to implementation, the instrument underwent expert validation and reliability testing to ensure its suitability for measuring students' mathematical literacy. This test was first pre-tested on students with matching characteristics who were not included in the main study sample, and Pearson product-moment correlation analysis was used to verify the validity of the test items. An item was declared valid if its correlation coefficient was greater than the r -table value at the 5% significance level (r -table = 0.444 for $N=20$). For instance, one of the valid items had a calculated r -value of 0.479. Next, the instrument's reliability was calculated using Cronbach's Alpha, which yielded a coefficient of 0.706. An instrument is considered reliable if its Cronbach's alpha is ≥ 0.70 (Nunnally & Bernstein, 1994), which confirms the reliability of this test. Only items that met the validity and reliability criteria were used in the pretest and posttest on 20 eighth-grade students who were the subjects of the limited field trial.

Data Analysis Techniques

This study focused on the ethnomathematical potential of the sweet potato cultivation culture of the Banggai group. Drawing on the interactive data analysis model proposed by Miles, Huberman, and Saldaña (2014), this study processes qualitative data collected through observation, interviews, and literature collation. This study focuses on the ethnomathematical potential of the sweet potato cultivation culture of the Banggai group. Drawing on the interactive data analysis model proposed by Miles,

Huberman, and Saldaña (2014), this study processes qualitative data collected through observation, interviews, and literature collation. In the data reduction stage, a manual thematic analysis was conducted, beginning with open coding of interview transcripts and field notes. These initial codes were grouped into broader categories based on recurring patterns, and these categories were subsequently synthesized to extract core themes. In the data display stage, these themes are presented using matrices, tables, and narrative descriptions. In the conclusion stage, continuous verification is carried out concurrently. This study also employs source triangulation, cross-referencing inputs from farming households, community leaders, and teachers with multiple types of literature to ensure the credibility of the research data.

Data validated by subject-matter experts, media experts, cultural experts, and teacher and student responses were analyzed descriptively using percentages. The percentage results were then interpreted using the following criteria:

Table 1. Criteria for assessing validation results and teacher and student responses

Score Interval	Assessment Criteria
81% - 100%	Very Valid / Very Practical
61% - 80%	Valid / Practical
41% - 60%	Fairly Valid / Fairly Practical
21% - 40%	Less Valid / Less Practical
0% - 20%	Not Valid / Not Practical

Source: Akbar (2017)

The initial effectiveness of the ethnomathematics-based mobile learning module was evaluated using a One-Group Pretest–Posttest Design. In this design, one group of students was given a pretest before using the module and a posttest after completing the module. The research design can be expressed as follows:

$$O_1 - X - O_2$$

Description:

O_1 : Pretest of mathematical literacy skills;

X : Learning using the ethnomathematics-based mobile module;

O_2 : Posttest of mathematical literacy skills.

The limited trial subjects consisted of 20 eighth-grade students. The pretest was administered to measure students' initial mathematical literacy skills, while the posttest was administered after students had completed the learning using the developed module. Product effectiveness was analyzed using the normalized gain (N-Gain) score proposed by Hake (1999). The N-Gain value is then interpreted based on the following criteria:

Table 2. Interpretation of N-Gain values

N-Gain Value	Category
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

A module is considered effective if the average increase in student learning outcomes is in the moderate or high category. In addition to the N-Gain analysis, descriptive statistics, including the mean, minimum, maximum, and percentage of learning completion, are calculated to provide an overview of changes in students' mathematical literacy skills following use of the module. Findings from the qualitative and quantitative analyses are then integrated to evaluate the validity, practicality, and initial effectiveness of the developed ethnomathematics-based mobile learning module.

This study is still in its early stages, and only a limited number of field tests have been completed. At present, effectiveness is analyzed using N-Gain calculation and descriptive statistics,

while the required large-sample inferential tests are left to future research.

■ RESULT AND DISCUSSION

This study systematically presents its findings following the ADDIE model, a structured framework for instructional design. The subsequent sections detail the outcomes of each phase, beginning with the Analysis of ethnomathematical practices in Banggai yam farming. This initial phase is crucial, as it grounds the entire project in the local cultural context and identifies authentic mathematical concepts that form the foundation of the learning module.

Following the analysis, the Design and Development phases translated these cultural findings into a tangible educational tool: an Android-based mobile application. This involved not only technical development but also pedagogical design, guided by constructivist

principles to foster active learning. The validity and practicality of this module were then rigorously assessed by both academic experts and a frontline teacher. Finally, the Implementation and Evaluation phases tested the module in a real-world setting with eighth-grade students, providing critical data on its reception and initial impact on mathematical literacy, thus completing the cyclical ADDIE process.

