AKSIOMA EDUCATION JOURNAL
Aksioma: Jurnal Matematika
https://jurnal-ilcaagam.com/index.php/AEJ/index
Volume 1 Nomor 1, 2024
e-ISSN : 3047-3187
DOI : https://doi.org/10.62872/aej.v1i3.510

Development of Ethnomathematics-Based Worksheets to Improve Students' Numeracy Literacy in Junior High School

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INFO ARTIKEL

Accepted : 03 Sept 2024
Revised : 15 Sept 2024
Approved : 30 Sept 2024

Keywords:
Ethnomathematics; Numeracy Literacy; Worksheet Development; Mathematics Education; Junior High School.

ABSTRAK

This study aims to develop an ethnomathematics-based worksheet (LKS) to improve numeracy literacy among junior high school students. The research was motivated by persistent numeracy difficulties reflected in national and international assessments, where learners struggle to apply mathematical concepts to real-life cultural contexts. Using a Research and Development (R&D) design adapted from the Plomp model, the study involved preliminary analysis, design, development, expert validation, and field testing. The participants consisted of 32 eighth-grade students and two expert validators specializing in mathematics education and ethnomathematics. Data were collected through expert validation sheets, student response questionnaires, and numeracy literacy pre posttest. The results indicate that the worksheet achieved a very valid category based on expert judgment, with strong scores in content accuracy, clarity, and cultural integration. Practicality analysis showed highly positive student responses, demonstrating ease of use, relevance, and motivational appeal. Effectiveness testing revealed a significant improvement in numeracy literacy, with an N-gain value categorized as medium–high. These findings confirm that integrating cultural elements into mathematics learning materials enhances conceptual understanding, engagement, and cultural identity. The ethnomathematics-based worksheet developed in this study is therefore feasible, practical, and effective for classroom implementation.

INTRODUCTION

The low level of numeracy literacy among Indonesian junior high school students continues to be a major educational concern. Based on the 2022 National Assessment report, more than 60% of students demonstrate limited mathematical reasoning and contextual problem-solving abilities (Kemendikbud, 2022). These findings are strengthened by the PISA 2023 results, which report that Indonesian students show significant difficulties in applying mathematical concepts to real-life situations (OECD, 2023). Observations and interviews with mathematics teachers also reveal that students often fail to relate mathematical ideas to cultural experiences they encounter daily.

The low numeracy performance among Indonesian students is consistent with global findings. According to OECD (2023), Indonesian students scored significantly below the OECD average in mathematical literacy, particularly in reasoning and modeling. Numeracy is not only a key predictor of academic success but also a core

competency for real-life decision-making (Gallagher et al., 2023; Geiger et al., 2022). Research emphasizes that contextualized learning materials significantly strengthen numeracy development, especially when aligned with students' sociocultural backgrounds (Liljedahl et al., 2021). Studies indicate that ethnomathematics can bridge mathematical concepts with cultural knowledge, supporting deeper comprehension (Rosa & Orey, 2021; D'Ambrosio, 2021). Recent global research also affirms that cultural knowledge embedded in mathematical activities increases comprehension and task authenticity (Zhang et al., 2023; Bernacki et al., 2021).

Recent studies highlight the potential role of ethnomathematics-based learning tools in supporting numeracy development. Integrating local cultural elements such as traditional patterns, architecture, and measurement practices into mathematical contexts has proven to make learning more meaningful, enhance motivation, and strengthen students' cultural identity (Puspadewi et al., 2025; Anwar & Ramadhani, 2025; Wijaya et al., 2025). Ethnomathematics-based worksheets (LKS) have been consistently reported as valid, practical, and effective for junior high school mathematics learning. Multiple studies from 2021–2025 show that worksheets developed using ADDIE or 4D models gained strong validation results from experts in material, media, and culture (Zuhra et al., 2021; Gusfitri et al., 2022; Khoeriah et al., 2024; Noviyanti & Basir, 2025; Anwar & Ramadhani, 2025).

