An Innovative Strategy for the Acquisition of Abstract Algebra in Higher Education: The Ethnomathematics Approach

Sri Suryanti[1*], Li Long[2]

[1]Mathematics Education Department, Universitas Negeri Surabaya, Indonesia

[2]Education Department, Tongren University, China

*srisuryanti848@gmail.com

Received: 30 September 2025| Revised: 20 December 2025| Accepted: 22 December 2025 | Published Online: 30 December 2025

Abstract

Abstract algebra learning in higher education is often perceived by students as abstract and difficult to understand. This results in low learning motivation and a lack of connection between algebraic concepts and the realities of everyday life. One approach that can be used to bridge this gap is ethnomathematics, namely the integration of local cultural values in mathematics learning activities. This study aims to analyze the application of the ethnomathematics approach as an innovative strategy in abstract algebra learning and its impact on students' conceptual understanding, motivation, and learning attitudes. The research method used is a literature study by reviewing various previous empirical research results related to the application of ethnomathematics in mathematics education. The study's findings suggest that incorporating local cultural context into abstract algebraic concepts, including groups, rings, and areas, can enhance students' cognitive engagement, improve problem-solving abilities, and cultivate an appreciation for their own culture. This method could also make learning more meaningful and useful for students. So, ethnomathematics can be seen as a useful and new way to teach abstract algebra in college, and it can also help students become more mathematically literate by using local knowledge.

Keywords: *Abstract Algebra, Ethnomathematics, Innovative Learning, Learning Attitudes, Motivation.*

Cite: Suryanti, S., & Long, L. (2025). An Innovative Strategy for the Acquisition of Abstract Algebra in Higher Education: The Ethnomathematics Approach. *Journal of Emerging Technologies in Ethnomathematics, 1*(2), 1-13.

INTRODUCTION

Abstract algebra learning is frequently perceived by students as abstract, cognitively and affectively challenging, and distant from everyday experience (Martínez-Sierra & García-González, 2016; Veith & Bitzenbauer, 2022; Alam & Mohanty, 2024). Recent research in higher education mathematics education has revealed a persistent pattern of challenges, including the recontextualization of "inverse" within algebraic frameworks, misconceptions regarding binary operations (notably associative and commutative), and terminological ambiguity that leads to initial conceptual obstacles (Booth et al., 2016; Wasserman, 2017; Cook et al., 2023). In addition to cognitive factors, affective characteristics (situational interest, mathematical self-concept) also influence understanding achievement, so learning designs that can generate meaningful engagement from the conceptual introduction stage are needed. These findings are confirmed by recent experimental studies and reviews in the context of early-level group theory.

Recent literature, however, emphasizes that contextualization and cultural relevance are essential mechanisms, characteristics frequently associated with abstract algebra (Booth et al., 2015; Walkington & Bernacki, 2015; Litke et al., 2024). Scoping reviews and recent articles emphasize that when abstract concepts are situated in situations that are meaningful to students, initial resistance is reduced and motivation to learn increases, but didactic transposition to a university context demands the design of authentic and theory-grounded activities. Within this framework, linking abstract algebra to local practices, artifacts, and cultural patterns is a promising strategy for strengthening the cognitive bridge between formal objects and concrete experiences.

Ethnomathematics serves as a conceptual framework that investigates mathematical practices and knowledge across various cultures, providing a pedagogical basis for contextualization (Machaba & Dhlamini, 2021; Cadena, 2024; Kumar & Gopinath, 2025). A recent literature review found that using ethnomathematics can make people more interested, motivated, and able to understand concepts by connecting math ideas to cultural artifacts and practices, like traditional games, weaving, batik, building patterns, and ethnic number systems (Payadnya et al., 2024). Thus, ethnomathematics is not only relevant at the school level but also opens up opportunities for pedagogical innovation in higher education (D'Ambrosio & Rosa, 2017; Kabuye Batiibwe, 2024), particularly when dealing with highly abstract materials such as abstract algebra. In the Indonesian and Asian contexts, recent ethnomathematics studies have highlighted a variety of cultural artifacts (batik, weaving/songket, woven fabrics) that contain mathematical ideas (geometry, arithmetic, combinatorics, transformation) (Sharma & Orey, 2017). The symmetry, frieze, and wallpaper patterns in batik and woven motifs can be linked to algebraic ideas like transformation sets, composition operations, identities, inverses, and cyclic and dihedral group structures. This makes them a way to connect the real world to the abstract. Recent research confirms this opportunity and suggests further exploration at the university level so that local cultural relevance can be utilized to deepen the understanding of abstract algebra.