Analysis

In the ethnomathematics exploration and analysis phase, we conducted cultural research in the villages of Landonan Bebeau and Kambani. Through observation and interviews, we found that local farmers use mathematical methods such as counting, measuring, estimating, and comparing in their farming work. The following table shows Ethnomathematic Practices in Sweet Potato Farming Culture in Banggai.

Table 3. Ethnomathematical practices in banggai yam farming culture

No.	Farming Stage	Cultural Activities	Mathematical Concepts
1	Land Preparation	Determining field size and planting capacity	Area measurement, estimation, ratio
2	Soil Cultivation	Determining hole depth and number of planting holes	Counting, measurement
3	Seed Selection	Calculating seed requirements using local units (<i>blek</i> and <i>tongol</i>)	Integer operations, multiplication, division
4	Planting Pattern	Organizing planting distances and triangular arrangements	Geometry, spatial reasoning
5	Crop Maintenance	Determining support poles and cultivation duration	Counting, time measurement
6	Harvesting	Estimating yield and converting units	Integer operations, unit conversion
7	Post-Harvest Activities	Product distribution and pricing	Arithmetic operations, comparison

This study finds that rich mathematical knowledge is embedded in the agricultural activities for Banggai yam: local farmers use two exclusive units of measurement, *blek* and *tongol*, which are converted at a ratio of 1:150. 10 *blek* is suited for 0.5 hectares of arable land, and

during harvest, farmers routinely convert metric measurements from kilograms to tons to estimate their crop yields.

These findings support D'Ambrosio's (1985) assertion that mathematical ideas emerge naturally from cultural activities and problem-

solving practices within communities. The results also reinforce the view of Rosa & Orey (2011) that cultural practices represent authentic mathematical knowledge that can be utilized as contextual learning resources. In this study, the mathematical concepts identified in Banggai yam farming were reconstructed into learning materials on integers, including the comparison of integers and the operations of addition, subtraction, multiplication, and division.

Furthermore, the findings demonstrate that local agricultural practices provide meaningful contexts for learning mathematics. This result is consistent with Clarkson and Presmeg (2008), who argued that connecting mathematics instruction with students' cultural backgrounds increases the relevance and accessibility of mathematical concepts. Therefore, integrating Banggai yam farming culture into mathematics learning may help students understand abstract concepts through familiar real-life experiences.

The findings presented in Table 3 offer a compelling illustration of how sophisticated mathematical reasoning is deeply integrated into the daily agricultural practices of the Banggai community. The data reveals that farming is not merely a manual task but a cognitive activity requiring constant calculation, estimation, and spatial organization. For instance, determining planting capacity based on field size involves concepts of area and ratio, while arranging plants in triangular patterns demonstrates an intuitive grasp of geometry. This aligns perfectly with D'Ambrosio's (1985) theory of ethnomathematics, which posits that mathematical thinking is a universal human activity that manifests differently across cultures. The farming activities are not applications of formal mathematics; they are a distinct, culturally embedded mathematical system.

Furthermore, the use of local, non-standard units such as 'blek' and 'tongol' (with a conversion ratio of 1:150) underscores the

existence of a functional indigenous measurement system. This practice, along with the conversion to metric units for yield estimation, showcases a high level of numeracy and problem-solving skill. As Rosa and Orey (2011) argued, recognizing such practices as legitimate mathematical knowledge is the first step toward creating culturally relevant learning resources. By deconstructing these activities, the study successfully identified concrete concepts, ranging from integer operations to unit conversion, that could be directly mapped onto the junior high school mathematics curriculum, making abstract ideas tangible and meaningful for students.

Design

Based on the results of ethnomathematics exploration and analysis, a mobile learning module was developed to facilitate contextual mathematics learning. The module was designed as an Android-based application consisting of several features, including user registration, login, learning materials, interactive exercises, downloadable resources, and user profiles. The learning content integrated mathematical concepts with examples derived from Banggai yam farming activities. Figure 1 presents the main interface of the mobile application, including the dashboard, registration page, and login page. Figure 2 presents examples of learning materials and learning activities contained in the module.

This learning module uses constructivist principles as its core design. It integrates images, videos, and interactive exercises to guide students in actively constructing knowledge and to help them connect mathematical concepts to familiar cultural practices. The mobile technology design of this study is grounded in Crompton's (2013) concept of mobile learning, which emphasizes flexibility and accessibility. This design not only supports students in accessing learning materials anytime, anywhere to engage in self-directed learning, but can also be adapted to blended