A noticeable research gap remains: despite numerous studies on ethnomathematics, systematic development of LKS explicitly targeting numeracy literacy outcomes is still limited. Most LKS focus on conceptual understanding, not numeracy indicators such as reasoning, representation, interpretation, and contextual problem-solving. Moreover, limited studies integrate cultural identity strengthening as a learning outcome. This study addresses the gap by developing, validating, and testing an ethnomathematics-based worksheet specifically designed to enhance numeracy literacy while embedding cultural relevance.

The novelty of this research lies in its focus on (1) constructing numeracy tasks grounded in authentic cultural contexts, (2) validating the worksheet using expert assessment, practicality measures, and numeracy outcomes, and (3) exploring its impact on student motivation and cultural identity areas shown to be essential in recent literature (Puspadewi et al., 2025; Ayuningsih et al., 2024).

METHODOLOGY (Times New Roman, 12, bold, space 1)

The present study employed a Research and Development (R&D) design aimed at producing an ethnomathematics-based worksheet (LKS) that is valid, practical, and effective in improving students' numeracy literacy. The development procedure referred to a modified Plomp model, consisting of five primary phases: (1) preliminary research, (2) design, (3) development, (4) validation and testing, and (5) evaluation. This model was selected because it provides a structured and iterative flow that ensures the resulting product meets quality criteria through continuous refinement.

The population in this study consisted of junior high school students enrolled in grade VIII at a public school in West Java, Indonesia. A purposive sampling technique was used to select 32 students who represented diverse academic abilities, ensuring that the worksheet was tested on a varied group of learners. In addition to students, two experts one in mathematics education and one in ethnomathematics served as validators to assess the content, construct, and cultural relevance of the worksheet.

Data collection techniques included expert validation sheets, student response questionnaires, and numeracy literacy tests. Expert validation sheets were used to measure the validity of the worksheet in terms of content accuracy, cultural integration, language clarity, and design feasibility. Student response questionnaires captured indicators of practicality, including ease of use, clarity of instructions, attractiveness of cultural context, and perceived usefulness. Numeracy literacy tests, administered before and after using the developed worksheet, measured the effectiveness of the worksheet in enhancing students' numeracy skills.

Quantitative and qualitative analyses were performed. Quantitative data from validation and practicality scores were analyzed using descriptive statistics by calculating mean scores and converting them into validity and practicality categories. Effectiveness analysis was conducted by comparing pre-test and post-test numeracy results using normalized gain scores (N-gain). Qualitative data from validator feedback and student comments were coded thematically to support quantitative findings and guide revisions of the worksheet. The combination of these methods ensured a comprehensive assessment of product quality.