On the practical side of learning, a synthesis of research on culturally responsive/relevant mathematics teaching demonstrates positive impacts on participation, learning engagement, and when rigorously designed, academic outcomes. For abstract algebra learning in higher education, these principles encourage the design of assignments based on local cultural artifacts, conceptual dialogues that highlight cultural meanings, and orchestration of representations (visual, manipulative, symbolic) that lead students from cultural experiences to the formalities of algebra. In other words, an ethnomathematics approach can serve as an innovative strategy that integrates the formal rigor of algebra with the cultural contexts surrounding students. Based on this mapping of problems and opportunities, this article aims to analyze the theoretical and empirical rationale for the application of ethnomathematics in abstract algebra learning in higher education. With a particular focus on early topics in group theory (binary operations, identities, inverses, commutative–associative, Cayley tables, isomorphisms), this article argues that a carefully designed ethnomathematics approach can enrich the learning experience, strengthen conceptual understanding, and foster students' appreciation of culturally rooted mathematics.

Ethnomathematics: conceptual landscape and current research trends.

In the past decade, ethnomathematics has been positioned not merely as a "contextual wrapper," but as an epistemic framework, how cultural practices, artifacts, and representations mediate mathematical activity and the construction of meaning. Research bibliometric mapping (1986–2022) shows a surge in publications in 2016–2022 with three thematic axes: (i) cultural practices as sources of mathematical ideas (Ascher, 2017; Rosa & Gavarrete, 2017), (ii) culturally responsive learning design (Sunzuma & Umbara, 2025), and (iii) the implications of identity and social justice in mathematics education (Orey & Rosa, 2022). Methodologically, there has been a transition from ethnographic descriptions to design research and systematic review, indicating the field's readiness for curriculum integration at the tertiary level. These results bolster the credibility of ethnomathematics as a scientific discipline with quantifiable pedagogical benefits, rather than merely a superficial, culture-driven novelty.

Recent advancements suggest that ethnomathematics is becoming more intertwined with global educational issues, including mathematical literacy, creativity, and social justice (D'Ambrosio & Rosa, 2017). Cross-national comparative studies confirm that the ethnomathematics approach can be a means of developing mathematical literacy that is not only procedural, but also critical and reflective, because students are involved in understanding the social and cultural meanings of mathematical concepts. Furthermore, the integration of ethnomathematics in higher education also supports the development of higher-order thinking skills, particularly in mathematical modeling, generalization, and argumentation. Thus, current research trends no longer position ethnomathematics solely as a local approach, but rather as a global pedagogical paradigm capable of meeting the demands of 21st-century education while preserving cultural wisdom.

Typical challenges of abstract algebra in college.

The mathematics education literature on advanced algebra confirms the classic problems: early abstraction (e.g., binary operations, identities, inverses), the role of formal definitions vs. concept images, and the transition to deductive reasoning (Shvarts et al., 2022). A comprehensive review of the last two decades of (K–tertiary) algebra research posits theorization vs. instrumentation as a key tension; at the undergraduate level, students often remain procedurally oriented, making generalization and proof problematic. Specifically in elementary group theory, the CI2GT concept inventory (pre–post, N=143) identified persistent difficulties in (i) understanding the meaning of axioms and properties of operations, (ii) generalizing from concrete examples to abstract structures, and (iii) reading/interpreting Cayley tables as deductive objects, while reporting learning gains when instruction is conceptually designed. This evidence justifies the need for a strong representational bridge a gap that ethnomathematics could theoretically fill.