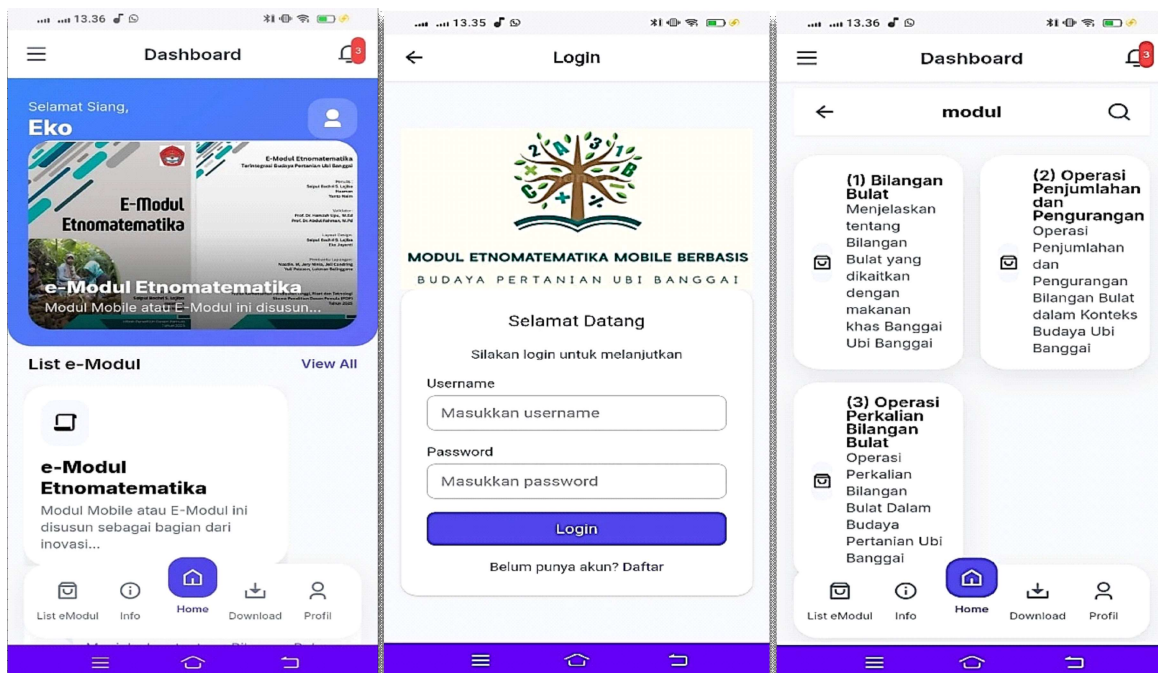


Figure 1. Mobile dashboard, registration page, and login page

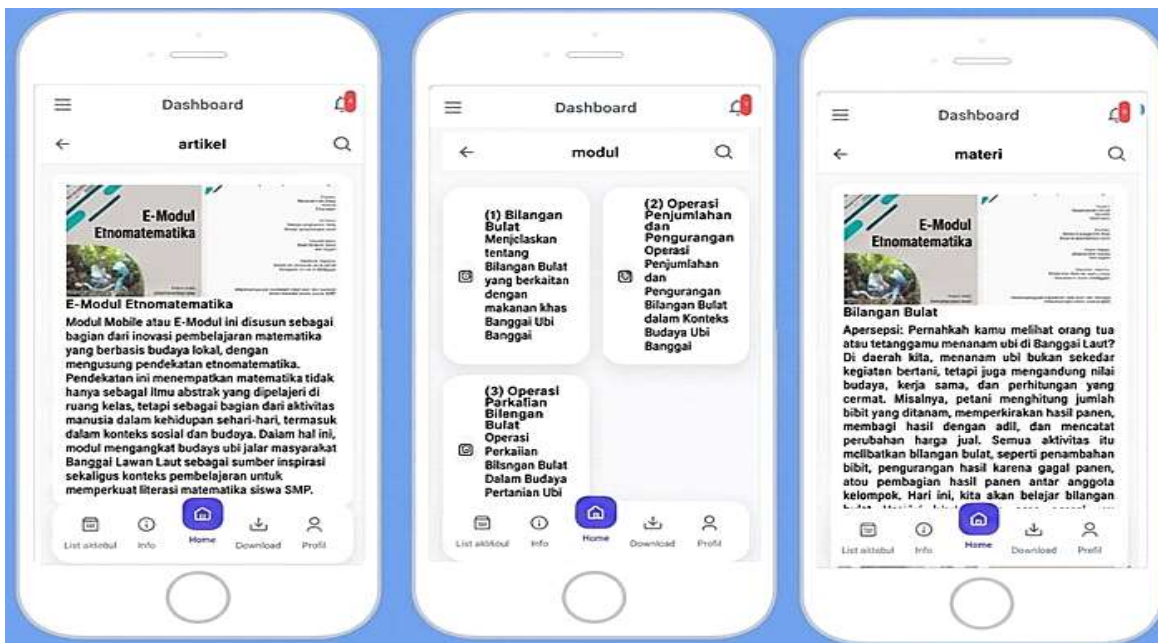


Figure 2. Learning material and learning activity interfaces

learning environments to integrate in-class and digital learning resources.