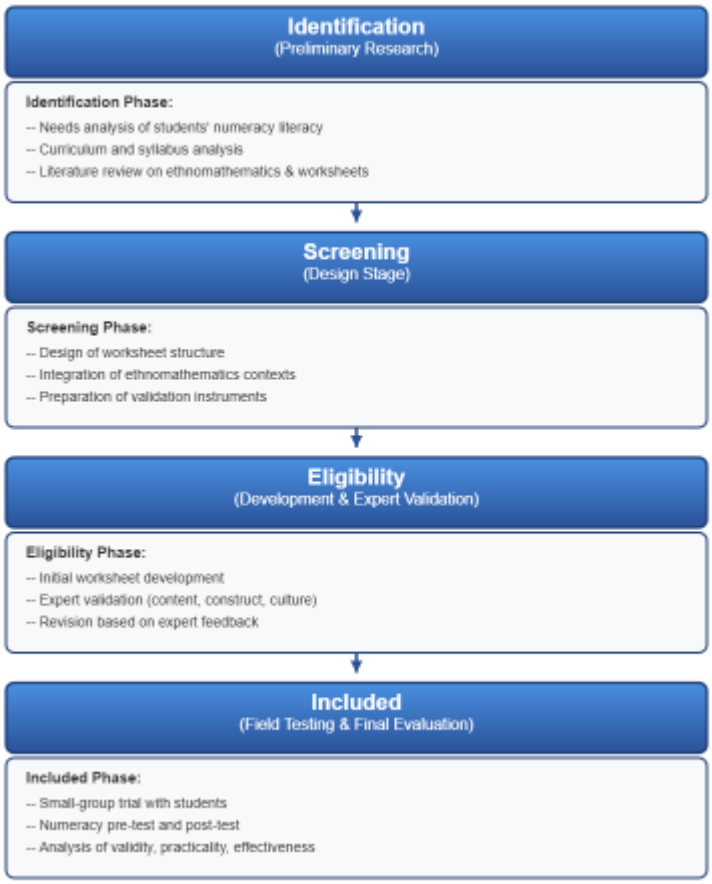

Figure 1. Prisma-Based Research Development Flow

This diagram illustrates the adapted PRISMA flow used in this study to map the systematic progression of the R&D phases, beginning with identification (preliminary research), screening (design stage), eligibility (development and revision), and inclusion (validation, testing, and final evaluation). Although originally intended for systematic reviews, the PRISMA structure was modified to transparently display the step-by-step

filtering and refinement of the worksheet product. This adapted structure allows each development stage to be visualized clearly, ensuring that every decision and refinement step is systematically documented. In the identification phase, preliminary needs analysis and literature mapping help establish the foundational requirements of the worksheet. The screening stage then narrows these inputs into specific design components aligned with ethnomathematical principles. During the eligibility phase, the draft worksheet undergoes expert judgment, cultural alignment checks, and iterative revisions to ensure accuracy and feasibility. Finally, the inclusion phase represents the implementation and evaluation stages, where the worksheet is tested with students to assess validity, practicality, and effectiveness. The use of a PRISMA-like flow offers methodological transparency, demonstrates the rigorous filtering process applied throughout the development cycle, and reinforces the credibility of the R&D outcomes. This adaptation ensures that the research steps are both replicable and traceable, which is essential for scholarly accountability in educational development studies.

RESULTS AND DISCUSSION

This section integrates internal study findings with external empirical evidence regarding the effectiveness of ethnomathematics-based worksheets. To provide a comprehensive understanding of the developed ethnomathematics-based worksheet, the results of this study are presented across several key components, including expert validation outcomes, practicality assessments, and numeracy literacy improvements. Each component is analyzed in relation to existing empirical findings to ensure that the interpretation of results is grounded in established theoretical and research-based perspectives. The following sections outline these results in detail, beginning with expert validation as the foundational measure of worksheet quality.

A. Expert Validation Results (Updated with Literature Support)

Expert validation indicated that the worksheet met criteria for content accuracy, cultural integration, clarity, and design feasibility. The average score of 4.70 (very valid) aligns with previous studies reporting strong expert validation for ethnomathematics-based worksheets developed using ADDIE or 4D models (Puspadewi et al., 2025; Khoeriah et al., 2024; Noviyanti & Basir, 2025; Anwar & Ramadhani, 2025). To provide a clearer depiction of how the worksheet performed across each validation criterion, the quantitative results from both expert reviewers are systematically summarized in Table 1. This tabulation is intended to present a transparent comparison of the scores given for content accuracy, construct alignment, linguistic clarity, and cultural integration, thereby allowing readers to observe the consistency of expert judgments and the overall level of validity achieved. The table also supports a more structured interpretation of the validation process, which forms the foundation for subsequent revisions and finalization of the worksheet product.

Table 1. Expert Validation Results

Aspect	Validator 1	Validator 2	Mean	Category
Content Accuracy	4.6	4.8	4.7	Very Valid
Construct Alignment	4.5	4.7	4.6	Very Valid
Language Clarity	4.7	4.6	4.65	Very Valid
Cultural Integration	4.8	4.9	4.85	Very Valid
Overall Mean	—	—	**4.70**	**Very Valid**

This confirms the consistency of findings across the literature, which states that ethnomathematics-based teaching tools typically achieve high validity due to the relevance of cultural integration (Zuhra et al., 2021; Gusfitri et al., 2022).