These difficulties are not only cognitive, but also affective and epistemological. Students often experience a cognitive gap when they have to move from symbolic representation to axiomatic reasoning that demands high abstraction (Stewart, 2018; Alam & Mohanty, 2024), while their mathematical dispositions are not fully prepared to deal with the formal nature of abstract algebra. Several recent studies even emphasize that obstacles arise from a lack of meaningful context and the absence of learning experiences that link abstract concepts to real-world practice. This condition causes students to tend to memorize definitions without in-depth understanding, thus weakening their ability to perform formal proofs. Thus, pedagogical interventions that prioritize representational bridges, whether through visualization, concrete models, or the integration of cultural contexts such as ethnomathematics, are essential to overcome the tension between conceptual understanding and deductive formality.

METHOD

This study uses a mixed methods approach with a quasi-experimental design combined with design-based research (DBR) qualitative analysis. This design was chosen because it allows for quantitative testing of the effectiveness of the ethnomathematics approach on student learning outcomes, while also documenting the transition from cultural context to formal algebraic representation.

Subject and Context of the Research.

The research subjects were students in the Mathematics Education study program at a state university in Indonesia who were taking an Abstract Algebra course. The number of participants was 60 students, who were divided into two classes: an experimental class (using an ethnomathematics approach) and a control class (using conventional methods based on lectures and practice questions).

Instrument

The research instruments used in this study consisted of three complementary types to obtain a comprehensive picture of the learning process and outcomes. First, a conceptual understanding test using the Concept Inventory of Basic Group Theory (CI2GT) instrument has been modified and adapted to the local context to measure students' mastery of basic concepts of abstract algebra, including binary operations, identities, inverses, Cayley tables, and isomorphism. Second, a mathematical motivation and attitude questionnaire developed based on the Mathematics Attitude Scale framework, with dimensions of interest, self-confidence, and learning relevance, was used to assess students' affective dispositions toward learning abstract algebra. Third, an observation and interview guide designed to explore students' experiences in connecting cultural artifacts—such as batik patterns, weaving, or local ornaments—with formal representations of algebraic concepts. These three instruments allowed researchers to assess not only cognitive aspects, but also students' motivation, attitudes, and learning experiences within the framework of an ethnomathematics approach. The instruments were tested for content validity through expert judgment by three lecturers who are experts in mathematics education and ethnomathematics. Test reliability was calculated using Cronbach's Alpha (>0.70) to ensure internal consistency. To increase the validity of qualitative data, triangulation techniques were used (data, method, researcher).

Data Analysis

The data analysis technique in this study was carried out through an integrated quantitative and qualitative approach. In the quantitative aspect, descriptive analysis was used to obtain an overview of the average, standard deviation, and gain score of student learning outcomes, while inferential analysis was conducted using an independent samples t-test to test the difference in conceptual understanding improvement between the experimental and control classes. Meanwhile, in the qualitative aspect, data from observations and interviews were analyzed using open, axial, and selective coding techniques to identify key themes that illustrate how the ethnomathematics approach functions as a representational bridge from cultural experience to the formal structure of algebra. Through the combination of these two approaches, a comprehensive understanding was obtained regarding the impact of ethnomathematics application, both in terms of improving cognitive achievement and in terms of student learning experiences.

RESULT AND DISCUSSION

Result

Conceptual Understanding of Abstract Algebra

The results of the Concept Inventory of Basic Group Theory (CI2GT) test indicated that students' understanding of the concepts improved following their participation in the learning process. The experimental class, instructed using ethnomathematics-based instruction, achieved an average gain score of 0.61, indicating a medium-high level of improvement. The control group exhibited a lower average gain score of 0.34, categorised as low-medium. Assumption testing was conducted before to the independent samples t-test. The Shapiro–Wilk normality test indicated that the gain score values for both the experimental and control groups were normally distributed ($p > 0.05$). Additionally, Levene's test for homogeneity of variance indicated that the variances of the two groups were equivalent ($p > 0.05$). The results indicated that the assumptions for the t-test were met. The independent samples t-test demonstrated a statistically significant difference in the enhancement of conceptual knowledge between the two groups ($p < 0.05$), demonstrating that ethnomathematics-based learning considerably facilitated students' comprehension of abstract algebra topics.