Development

The teaching module developed for this study was reviewed and validated by 2 experts

and 1 frontline mathematics teacher in line with six core dimensions. The professional validators for this learning module put forward three improvement requirements, all of which were incorporated into the revised version. The three requirements are as follows: completing the

learning objectives for each activity, enriching image and video materials, and aligning practice exercises with the mathematical literacy indicators.

The practitioner module assessment, organized and conducted for this study, earned an average score of 95% and was rated “very good”. This module is practical and well-suited for implementation in conventional classroom settings.

This study collected evaluation data from frontline education experts, verified that this mathematics teaching module has good adaptability, confirmed the validity of this conclusion by drawing on previous research in the field of educational technology, and further derived that the module possesses the practical foundation required for frontline implementation (Aslan & Zhu, 2016).

The development of the mobile learning module represents a critical bridge between cultural knowledge and formal education, guided by established pedagogical and technological principles. The design’s foundation in constructivism is evident in its emphasis on interactive exercises that prompt students to actively build connections between abstract mathematical concepts and the familiar context of yam farming. This approach moves beyond

rote memorization, encouraging students to construct their own understanding. The choice of a mobile platform, as theorized by Crompton (2013), enhances this by providing flexible, accessible learning opportunities that transcend the traditional classroom and support self-paced study.

The validation process confirms the module’s quality and suitability for educational use. The high practicality score of 95% from a practitioner indicates that the module is not just a theoretical concept but a tool well suited to the realities of classroom implementation. The specific, actionable feedback from experts to add learning objectives, enrich multimedia content, and align exercises with literacy indicators demonstrates a rigorous, iterative development cycle. By incorporating this feedback, the final product achieved a high degree of content validity and pedagogical soundness, establishing the practical foundation necessary for effective implementation in schools, a principle supported by research from Aslan & Zhu (2016).

Implementation

This study conducted a limited-scope field trial. We selected 20 eighth-grade students from SMP Negeri 2 Buko Selatan and collected data

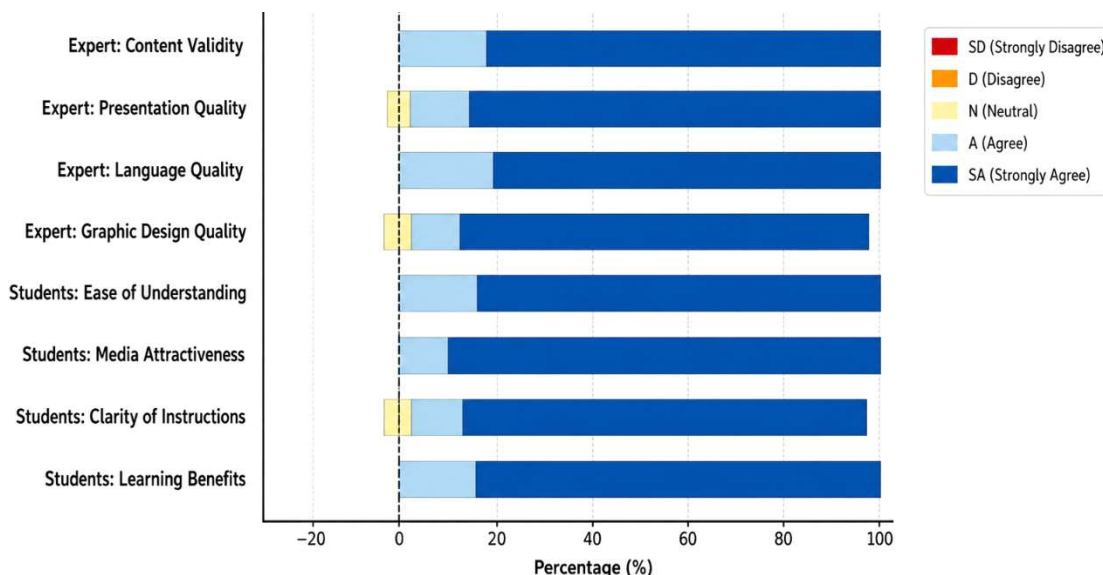


Figure 3. Diverging stacked bar chart of variation in respondents’ answers

from questionnaires and mathematical literacy assessments after implementing the teaching module. Feedback from the student samples collected for this study shows that the learning module received an average score of 96.88%. Students held extremely positive perceptions of the module and rated its learning materials as

interesting, easy to understand, and closely connected to everyday life. The following is a visualization of the data, modified to show variation in respondents' Likert-scale answers.

The following shows a comparison of data distribution and outliers in the pre-test and post-test values.