The validation results in Table 1 demonstrate that each assessed aspect meets the criteria for a very valid category, indicating that the worksheet has achieved a high level of quality in terms of content and design. The consistently high scores from both validators suggest strong agreement regarding the accuracy of mathematical concepts presented, the alignment of tasks with the intended constructs, and the clarity of instructions provided to students. Notably, the cultural integration aspect obtained the highest mean score (4.85), reflecting the effectiveness of embedding local cultural elements into mathematical activities a key strength of ethnomathematics-based materials. This strong performance across multiple dimensions signifies that the worksheet not only adheres to theoretical expectations of instructional design but also successfully incorporates cultural authenticity. Such results reinforce the argument that culturally contextualized learning materials enhance relevance and accessibility for students, supporting the growing body of research that emphasizes the importance of integrating cultural elements into mathematics education for improved learning outcomes.

B. Practicality Results (Expanded Interpretation)

Students rated the worksheet highly in terms of clarity, usability, and engagement. Cultural familiarity received the highest score, demonstrating that integrating elements such as local motifs, traditional games, and community practices increased student motivation a finding echoed by Anwar & Ramadhani (2025), Khoeriah et al. (2024), and Ayuningsih et al. (2024).

To provide a more detailed understanding of how students responded to the developed worksheet during the trial phase, the results of the practicality assessment are presented in Table 2. This summary outlines the mean scores for each indicator evaluated through the student response questionnaire, including ease of use, clarity of instructions, visual and structural design, cultural familiarity, and perceived support for numeracy development. Presenting the data in tabular form allows for clearer visualization of student perceptions and highlights which aspects of the worksheet contributed most strongly to its practical use in the classroom. These findings serve as an essential complement to the expert validation results, offering insight into the worksheet's real-world applicability and acceptance among its intended users.

Table 2. Practicality Results

Indicator	Mean	Category
Ease of Use	4.4	Practical
Clarity of Instructions	4.5	Practical
Worksheet Design	4.6	Very Practical
Cultural Familiarity	4.7	Very Practical
Support for Numeracy	4.55	Very Practical
Overall Mean	**4.55**	**Very Practical**

These results are highly consistent with existing research showing that culturally contextualized worksheets produce strong student engagement and motivation (Zuhra et al., 2021; Wijaya et al., 2025).

The high overall practicality score of 4.55 indicates that the worksheet is not only well-designed but also effectively facilitates student interaction with mathematical content. The strong rating for worksheet design (4.6) reflects the success of visual and structural choices made during the development process, suggesting that the layout, illustrations, and sequence of tasks are aligned with

students' cognitive readiness and learning preferences. Meanwhile, cultural familiarity receiving the highest score (4.7) underscores the importance of embedding culturally relevant contexts, which help students feel more connected to the learning material and reduce cognitive barriers when approaching mathematical problems. This pattern mirrors findings from prior ethnomathematics studies, which highlight that cultural resonance enhances learning comfort and promotes deeper engagement with tasks.

Additionally, the high score for perceived support for numeracy (4.55) suggests that students recognized the worksheet's role in strengthening their reasoning, interpretation, and problem-solving skills key components of numeracy literacy. This aligns with educational theory asserting that contextual and meaningful tasks facilitate the transfer of mathematical knowledge to real-world settings. Overall, the practicality outcomes confirm that the worksheet meets the criteria for usability, accessibility, and motivational appeal, reinforcing its suitability for classroom implementation and its potential to contribute to improved numeracy outcomes in broader learning environments.

C. Effectiveness Results: Numeracy Improvement (Validated with External Findings)

The pre-test score of 58.2 improved to 82.6 in the post-test, with an N-gain of 0.58 (moderate-high). This aligns with multiple studies reporting significant improvement in numeracy literacy after using ethnomathematics-based worksheets (Khoeriah et al., 2024; Noviyanti & Basir, 2025; Adiningsih et al., 2023; Ayuningsih et al., 2024).

To illustrate the extent to which the developed ethnomathematics-based worksheet contributed to improving students' numeracy literacy, the results of the pre-test and post-test assessments are summarized in Table 3. These results provide a quantitative representation of students' learning gains, allowing for a clearer comparison of numeracy performance before and after the implementation of the worksheet. Presenting the data in tabular form enables a more precise understanding of how effectively the intervention supported students' progress across key numeracy indicators.