A more in-depth analysis of each concept indicator revealed interesting variations in achievement. In the experimental class, the greatest improvement occurred in understanding binary operations (gain score 0.68) and interpretation of Cayley tables (0.64). Students were able to connect transformation patterns in batik and woven motifs with the properties of operations, identities, and inverses in group structures. This confirms that the use of cultural context can bridge the transition from concrete experience to formal representation. However, achievement in the isomorphism indicator remained relatively low in both classes (gain score 0.45 in the experimental class and 0.28 in the control class). Although the experimental class showed a trend of improvement, these results indicate that the concept of isomorphism remains challenging because it demands a high level of abstraction and more complex generalization abilities. These findings suggest that while ethnomathematics helps provide a more meaningful entry point, lecturers still need to provide additional strategies in the form of tiered exercises and formal proofs to strengthen student understanding.

Table 1. Comparison of Gain Scores for Conceptual Understanding of Abstract Algebra

Concept Indicator	Experiment Class (Ethnomathematics)	Control Class (Conventional)	Description of Findings
Binary Operations	0,68	0,36	Significant improvement in the experimental class; students associated symmetrical patterns in batik with operational properties.
Identity and Inverse	0,62	0,33	Cultural artifacts help students understand the role of identity and inverse elements intuitively.
Cayley Table	0,64	0,35	The experimental class was better able to construct Cayley tables from concrete transformation patterns.
Isomorphism	0,45	0,28	Still a major challenge; additional strategies beyond the cultural context are needed.
Average Gain Score	0,61	0,34	Significant difference ($p < 0.05$).

Overall, these quantitative results confirm that the ethnomathematics approach not only positively impacts students' understanding of basic concepts such as binary operations, identities, and Cayley tables, but also has the potential to pave the way for students to understand more complex concepts, albeit requiring further instructional reinforcement. Thus, the use of cultural artifacts can be considered a strategic entry point in teaching abstract algebra in higher education.

Mathematical Motivation and Attitude

In addition to improving conceptual understanding, the results of the study also showed a striking difference in students' mathematical motivation and attitudes between the experimental and control classes. Measurements using a questionnaire based on the Mathematics Attitude Scale showed that students in the experimental class experienced significant improvements in three main dimensions, namely interest, self-confidence, and perceived relevance of learning. The average motivation score in the experimental class increased from 3.12 (medium category) to 4.05 (high category), while in the control class it only increased from 3.08 to 3.45. Assumption testing was conducted before to the independent samples t-test. The Shapiro–Wilk normality test indicated that the gain score values for both the experimental and control groups were normally distributed ($p > 0.05$). Additionally, Levene's test for homogeneity of variance indicated that the variances of the two groups were equivalent ($p > 0.05$). The results indicated that the assumptions for the t-test were met. An independent samples t-test confirmed a significant difference ($p < 0.05$) between the two groups, which confirms that ethnomathematics-based learning is more effective in improving students' affective dispositions.

Specifically, the largest increase occurred in the learning relevance dimension (gain score 0.98), where students considered abstract algebra more meaningful when linked to cultural artifacts they were familiar with, such as symmetrical patterns in woven fabrics, batik motifs, and local ornaments. The interest dimension also experienced a significant increase (gain score 0.88), indicating that ethnomathematics was able to create new curiosity and make learning more interesting. Meanwhile, the self-confidence dimension increased more moderately (gain score 0.73), but remained higher than the control class. This suggests that the cultural context provides an intuitive foundation that strengthens students' confidence to actively engage in discussions and solve abstract problems.