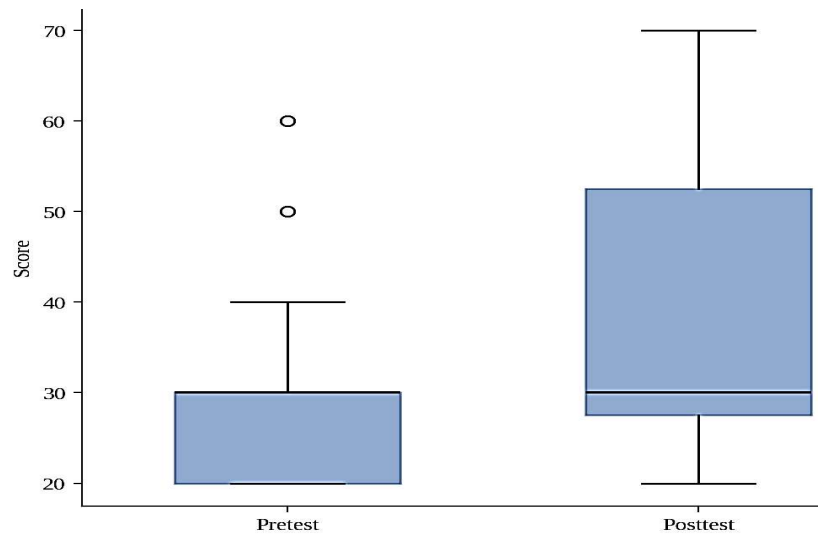


Figure 4. Paired boxplot of pretest and posttest scores

The following is a scatter plot showing the pretest and posttest scores for each student.

In terms of learning outcomes, the module's initial effectiveness was evaluated using pre- and

