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Integrating ethnomathematics into a transformation geometry module to enhance self-efficacy

Maria Editha Bela*, Melkior Wewe
Sekolah Tinggi Keguruan dan Ilmu Pendidikan Citra Bakti, Indonesia
✉ itabella09@gmail.com*

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Abstract

Background: Improving self-efficacy is essential for student success in mathematics, especially in complex topics like transformation geometry. Incorporating ethnomathematics into instructional modules provides a meaningful connection between mathematical concepts and cultural contexts, which can enhance student engagement and confidence.

Aim: This research focuses on developing a teaching module grounded in ethnomathematics to foster self-efficacy among Class XI high school students in transformation geometry. The study also evaluates the module's validity and practicality.

Method: Using the ADDIE framework (Analyze, Design, Develop, Implement, Evaluate) within a Research and Development (R&D) approach, the study utilized expert validation sheets to assess content and design quality. Practicality was measured through teacher and student feedback collected via questionnaires. Data were analyzed through qualitative and quantitative descriptive methods.

Results: Expert reviews on content and design yielded an average score of 86, indicating the module's strong validity. Feedback from teachers and students produced an average score of 85.72, demonstrating the module's high level of practicality.

Conclusion: The ethnomathematics-based module is validated as both effective and practical, making it a valuable resource for improving self-efficacy in transformation geometry.

INTRODUCTION

Mathematics is a fundamental subject taught at every level of education and plays an essential role in students' daily lives. However, it is often perceived as difficult, boring, and anxiety-inducing due to its heavy reliance on numbers and formulas (Hindi & Muthahharah, 2021; Yavuz, 2018; Yazlık & Çetin, 2020). This perception results in a lack of student motivation and interest in learning mathematics. One mathematical topic that is closely related to real-life applications is transformation geometry, which requires strong spatial reasoning and conceptual understanding (Purniati et al., 2021; Yazlık & Çetin, 2020). To address these challenges, innovative approaches are necessary to connect mathematical concepts to students' daily experiences and cultural contexts. This need becomes even more critical with the implementation of the *Kurikulum Merdeka* (Independent Curriculum), which demands teachers develop engaging and relevant teaching modules tailored to students' needs and learning goals.

Ethnomathematics emerges as an innovative solution to overcome the challenges in mathematics education, particularly in teaching transformation geometry, which is

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often viewed as abstract and complex. Ethnomathematics integrates mathematical concepts with local cultural practices, providing contextual meaning and helping students realize that mathematics exists in their everyday lives (Lidinillah et al., 2022; Nst & Batubara, 2024; Prahmana & D'Ambrósio, 2020). According to Dwidayati & Suyitno (2019), ethnomathematics-based learning not only enhances students' understanding of mathematical concepts but also fosters a sense of pride in local culture, environmental awareness, and nationalism. A well-designed teaching module based on ethnomathematics offers a practical solution for teachers to deliver engaging lessons that are culturally relevant and meaningful. This approach can significantly improve students' self-efficacy, their confidence in understanding and solving mathematical problems. Prior research by Vitoria et al. (2021) demonstrated that teaching materials incorporating ethnomathematics were both practical and effective in improving student comprehension. Therefore, developing an ethnomathematics-based teaching module for transformation geometry is expected to offer an innovative strategy for enhancing students' understanding and self-efficacy in mathematics learning.