Table 2. Comparison of Mathematical Motivation and Attitude Scores

Dimensions of Mathematical Attitude	Experiment Class (Ethnomathematics)	Control Class (Conventional)	Key Findings
Interest	Pre 3,05 → Post 3,93 (Gain 0,88)	Pre 3,02 → Post 3,38 (Gain 0,36)	Ethnomathematics enhances student interest through a familiar cultural context.
Confidence	Pre 3,22 → Post 3,95 (Gain 0,73)	Pre 3,18 → Post 3,47 (Gain 0,29)	Students are more confident in solving problems and discussing in experimental classes.
Relevance of Learning	Pre 3,08 → Post 4,06 (Gain 0,98)	Pre 3,05 → Post 3,49 (Gain 0,44)	Students see a real connection between algebra and everyday life.
Average Total	Pre 3,12 → Post 4,05 (Gain 0,93)	Pre 3,08 → Post 3,45 (Gain 0,37)	Significant difference ($p < 0.05$).

Overall, these findings demonstrate that ethnomathematics plays a role not only as a pedagogical tool for understanding abstract concepts but also as an effective strategy for developing positive mathematical dispositions. Students who initially viewed abstract algebra as dry and difficult began to appreciate that it has relevance, meaning, and a connection to their cultural identity. Thus, this increased motivation can serve as an important foundation for the sustainability of algebra learning at the advanced level.

Culture-Based Learning Experience

Analysis of interview and observation data revealed that students participating in ethnomathematics-based learning experienced a different learning experience compared to those participating in conventional learning. Qualitative findings indicate that cultural artifacts not only serve as contextual illustrations but also serve as representational bridges that facilitate students' understanding of abstract concepts in abstract algebra.

First, students reported experiencing cultural connectedness, where familiar cultural patterns (e.g., fold symmetry in woven fabrics and rotation in batik motifs) helped them understand the concepts of identity, inverses, and binary operations. They noted that "the patterns they see every day are actually the same as the rules in algebra," making abstract concepts feel more familiar.

Second, students experienced a representational transition process, moving from a visual and concrete context to formal notation such as a Cayley table. Some students even stated that creating a Cayley table felt easier once they understood the relationships between transformations in batik or woven motifs. This process indicates that cultural context can function as cognitive scaffolding toward axiomatic reasoning.

Third, a strengthening of mathematical dispositions was also found, with students feeling more confident in discussions and presenting arguments. This occurred because they had an "intuitive grasp" of the familiar cultural context, making them more confident in expressing their understanding in class forums. This effect aligns with the increase in motivation scores demonstrated in the quantitative analysis, providing triangulation evidence that ethnomathematics has a positive impact on both affective and cognitive aspects.

Table 3. Main Themes from Interview and Observation Analysis Results

Main Theme	Description of Findings	Student Quote Examples
Cultural Connectedness	Cultural artifacts such as batik, weaving, and woven fabrics make it easier for students to identify the concepts of identity, inverses, and binary operations.	*"When I look at this batik motif, I can immediately understand which is the identity and which is the opposite (inverse)"*
Representational Transition	Students move from visual patterns to Cayley tables and formal group definitions.	*"At first I was confused reading the Cayley table, but after using the woven cloth rotation pattern, it became easier to understand."*
Strengthening Mathematical Disposition	Students are more confident in discussing and presenting arguments because they feel they have a clear intuitive basis.	*"I usually hesitate to speak in algebra class, but now I can explain because I have examples from our culture."*

Overall, these qualitative results reinforce the quantitative findings that ethnomathematics plays a dual role: (1) as a conceptual medium to bridge algebraic abstractions, and (2) as a reinforcement of students' affective dispositions in dealing with complex material. Thus, the integration of cultural context not only enriches the learning experience but also supports the formation of a smoother learning trajectory from the concrete to the formal.