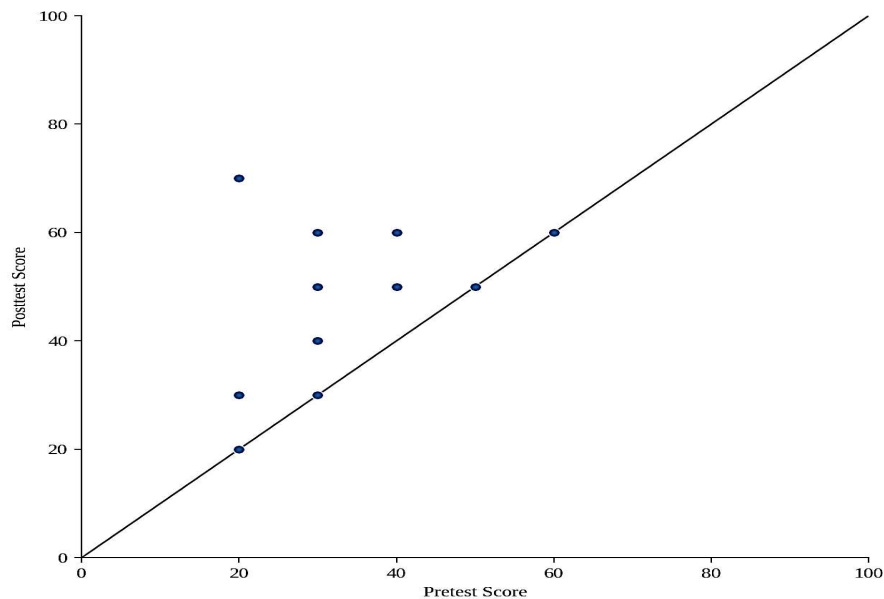


Figure 5. Distribution of students' pretest and posttest scores

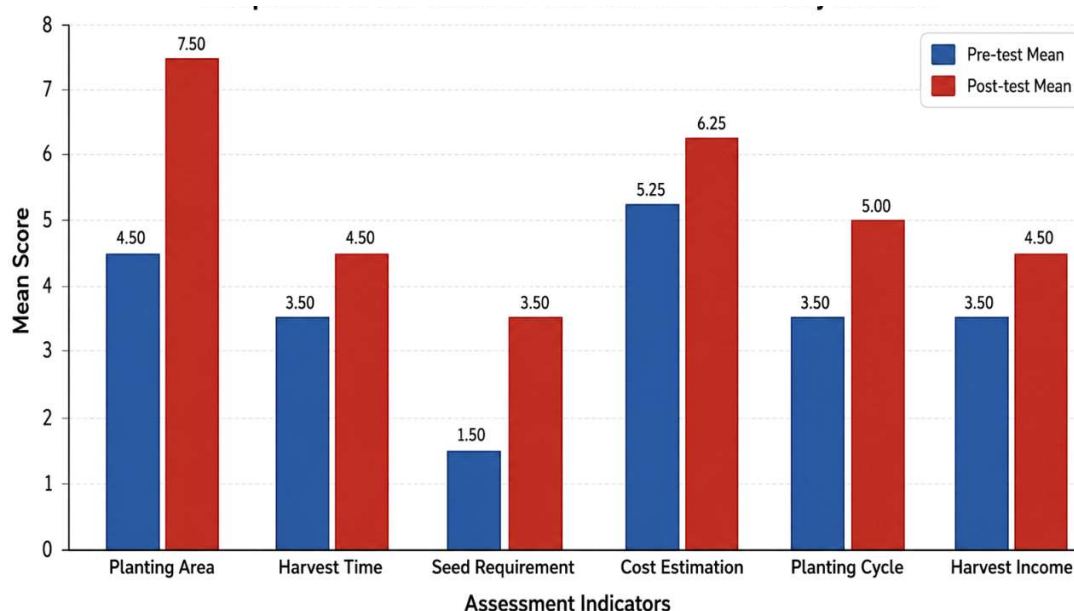


Figure 6. Comparison of scores per indicator

post-test data. Descriptive statistics, presented in Table 4, revealed an increase in the mean score from 30.00 (SD = 10.49) on the pre-test to 39.00 (SD = 16.40) on the post-test. Despite this positive change, the average normalized gain (N-

Gain) score was 0.13, which is classified as a low level of improvement.

The difference between the high response scores and the relatively low N-Gain scores suggests that several factors contributed to the

Table 4. Descriptive statistics

Statistic	Pre-test	Post-test
Number of Participants (n)	20	20
Mean	30	39
Standard Deviation (SD)	10.49	16.40
Minimum Score	20	30
Maximum Score	60	70

improvement in low mathematics literacy, including learning time using the module, teacher readiness, student characteristics, and the intensity of mentoring during learning. Although student feedback on the module was highly positive, the improvement in mathematical literacy, as measured by the N-Gain score, remained in the low category. Based on observations during implementation, this discrepancy can be explained by several factors. Most students still required teacher guidance to connect the cultural context of Banggai yam farming with mathematical

concepts. Some students also had difficulty interpreting contextual problems and selecting appropriate solution strategies, which necessitated direct teacher intervention. These findings suggest that the module's effectiveness was influenced by the intensity of teacher mentoring, as it did not yet fully facilitate independent learning. Additionally, the limited duration of the implementation may not have provided sufficient time for students to adapt to the module and the ethnomathematics-based learning approach.

The conclusions drawn in the earlier sections of this study are consistent with the 2020 study by Purnomo et al. That study proposed that ethnomathematics-based learning can promote the development of mathematical literacy, and that this approach must be implemented consistently to achieve significant gains. The reasoning, problem-solving, and explanatory capabilities encompassed by mathematical literacy inherently require long-term accumulation.

The implementation results present a nuanced picture of the module's initial impact. The overwhelmingly positive student perception, reflected in an average score of 96.88%, is a significant achievement. It suggests that the ethnomathematics approach was highly successful in capturing student interest and making mathematics feel relevant and accessible. Students found the material engaging and easy to understand, indicating that the module effectively bridged the gap between their cultural background and formal curriculum, a key goal of culturally responsive teaching. This high level of engagement is a critical prerequisite for meaningful learning.

In contrast, the low N-Gain score of 0.13 indicates that this high engagement did not immediately translate into significant, measurable improvements in mathematical literacy test scores. This discrepancy does not necessarily signify a failure of the module itself. As the study notes, factors like limited intervention time and teacher readiness play a crucial role. More importantly, this finding aligns with the conclusions of Purnomo et al. (2020), which emphasize that mathematical literacy is a complex skill involving reasoning and problem-solving that develops over a prolonged period. The module appears to be an effective tool for sparking interest and building a conceptual foundation, but realizing its full potential to improve literacy scores likely requires sustained, long-term integration into the curriculum.

This study verified that the developed ethnomathematics-based mobile module is valid and practical, and has the potential to serve as a contextual mathematics learning resource that integrates local cultural knowledge with digital technology. We reconstructed the mathematical knowledge embedded in the Banggai community's yam cultivation culture, integrated it into mobile learning scenarios, and expanded the existing research stock in the field of ethnomathematics; the study confirms that combining local culture with digital technology can create more meaningful and contextualized learning experiences, strengthen the bridging role of ethnomathematics, and provide innovative resources for culturally responsive mathematics teaching in junior high schools.

Evaluation

The evaluation phase was conducted both formatively and summatively. We conducted formative evaluation through a review of analysis results, expert validation, and product revision. The analysis showed that the Banggai sweet potato farming culture incorporates mathematical knowledge, such as counting, measuring, estimating, and comparing, during cultivation. The expert validation review concluded that it was necessary to add learning objectives to each learning activity, include more relevant images and videos, and align practice questions with mathematical literacy indicators. Meanwhile, the pilot test required improvements in content, learning strategies, and implementation. Meanwhile, the summative evaluation was conducted based on implementation results, including analysis of learning outcomes, module practicality, and user feedback. We used the evaluation results to refine the final product to produce a valid, practical, and suitable ethnomathematics-based mobile learning module for use in junior high school mathematics teaching.