Recent investigations highlight the significant role of ethnomathematics in fostering student engagement and enhancing cognitive skills through the incorporation of cultural contexts into mathematical learning. For example, Supriyadi et al. (2022) introduced a Sundanese Gamelan Ethnomathematics e-Module aimed at improving junior high school mathematics understanding. Similarly, Rahayu et al. (2023) developed a mobile ethnomathematics module to boost mathematical thinking, while Kurnia et al. (2022) focused on creating a blended learning ethnomathematics module tailored for university students. Moreover, Muzaki et al. (2022) demonstrated how ethnomathematics-based e-modules could improve metacognitive abilities, especially within 3D geometry topics. Despite these advancements, the integration of ethnomathematics into specific areas, such as transformation geometry, remains underexplored. Additionally, while the concept of self-efficacy is acknowledged as pivotal to academic success and student motivation, there has been limited exploration into its enhancement through ethnomathematics-based modules. Research efforts like those by Turmuzi et al. (2023), Permana (2023), and Anggara (2023) have largely concentrated on cultural relevance, problem-solving skills, or general academic outcomes, rather than explicitly linking ethnomathematics to the development of self-efficacy. This gap becomes particularly critical in transformation geometry, a field that demands strong spatial reasoning and confidence in tackling abstract concepts. To bridge this void, the present study develops an ethnomathematics-based module targeting self-efficacy improvements in transformation geometry, thereby providing fresh insights into an understudied domain within mathematics education. The study also evaluates the validity and practicality of the module to ensure its effectiveness and usability in real classroom settings.

This study addresses the research gap by introducing a novel teaching module that incorporates ethnomathematics to strengthen students' self-efficacy. By focusing on transformation geometry, the research not only contributes to the development of culturally relevant educational resources but also aligns with the goals of the Kurikulum

Merdeka. The findings aim to provide practical solutions for educators and enrich the literature on integrating cultural contexts into mathematics instruction. This paper is organized into several sections: the introduction outlines the background and research gap, the methodology explains the module development process, and the subsequent sections discuss the findings and implications.

METHODS

Design

This study utilizes a development research method, specifically Research and Development (R&D), as defined by Sugiyono (Jawa et al., 2022). Development research aims to produce effective and practical products for educational purposes. The ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) was adopted as the framework for this study. However, this research focuses solely on the validation phase, involving evaluations by expert validators. The primary outcome of this study is an ethnomathematics-based teaching module designed for transformation geometry topics.

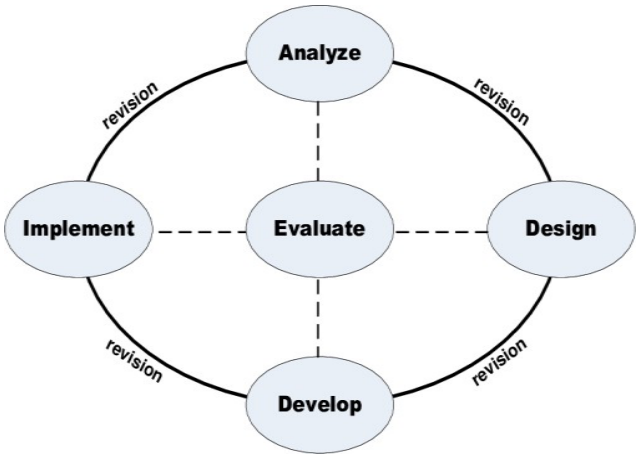

Figure 1. ADDIE Model Development Framework

Participants

The participants of this study were Class XI students from SMA Citra Bakti, as well as experts who validated the teaching module. The experts included a material expert and a media expert, who evaluated the module's content and design validity. Additionally, students and teachers provided responses to measure the module's practicality.

Research Procedure

The study followed the ADDIE development model:

1. Analysis:
    - Conducted a needs analysis to explore students' difficulties and the absence of innovative teaching materials.
    - Analyzed the curriculum (Kurikulum Merdeka) to identify relevant topics, focusing on transformation geometry (translation, reflection, rotation, dilation).

- Selected Ngada culture as an ethnomathematics context for module development.

2. Design:
   - Created a preliminary design of the ethnomathematics-based module, aligning it with Kurikulum Merdeka and emphasizing self-efficacy.
   - The output of this stage was a soft file of the module.
3. Development:
   - Conducted validity testing with material and media experts using assessment instruments.
   - Evaluated the content validity (material relevance) and design validity (visual appeal).
   - Practicality was assessed using response questionnaires filled out by teachers and students.
4. Implementation:
   - The developed product was implemented at SMA Citra Bakti to observe its usage and collect feedback.
5. Evaluation:
   - Revised the module based on expert and user feedback for broader applicability in various educational settings.