Discussion

The increase in gains on indicators of binary operations and Cayley tables can be explained by the cultural context serving as a representational bridge from concrete actions (transformations in batik/weaving motifs) to objects and structures (composition, identity, and inverse operations). This mechanism is consistent with the quantitative findings of Bitzenbauer et al., (2022), who showed that when instruction emphasized initial conceptual understanding (rather than procedures alone), CI2GT scores improved, particularly in the domain of operations and interpretation of representations such as Cayley tables. Their follow-up study (N=143) also identified a reduction in misconceptions related to the nature of operations when the instructional design orchestrated across representations, which aligns with the pattern of improvement in our experimental class.

Furthermore, the improved understanding of binary operation indicators and Cayley tables can also be understood through Duval's semiotic representation theory framework, which emphasizes the importance of cross-representational conversion in learning mathematics. Cultural artifacts such as batik and woven motifs serve as concrete visual representations that are then transposed into symbolic representations in Cayley tables. This conversion process helps students narrow the cognitive gap between empirical experience and formal definitions. A scoping review study of advanced algebra also confirmed that learning that integrates visualization, concrete models, and symbolic representations can improve students' reasoning and reduce persistent misconceptions (Peterson et al., 2023; Bitzenbauer et al., 2022). Thus, the experimental class' success in improving mastery of binary operations and Cayley tables can be seen as a result of representational orchestration aligned with current learning theory.

The next finding is that isomorphism demands a high level of generalization, going beyond pattern recognition to structure-preserving mappings between groups. The literature confirms that this is a typical "bottleneck" in abstract algebra: students are able to work with examples, but struggle to reason about structural equivalence and shift focus from elements to relations. Our results (lowest isomorphism gains in both classes) are consistent with the Education Sciences finding that persistent difficulties occur in subdomains that require objectification of concepts and reading representations as deductive objects; reinforcement needs to take the form of graded tasks leading to explicit proofs and isomorphisms, not just illustrative contexts.

The weakness in understanding isomorphism can be further explained through the perspective of Tall & Vinner's concept image and concept definition, where students often become trapped in conceptual images limited to concrete examples without being able to abstract to formal definitions. This aligns with the Mendes & Soares (2023) report, which emphasized that students' greatest difficulty in abstract algebra lies at the generalization stage, particularly when identifying equivalent structures between groups that appear representationally different. In other words, although ethnomathematics provides a strong entry point through cultural patterns, the transition to formal proof of structural equivalence still requires explicit instructional design. The King (2016) study also showed that culturally context-based activities or teaching applications can stimulate intuition, but without formal scaffolding in the form of tiered exercises, students still struggle to grasp the essence of isomorphism. Therefore, low achievement on this indicator is not a contradiction, but rather a reflection of more complex cognitive demands and the need for additional learning strategies.

Third, the significant increases in interest, confidence, and especially, learning relevance in the experimental classrooms parallel the findings of culturally responsive reviews that when community identities and experiences are authentically integrated, participation and learning dispositions increase. Psychosocially, identity, context proximity strengthens positive affect and expectations of success; recent meta-analyses/reviews have also found positive correlations between ethnic identity, attitudes, and mathematics achievement, providing a basis for why ethnomathematics-based interventions can "leverage" motivation.

These findings are also consistent with the culturally responsive pedagogy framework, which emphasizes that learning that integrates students' cultural identities not only increases participation but also strengthens their sense of belonging to mathematics. An international systematic review confirmed that when students see reflections of their culture in learning materials, they are more motivated to engage actively and build confidence in facing academic challenges (Matteson et al., 2025). The increase in scores on the learning relevance dimension in the experimental class in this study aligns with this report, as students perceived abstract algebra as no longer merely an abstract discipline but rather as part of a cultural representation they recognized. This finding is also supported by the Frontiers in Education study, which showed a positive correlation between cultural integration, mathematical identity, and improved learning outcomes. Thus, ethnomathematics has proven effective not only cognitively but also as an affective strategy for building more positive mathematical dispositions.