Research Limitations

This study has several limitations that should be considered when interpreting the research results. First, the module effectiveness test uses a One-Group Pretest-Posttest design, so it does not involve a control group for comparison. This design has methodological limitations because it is susceptible to threats to internal validity, including historical, maturation, and testing effects. Thus, the increase in mathematics literacy scores observed after using the modules cannot be fully attributed to the modules themselves. Second, the trial was conducted on a limited scale involving 20 students from one school. Hence, the characteristics of the students and the relatively homogeneous learning context limited the generalization of the research results to a wider population. In addition, this research is still in the product development stage (Research and Development), which focuses on testing the initial validity, practicality, and effectiveness. Therefore, further research with stronger experimental designs, such as Pretest-Posttest Control Group Design or quasi-experimental designs involving control groups, larger sample sizes, and implementation on various school characteristics, is needed to obtain stronger empirical evidence regarding the effectiveness of modules in improving students' mathematical literacy.

■ CONCLUSION

The rich ethnomathematical knowledge embedded in the farming culture of Banggai yams can be systematically restructured into junior high school mathematics learning content and integrated into mobile learning environments. The relevant modules developed in this study can connect formal mathematics with students' local experiences, enhance the relevance of learning, and expand ethnomathematics research from mere cultural exploration into the field of technology-supported learning resource development.

The classroom teaching module developed in this study has been verified through classroom practice as a practical resource. It has the potential to serve as a resource for contextual mathematics learning. Ethnomathematics can serve as a bridge connecting culture and mathematics and is also a viable teaching strategy for culturally adapted learning. This study has limitations, namely that improvements in students' mathematical literacy remain low. This suggests that simply integrating cultural context and mobile technology is not sufficient to produce significant learning improvements, and supporting implementation mechanisms and appropriate teaching support are needed. A critical factor appears to be the need for 'appropriate teaching support,' which raises important questions about the module's implementation model. While designed with features for independent use, the findings suggest that the module may be more effective as a teacher-facilitated tool than as a fully self-directed learning resource. This potential dependence on teacher guidance could affect the module's scalability and underscore the importance of a blended approach in which the teacher's role in scaffolding the learning experience remains central.

This study successfully developed a mobile module based on the ethnomathematics of Banggai yam cultivation that meets validity and practicality criteria as a medium for contextual mathematics learning. However, initial effectiveness test results indicated that students' mathematical literacy remained in the low category; thus, the module's effectiveness could not be conclusively determined. These findings suggest that the module is best positioned as a supplementary learning tool used in conjunction with teacher facilitation, rather than as a standalone resource for independent study. The teacher's role in providing scaffolding, facilitating discussions, and helping students connect cultural contexts to mathematical concepts is crucial to

the module's implementation. Consequently, scaling up the module's application requires not only the distribution of the digital product but also adequate teacher training and implementation strategies to optimize its benefits across diverse learning contexts. Future research should evaluate the module's effectiveness using a more robust experimental design and a larger sample to gather more comprehensive empirical evidence.

This study will advance two practical implementation tasks in its follow-up work. The first is to expand the existing modules to include geometry, algebra, and statistics, and to add four new interactive functions. The second is to conduct rigorous, large-sample, long-cycle experiments to provide stronger empirical support for the implementation of this ethnic mathematics mobile learning model.

■ DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the preparation of this manuscript, the author utilized Google Translate, ChatGPT, Auto Revise AI, and Imrecs Authoring Service to assist with grammar editing, clarity enhancement, manuscript refinement, and proofreading. The author has reviewed and edited the content generated by these tools and bears full responsibility for the content of the published article.