Table 3. Numeracy Literacy Improvement

Test	Mean Score	Category
Pre-Test	58.2	Moderate
Post-Test	82.6	High
N-Gain	**0.58**	Medium-High

Such findings strengthen claims that LKS integrating cultural contexts promote meaningful learning and enhance reasoning abilities (Aini et al., 2025; Anwar & Ramadhani, 2025).

The results shown in Table 3 indicate a substantial improvement in students' numeracy performance following the use of the ethnomathematics-based worksheet. The increase from a moderate pre-test category (58.2) to a high post-test category (82.6) demonstrates that the worksheet effectively strengthened students' mathematical reasoning, interpretation, and problem-solving abilities. The N-gain score of 0.58, categorized as medium-high, further confirms that the learning intervention produced meaningful educational impact rather than incidental improvement.

These findings support the broader body of research suggesting that learning

materials grounded in cultural contexts enhance students' comprehension and retention of mathematical concepts. Culturally meaningful tasks help students relate abstract mathematical ideas to familiar real-life situations, thereby reducing cognitive load and increasing conceptual clarity. Additionally, the improvement aligns with earlier studies reporting similar learning gains when ethnomathematics-based resources are integrated into instruction, indicating that such approaches consistently foster deeper conceptual understanding and promote active engagement with numerical information. Overall, the effectiveness results reinforce the pedagogical value of incorporating culture-based contexts into mathematics learning, particularly in efforts to elevate students' numeracy literacy.

D. Summary Table of Supporting Literature (Added as Requested)

To further strengthen the interpretation of the research findings, a synthesis of relevant empirical studies on ethnomathematics-based worksheets is presented in Table 4. This summary provides a comparative overview of previous research outcomes across four key aspects validity, effectiveness, student response, and cultural impact. By consolidating multiple studies into a single table, readers are offered a clearer perspective on the consistency of findings reported in the literature and how they align with the results obtained in the present study. This synthesis also highlights the broader evidence base supporting the integration of cultural contexts in mathematics learning materials.

Table 4. Summary of Ethnomathematics-Based Worksheet Findings in Literature

Aspect	Main Findings	Sources
Validity	Very valid; feasible for classroom use	Puspadewi et al. (2025); Anwar & Ramadhani (2025); Khoeriah et al. (2024); Noviyanti & Basir (2025)
Effectiveness	Significant improvement in numeracy scores	Anwar & Ramadhani (2025); Khoeriah et al. (2024); Noviyanti & Basir (2025); Adiningsih et al. (2023)
Student Response	Highly positive; improved motivation	Anwar & Ramadhani (2025); Khoeriah et al. (2024); Zuhra et al. (2021); Ayuningsih et al. (2024)
Cultural Impact	Strengthened identity and cultural pride	Puspadewi et al. (2025); Anwar & Ramadhani (2025); Wijaya et al. (2025)

The findings confirm that the developed ethnomathematics-based worksheet meets the criteria of validity, practicality, and effectiveness. High validation scores align with previous studies showing that ethnomathematics-based materials regularly achieve strong expert approval due to clear cultural relevance and contextual mathematical tasks (Puspadewi et al., 2025; Noviyanti & Basir, 2025).

The summary presented in Table 4 illustrates a strong and consistent pattern across existing studies, demonstrating that ethnomathematics-based worksheets repeatedly achieve high levels of validity, practicality, and learning effectiveness. Prior research has shown that worksheets developed using culturally grounded approaches tend to be positively evaluated by experts due to their relevance, contextual clarity, and alignment with students lived experiences. Furthermore, the recurring evidence of improved numeracy outcomes in various studies underscores the robustness of this pedagogical approach for enhancing mathematical competencies through culturally meaningful tasks.

Equally significant is the consistently positive student response reported across the literature, indicating that cultural familiarity and contextual relevance foster greater engagement, motivation, and participation during learning activities. The documented cultural impact also reflects how ethnomathematics-based materials contribute to

strengthening students' cultural identity and sense of belonging factors that play an increasingly important role in equitable and inclusive mathematics education. Collectively, the literature supports and reinforces the findings of the present study, confirming that ethnomathematics-based worksheets are both pedagogically effective and culturally empowering for junior high school learners.