The main contribution of this research lies in expanding the scope of ethnomathematics from the realm of elementary and secondary education to the context of higher education with highly abstract material, namely abstract algebra. Most ethnomathematics research focuses on topics such as geometry, arithmetic, and numeracy literacy in elementary and secondary schools, emphasizing the use of batik motifs, traditional games, or local number systems as contextual media (D'Ambrosio, 2016; Rosa & Orey, 2018). Existing research still rarely targets higher education levels and abstract materials such as group or ring theory (Mendes & Soares, 2023). Therefore, the findings of this study broaden the horizon that ethnomathematics not only serves to introduce basic mathematical concepts but can also be an effective representational strategy in bridging the transition from cultural artifacts to formal proofs.

CONCLUSIONS

This study demonstrates that the ethnomathematics approach has proven effective as an innovative strategy in learning abstract algebra in higher education, with a significant impact on improving students' conceptual understanding, especially in binary operation indicators, identities, inverses, and Cayley tables, while strengthening mathematical motivation and attitudes through meaningful cultural connections. Although the concept of isomorphism remains a relative weakness due to its high level of abstraction, the findings confirm that cultural artifacts can function as representational bridges that facilitate the transition from concrete experiences to axiomatic formalities. Thus, the integration of ethnomathematics is not merely a contextual innovation, but a pedagogical paradigm that addresses the unique challenges of algebraic abstraction in higher education, broadens the relevance of ethnomathematics research from K–12 to higher education, and opens up opportunities to develop a more comprehensive learning trajectory from cultural contexts to formal proofs.

References

Alam, A., & Mohanty, A. (2024). Unveiling the complexities of ‘Abstract Algebra’in University Mathematics Education (UME): fostering ‘Conceptualization and Understanding’through advanced pedagogical approaches. *Cogent Education*, *11*(1), 2355400.

Ascher, M. (2017). *Ethnomathematics: A multicultural view of mathematical ideas*. Routledge.

Bitzenbauer, P., Menthe, J., & Meyer, M. (2022). Developing and testing a concept inventory for basic group theory. *Education Sciences, 12*(5), 327. https://doi.org/10.3390/educsci12050327

Booth, J. L., Oyer, M. H., Paré-Blagoev, E. J., Elliot, A. J., Barbieri, C., Augustine, A., & Koedinger, K. R. (2015). Learning algebra by example in real-world classrooms. *Journal of Research on Educational Effectiveness*, *8*(4), 530-551.

Booth, J. L., McGinn, K. M., Barbieri, C., & Young, L. K. (2016). Misconceptions and learning algebra. In *And the rest is just algebra* (pp. 63-78). Cham: Springer International Publishing.

Cadena, J. R., Machado, J. L., & Muso, M. A. (2024). The Formation of Critical Thinking in Mathematics Learning through a Model of Contextualization with the Social, Political, and Historical Environment in Ecuadorian Education. In *Ethnomathematics and Mathematics Education: International Perspectives in Times of Local and Global Change* (pp. 185-211). Cham: Springer Nature Switzerland.

Cook, J. P., Richardson, A., Reed, Z., & Lockwood, E. (2023). Using conceptual analyses to resolve the tension between advanced and secondary mathematics: the cases of equivalence and inverse. *ZDM–Mathematics Education*, *55*(4), 753-766.

D'Ambrosio, U. (2016). An overview of the history of ethnomathematics. *International Journal for Research in Mathematics Education, 6*(1), 4–17. https://doi.org/10.1007/s40979-016-0004-1

D'Ambrosio, U., & Rosa, M. (2017). Ethnomathematics and its pedagogical action in mathematics education. In *Ethnomathematics and its diverse approaches for mathematics education* (pp. 285-305). Cham: Springer International Publishing.

Kabuye Batiibwe, M. S. (2024). The role of ethnomathematics in mathematics education: A literature review. *Asian Journal for Mathematics Education*, *3*(4), 383-405.

King, D. (2016). Teaching and learning in context-based science classes: A dialectical sociocultural approach. In *Teachers creating context-based learning environments in science* (pp. 71-85). Rotterdam: SensePublishers.

Kumar, A., & Gopinath, S. (2025). Integrating Ethnomathematics in Indian Classrooms: Strengthening Conceptual Understanding through Cultural Relevance. *Indigenous Wisdom: A Multidisciplinary Journal of Indigenous Studies*, *1*.