■ REFERENCES

- Abidin, Z., Mathrani, A., Parsons, D., & Suriadi. (2016). Opportunities and challenges of mobile learning for promoting mathematical literacy. *International Journal of Mobile and Blended Learning*, 8(4), 1–15.
- Akbar, S. (2017). *Instrumen perangkat pembelajaran*. Bandung: Remaja Rosdakarya
- Arikunto, S. (2018). *Dasar-Dasar Evaluasi Pendidikan*. (3rd ed.). Bumi Aksara.
- Aslan, A., & Zhu, C. (2016). Influencing factors and integration of mobile technologies in mathematics education. *EURASIA Journal of Mathematics, Science and Technology Education*, 12(11), 2975–2989.
- Batiibwe, M. S. K. (2024). The role of ethnomathematics in mathematics education: A literature review. *SAGE Open*, 14(4), 1–18.
- Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer.
- Cartwright, T. J., & Hallar, B. (2018). Taking risks with a growth mindset: Long-term influence of an elementary pre-service after school science practicum. *International Journal of Science Education*, 40(3), 348–370.
- Clarkson, P., & Presmeg, N. (2008). Critical issues in mathematics education: Major contributions of culture and communication. *Mathematics Education Research Journal*, 20(2), 1–18.
- Crompton, H. (2013). A historical overview of mobile learning: *Toward learner-centered education*. In Z. L. Berge & L. Y. Muilenburg (Eds.), *Handbook of Mobile Learning* (pp. 3–14). New York, NY: Routledge.
- D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics*, 5(1), 44–48.
- Dicle, R. M. (2025). Mobile learning in mathematics: Benefits, challenges, strategies, and proponents' and opponents' views. *International Review of Research in Open and Distributed Learning*, 26(4), 1–22.
- Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American*

- Journal of Physics*, 66(1), 64–74
- Graham, C. R. (2006). *Blended learning systems: Definition, current trends, and future directions*. In C. J. Bonk & C. R. Graham (Eds.), *The handbook of blended learning: Global perspectives, local designs* (pp. 3–21). San Francisco, CA: Pfeiffer.
- Khikmiyah, F., & Rakhma, P. A. (2019). Mathematics literacy mobile learning application: Development of Android-based mathematical literacy learning materials. *Didaktika*, 25(2), 201–214.
- Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). Sage Publications.
- Molenda, M. (2003). In search of the elusive ADDIE model. *Performance Improvement*, 42(5), 34–37. <https://doi.org/10.1002/pfi.4930420508>
- Mulyadi, F. J., Rohati, R., & Nusantara, D. S. (2025). Mapping research trends and thematic evolution in ethnomathematics 2020–2025: A bibliometric analysis in mathematics education. *Journal of General Education and Humanities*, 5(2), 1–18.
- Nasrum, A., Salido, A., & Chairuddin. (2025). Unveiling emerging trends and potential research themes in future ethnomathematics studies: A global bibliometric analysis. *International Journal of Learning, Teaching and Educational Research*, 24(1), 1–20.
- OECD. (2019). *PISA 2018 Results (Volume I): What Students Know and Can Do*. Paris, France: OECD Publishing.
- OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. Paris, France: OECD Publishing.
- Orey, D. C., & Rosa, M. (2023). Revisiting the theoretical foundations of ethnomodelling. *Educação Por Escrito*, 14(1), e45054.
- Purnomo, I., Yusuf, Y., & Rosita, N. T. (2025). From GeoGebra to Canva: Systematic literature review on the shift to interactive media trends in mathematical literacy (2020–2025). Mosharafa: *Jurnal Pendidikan Matematika*, 14(4), 1–20.
- Putra, E. C. S., & Mahmudah, F. N. (2021). The implementation of ethnomathematics-based learning for students. *Supremum Journal of Mathematics Education*, 5(2), 162–169.
- Rezeki, S., Andrian, D., & Safitri, Y. (2021). Mathematics and cultures: A new concept in maintaining cultures through the development of learning devices. *International Journal of Instruction*, 14(3), 375–392.
- Rosa, M., & Orey, D. C. (2011). Ethnomathematics: The cultural aspects of mathematics. *Revista Latinoamericana de Etnomatemática*, 4(2), 32–54.
- Rosa, M., & Orey, D. C. (2021). An ethnomathematical perspective of STEM education in a globalized world. *BOLEMA: Boletim de Educação Matemática*, 35(70), 840–876.
- Rosa, M., & Orey, D. C. (2023). Considerations about ethnomathematics, culturally relevant pedagogy and social justice in mathematics education. *Educação Matemática Pesquisa*, 25(2), 145–165.
- Siregar, N., Prahmana, R. C. I., & Widodo, S. A. (2022). Ethnomathematics in mathematics learning: A systematic literature review. *Journal on Mathematics Education*, 13(2), 245–264.
- Sugiyono. (2022). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.
- Utami, R. E., Widodo, S. A., & Prahmana, R. C. I. (2023). Ethnomathematics-based learning and students' mathematical

- literacy: A meta-analysis study. *Journal on Mathematics Education*, 14(1), 57–74.
- Wulandari, I. G. A. P. A., Payadnya, I. P. A. A., Puspawati, K. R., & Saelee, S. (2024). The significance of ethnomathematics learning: A cross-cultural perspective between Indonesian and Thailand educators. *Journal of Mathematics Education Research*, 15(2), 1–15.
- Xu, H., & Ball, R. (2024). Multiple forms of knowing in mathematics: A scoping literature study. *Educational Studies in Mathematics*, 117(1), 1–24.