Instruments

1. Validation Sheets:
   - Used by material and media experts to evaluate the module's validity, focusing on content and design quality.
2. Questionnaires:
   - Distributed to students and teachers to assess the module's practicality in classroom settings.
3. Data Conversion Formula:
   - Validity and practicality scores were calculated using the formula:

$$p = \frac{\sum xi - min}{maks - min} x\ 100\%$$

   - The results were interpreted using a scale adapted from Arikunto (2010).

Data Analysis

The data collected in this study were analyzed using both quantitative and qualitative approaches. Quantitative analysis was conducted by scoring the responses from validation sheets and questionnaires to determine the module's validity and practicality. A module is categorized as valid or practical if the score falls within the range of 66-79 or higher. Meanwhile, qualitative analysis was employed to interpret expert feedback and suggestions, which were used to refine and improve the module during the development process.

RESULTS AND DISCUSSION

Result

The development of this study resulted in an ethnomathematics-based mathematics teaching module designed to enhance students' self-efficacy in learning transformation geometry. Employing the ADDIE model, the development process was carried out systematically through five stages: Analysis, Design, Development, Implementation, and Evaluation. This module aims to provide students with a culturally relevant and engaging learning experience, addressing challenges in mastering abstract mathematical concepts.

Analysis Stage

The analysis phase is the initial step in this development research, aimed at identifying the need for developing a teaching module. This phase involved three main components: analyzing needs, curriculum, and student characteristics. The needs analysis revealed that mathematics teaching for Grade XI students at SMA Citra Bakti, particularly on transformation geometry, predominantly relied on lecture methods, resulting in teacher-centered instruction and passive student participation. Furthermore, the school faced limitations in teaching resources, including textbooks and learning modules, which were mostly simplified summaries of standard textbooks. Through curriculum analysis, it was found that SMA Citra Bakti implements the *Kurikulum Merdeka*, which prioritizes interactive and student-centered learning approaches. Transformation geometry, comprising topics such as translation, reflection, rotation, and dilation, is one of the essential materials emphasized in this curriculum. Finally, an analysis of student characteristics showed that students generally perceive mathematics as a difficult subject, leading to low motivation and minimal engagement in the learning process. They tended to wait for teacher explanations rather than actively participating, highlighting the need for innovative and engaging teaching materials to support their learning.

Design Stage

The design phase was conducted based on the results of the previous analysis stage. During this phase, the researcher developed a draft of the teaching module, collected references to support the module's development (including materials and images), and prepared evaluation instruments to assess the module's quality. The evaluation instruments included validation sheets for material and design experts to assess the module's validity and questionnaires for teachers and students to measure its practicality. The output of this stage was a preliminary draft of the ethnomathematics-based teaching module, ready for validation and refinement.

Development Stage

The development stage focused on creating the teaching module based on the design phase. The module, titled "Geometri Transformasi," was developed to enhance self-efficacy among Grade XI high school students. The ethnomathematics-based module includes the following components: cover, preface, user guidelines, a brief description of learning activities incorporating ethnomathematics, table of contents, competencies,

basic and indicator achievement competencies, concept maps, learning activities (organized by subtopics on transformation geometry), competency tests, and references.

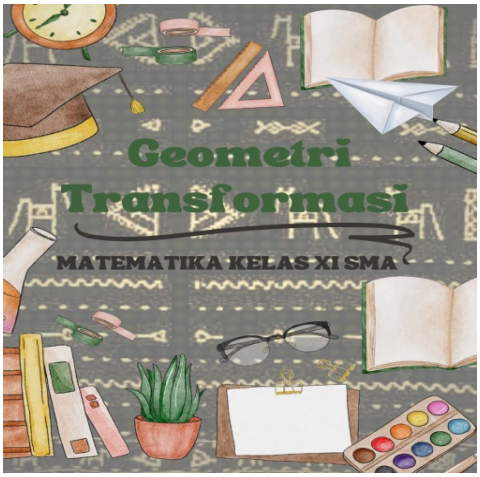

Figure 2. Cover of the Module

After the module development, validation was conducted by material and design experts using pre-designed evaluation instruments. The validation process assessed the module's content quality and design aspects. The validation results are presented in Table 2 below:

Table 2. Validation Analysis Results

No	Expert	Max Score	Achieved Score	Average	Criteria
1	Material Expert	100	89	89	Very Valid
2	Design Expert	100	83	83	Very Valid

Based on the table above, the average score from the two experts is 86, which falls under the "very valid" category. This indicates that the teaching module is suitable for use in mathematics instruction, particularly in transformation geometry.