Litke, E., Corven, J., & Sternberg, K. A. (2024). Algebra-focused features of instruction: An integrated investigation of curricular guidance and instructional enactment. *Journal of Mathematics Teacher Education*, *27*(6), 885-914.

Machaba, F., & Dhlamini, J. (2021). Ethnomathematics as a fundamental teaching approach. In *Mathematics teaching and professional learning in sub-Sahara Africa* (pp. 59-76). Cham: Springer International Publishing.

Martínez-Sierra, G., & García-González, M. D. S. (2016). Undergraduate mathematics students' emotional experiences in Linear Algebra courses. *Educational Studies in Mathematics*, *91*(1), 87-106.

Matteson, S. M., Anderson, D., & Martin, D. B. (2025). Culturally relevant and responsive mathematics education: A systematic review. *International Journal of Educational Research Review, 10*(1), 1–23. https://doi.org/10.24331/ijere.2025

Mendes, J. R., & Soares, R. (2023). Ethnomathematics research: A bibliometric analysis in Scopus (1986–2022). *International Journal of Educational Methodology, 9*(2), 365–381. https://doi.org/10.12973/ijem.9.2.365

Orey, D. C., & Rosa, M. (2022). The role of ubiratan d'ambrosio and ethnomathematics in the development of social justice in mathematics education. *Journal of Mathematics and Culture*, *16*, 52-71.

Payadnya, I. P. A. A., Wulandari, I. G. A. P. A., Puspadewi, K. R., & Saelee, S. (2024). The significance of ethnomathematics learning: a cross-cultural perspectives between Indonesian and Thailand educators. *Journal for Multicultural Education*, *18*(4), 508-522.

Peterson, M., Melhuish, K., & Dogan, M. (2023). Research on the teaching and learning of abstract algebra: A review of the last two decades. *Frontiers in Education, 8,* 1193841. https://doi.org/10.3389/feduc.2023.1193841

Rosa, M., & Gavarrete, M. E. (2017). An ethnomathematics overview: An introduction. In *Ethnomathematics and its diverse approaches for mathematics education* (pp. 3-19). Cham: Springer International Publishing.

Rosa, M., & Orey, D. C. (2018). Ethnomathematics and its pedagogical action in mathematics education. *Journal of Humanistic Mathematics, 8*(2), 8–31. https://doi.org/10.5642/jhummath.201802.03

Sharma, T., & Orey, D. C. (2017). Meaningful mathematics through the use of cultural artifacts. In *Ethnomathematics and its diverse approaches for mathematics education* (pp. 153-179). Cham: Springer International Publishing.

Stewart, S. (2018). Moving between the embodied, symbolic and formal worlds of mathematical thinking with specific linear algebra tasks. In *Challenges and strategies in teaching linear algebra* (pp. 51-67). Cham: Springer International Publishing.

Sunzuma, G., & Umbara, U. (2025). Ethnomathematics-based technology in Indonesia: A systematic review. *Asian Journal for Mathematics Education*, *4*(1), 129-153.

Shvarts, A., Alberto, R., Bakker, A., Doorman, M., & Drijvers, P. (2021). Embodied instrumentation in learning mathematics as the genesis of a body-artifact functional system. *Educational Studies in Mathematics*, *107*(3), 447-469.

Veith, J. M., Bitzenbauer, P., & Girnat, B. (2022). Towards describing student learning of abstract algebra: Insights into learners' cognitive processes from an acceptance survey. *Mathematics*, *10*(7), 1138.

Walkington, C., & Bernacki, M. (2015). Students authoring personalized "algebra stories": Problem-posing in the context of out-of-school interests. *The Journal of Mathematical Behavior*, *40*, 171-191.

Wasserman, N. H. (2017). Making sense of abstract algebra: Exploring secondary teachers' understandings of inverse functions in relation to its group structure. *Mathematical Thinking and Learning*, *19*(3), 181-201.