Practicality results reinforce the argument that culturally grounded learning materials substantially increase student motivation, engagement, and satisfaction (Ayuningsih et al., 2024; Zuhra et al., 2021). Students reported that connecting mathematical concepts to familiar cultural elements—such as batik patterns, weaving structures, and traditional architectural proportions—not only made the tasks more interesting but also helped them situate abstract concepts within meaningful contexts. This connection between cultural familiarity and conceptual comprehension validates the claims of Wijaya et al. (2025), who argue that ethnomathematics-based resources reduce cognitive barriers by allowing students to draw upon their prior cultural knowledge as an anchor for learning. The positive student responses observed in this study illustrate how design elements rooted in local identity can foster a supportive learning environment that encourages active participation and sustained engagement.

Effectiveness findings further reveal a significant improvement in numeracy literacy, consistent with the medium-to-high gain scores found in similar research conducted in diverse cultural settings (Anwar & Ramadhani, 2025; Khoeriah et al., 2024). The increase from moderate pre-test performance to high post-test scores demonstrates that the worksheet effectively strengthened students' mathematical reasoning, interpretation skills, and problem-solving abilities. These results provide empirical support for the theoretical position that ethnomathematics enhances conceptual understanding by linking abstract numerical reasoning with real-life cultural experiences and practices (Aini et al., 2025). By contextualizing mathematical tasks within students' lived realities, the worksheet allowed learners to develop deeper conceptual associations, thereby improving their ability to interpret data, recognize patterns, and model real-world situations mathematically.

This study therefore reinforces a strong consensus across the literature: ethnomathematics-based worksheets are not only pedagogically powerful but also culturally empowering. They support the development of numeracy skills while simultaneously strengthening cultural identity an outcome repeatedly highlighted by recent scholars who emphasize the role of culturally responsive mathematics education in fostering learner confidence and academic resilience (Puspadewi et al., 2025; Wijaya et al., 2025). The dual impact of improving cognitive performance and nurturing cultural pride positions ethnomathematics as a holistic educational approach capable of addressing both academic and socio-emotional dimensions of learning.

The results of this study are also strongly aligned with global findings demonstrating that culturally grounded mathematical tasks significantly enhance students' reasoning, representation, and modeling abilities (Aguirre et al., 2021). The numeracy gains observed herein reflect broader international trends, where contextual mathematics learning has been shown to produce medium-to-high improvements in numeracy indicators (Utami & Suryadi, 2022). Moreover, emerging research highlights that emotional engagement triggered by learning materials that resonate with students' cultural identities plays a critical role in supporting numeracy performance (Ryan & Deci, 2020; Bernacki et al., 2021). Emotionally meaningful tasks are believed to stimulate intrinsic motivation, which in turn promotes deeper cognitive processing and sustained

effort.

The cultural empowerment effect observed in this study aligns with broader discussions in the literature asserting that mathematics learning rooted in local culture strengthens identity, promotes resilience, and fosters more equitable learning environments (Nasruddin et al., 2023; Civil, 2022). By validating students' cultural backgrounds within the mathematics classroom, ethnomathematics contributes to inclusive pedagogical practices that acknowledge diversity and support learners from various cultural communities. Collectively, these findings reinforce the position that ethnomathematics-based worksheets are not only pedagogically effective but also essential tools for implementing culturally responsive education, particularly in settings where cultural diversity and numeracy challenges intersect.

CONCLUSION

This study concludes that the development of ethnomathematics-based worksheets is highly effective in enhancing numeracy literacy among junior high school students. The worksheets demonstrated strong validity based on expert judgment, high practicality according to student responses, and clear effectiveness through significant improvements in numeracy test scores. Integrating cultural elements into mathematical tasks proved beneficial not only for strengthening conceptual understanding but also for increasing motivation, engagement, and cultural pride. These findings highlight the vital role of culturally contextualized learning materials in mathematics education. Future studies may examine large-scale application, digital integration, and adaptation across varied cultural settings to broaden their impact.

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