Implementation Stage

The implementation stage involved testing the mathematics teaching module at SMA Citra Bakti, involving a mathematics teacher and 10 students. The trial was conducted on Thursday, August 8, 2024, and focused on collecting feedback through teacher and student response questionnaires to evaluate the module's practicality. The analysis of the practicality scores is presented in **Table 3** below:

Table 3. Practicality Analysis Results

No	Participant	Max Score	Achieved Score	Average	Criteria
1	Teacher	100	78		
2	Student 1	80	90		
3	Student 2	80	88		
4	Student 3	80	88		
5	Student 4	80	88		
6	Student 5	80	86	85.72	Very Practical
7	Student 6	80	90		
8	Student 7	80	88		
9	Student 8	80	85		
10	Student 9	80	82		
11	Student 10	80	80		

The analysis results indicate that the average score from the teacher and student responses is 85.72, which falls into the "Very Practical" category. This demonstrates that the ethnomathematics-based teaching module is highly practical and ready to be implemented in classroom settings.

Evaluation Stage

The evaluation phase focused on revising the ethnomathematics-based teaching module based on feedback and suggestions from material and design experts. The revisions addressed issues related to the clarity of content, visual layout, and the inclusion of additional examples to enhance students' understanding. After incorporating these revisions, the module underwent a final review to ensure it met the standards of validity and practicality. The finalized module was deemed ready for broader implementation in mathematics classrooms, particularly for transformation geometry topics.

Discussion

This research aimed to create an ethnomathematics-based teaching module designed to enhance students' confidence in learning transformation geometry. The study's results demonstrate that the module satisfies both validity and practicality standards, confirming its effectiveness as a teaching resource. By embedding cultural elements into the learning process, the module helps bridge the gap between abstract mathematical concepts and students' real-life experiences. For example, by relating transformation geometry to culturally significant practices or artifacts, students gain a deeper appreciation for the relevance of mathematics in their everyday lives. These findings are consistent with prior research, such as that by Dwidayati & Suyitno (2019), Kurniawan et al. (2023), and Mendrofa et al. (2024), which highlight the positive impact of integrating cultural elements into mathematics education to foster student engagement and understanding. Additionally, this module supports the goals of the Kurikulum Merdeka, which emphasizes the importance of contextual and culturally responsive teaching in achieving well-rounded education. Ultimately, the success of this module underscores the potential of mathematics as a tool to enhance both intellectual development and cultural appreciation.

Building upon the module's strong theoretical foundation discussed earlier, the validation process further reinforced its quality and effectiveness. The module achieved an average score of 86, categorized as "very valid," underscoring its alignment with the principles of the Kurikulum Merdeka. This alignment is evident in the seamless integration of mathematical concepts with cultural elements that resonate with students' lived experiences, as highlighted in the first paragraph. Experts in the field provided valuable feedback, with material experts commending the depth and accuracy of the content, ensuring that the module effectively supports learning objectives. At the same time, design experts praised the module's visual layout and structural organization, which enhance its functionality and aesthetic appeal. These aspects collectively make the module not only a tool for academic success but also an engaging resource that motivates students to actively participate in learning. This outcome resonates with prior studies, such as those by Supriyadi et al. (2022) and Muzaki et al. (2022), which emphasize that

high-quality, culturally enriched teaching materials can significantly improve student engagement and comprehension. The validation findings, therefore, confirm the module's capacity to bridge the gap between abstract mathematical concepts and meaningful cultural contexts, further supporting its role as a transformative educational tool.

Following the strong validation results, the practicality of the module was further demonstrated through teacher and student feedback, which yielded an average score of 85.72, categorizing it as "very practical." The structured design and integration of ethnomathematics, which were key strengths identified during the validation phase, translated effectively into the classroom setting. Teachers reported that the module streamlined the teaching process by offering clear and culturally relevant examples, making complex topics such as transformation geometry more approachable for students. Specifically, the module's focus on cultural connections helped demystify abstract concepts like translation, reflection, rotation, and dilation, facilitating a smoother teaching and learning experience. Students also expressed heightened interest and confidence in learning mathematics, indicating that the module effectively addressed the previously identified challenges of low engagement and passive participation. This positive shift highlights the module's ability to enhance not only comprehension but also attitudes toward mathematics. These findings align with the research of Turmuzi et al. (2023) and Jamilah et al. (2024), which emphasized that teaching materials enriched with cultural elements can significantly boost student motivation and understanding. Furthermore, the practicality outcomes reinforce the validation findings, showing how the module's thoughtful design translates into real-world application. By bridging theoretical rigor with practical usability, this module presents itself as an innovative resource for improving mathematics education, particularly in fostering active student engagement and simplifying abstract mathematical ideas.

The integration of ethnomathematics in the module has broader implications beyond mathematics learning. By contextualizing mathematical concepts within local culture, the module not only enhances students' cognitive abilities but also fosters a sense of cultural pride and awareness. This is particularly significant in supporting the goals of the Kurikulum Merdeka, which emphasizes holistic education and cultural appreciation.

Implication

This research provides valuable insights into mathematics education by showcasing the potential of culturally responsive teaching materials. The development of an ethnomathematics-based module demonstrated its effectiveness in improving students' self-efficacy and engagement, particularly in mastering transformation geometry. By embedding mathematical concepts within cultural contexts, the module offers students a more meaningful learning experience, helping them connect abstract theories with practical applications in their daily lives. This aligns with the principles of the *Kurikulum Merdeka*, which advocates for a holistic educational approach that integrates cognitive, emotional, and cultural elements. For educators, the module represents a practical resource that simplifies the delivery of complex topics while encouraging active student

participation. Moreover, the study highlights the importance of designing instructional materials that are culturally relevant, not only to enhance comprehension but also to reduce students' anxiety and disinterest in mathematics. On a broader level, this research illustrates how the integration of ethnomathematics and structured module development can transform traditional teaching methods into more engaging, contextually meaningful, and effective practices, paving the way for improved mathematics learning outcomes.

Limitation

However, this study has several limitations. The implementation phase involved only 10 students and one teacher, limiting the generalizability of the findings. Additionally, the module's long-term impact on students' self-efficacy and problem-solving skills remains unexplored. Future research should focus on larger-scale implementations and investigate the module's effects over extended periods to provide more comprehensive insights. Despite these limitations, this study contributes to the growing body of literature on ethnomathematics and offers an innovative approach to addressing challenges in mathematics education. Future studies could also explore the application of this approach in other mathematical topics and grade levels to broaden its impact.

CONCLUSIONS

This study successfully developed an ethnomathematics-based teaching module aimed at enhancing self-efficacy in learning transformation geometry for Grade XI students. The module was validated as "very valid," with an average score of 86, and assessed as "very practical," with an average score of 85.72. These findings demonstrate the module's effectiveness in integrating cultural elements into mathematics education, aligning with the goals of the *Kurikulum Merdeka*. The module not only simplifies the teaching of abstract mathematical concepts but also increases student engagement and confidence. It provides an innovative and practical solution for addressing challenges in mathematics education, offering meaningful learning experiences that connect mathematical theories with cultural contexts. Future research could expand the scope of implementation to diverse educational settings and explore the long-term impact of such modules on students' academic and cultural development.

AUTHOR CONTRIBUTION STATEMENTS

Maria Editha Bela took the lead in designing the study, developing the ethnomathematics-based teaching module, collecting and analyzing data, and preparing the initial draft of the manuscript. Meanwhile, Melkior Wewe played a key role in enhancing the module content, overseeing the validation process with material and design experts, and thoroughly reviewing the manuscript to improve its quality and readability. Both authors worked collaboratively to ensure the research met academic and ethical standards.

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