

The Role of Ethnomathematics and the Contextual Teaching and Learning Approach in Managing Students' Cognitive Load

Ade Susanti^{1*}, Kamid², Nizlel Huda³

^{1,2,3} Universitas Jambi, Jambi and Postcode 36133, Indonesia

Corresponding Author.

*Email: susantiade050@gmail.com

Abstract: *Conventional mathematics instruction often neglects students' local cultural contexts, which can increase extraneous cognitive load and hinder conceptual understanding. This study explores the integration of ethnomathematics within the Contextual Teaching and Learning (CTL) approach as a strategy to optimize students' cognitive load based on Cognitive Load Theory (CLT). Using a systematic literature review approach, this study analyzes 47 articles published between 2015 and 2024 in journals indexed by Scopus and Sinta, following the PRISMA protocol. The findings indicate that ethnomathematics-based CTL instruction is effective in reducing extraneous load and enhancing germane load by activating cognitive schemas that are aligned with students' cultural experiences. The key strategies identified include: (1) the construction of learning contexts based on local cultural artifacts, which reduce intrinsic load through conceptual familiarity; (2) graduated scaffolding using ethnomathematical practices to minimize extraneous load; and (3) modeling grounded in local wisdom to optimize germane load. The novelty of this study lies in its systematic integrative framework that connects principles of ethnomathematics, CTL components, and cognitive load management, which has not been comprehensively documented in prior literature. These findings offer practical implications for the design of culturally responsive and cognitively efficient mathematics instruction, particularly within the culturally diverse context of Indonesian education. Further research is recommended to empirically validate the proposed framework through experimental studies and to develop context-specific instruments for measuring cognitive load.*

Keywords: *Ethnomathematics; Contextual Teaching and Learning (CTL); Cognitive Load Theory (CLT); Cognitive Load; Mathematics Learning*

© 2026 International Conference on Multidisciplinary Engagement. All rights reserved.

1. INTRODUCTION

Mathematics education in Indonesia faces complex challenges related to students' low achievement in international mathematical literacy. Data from the Programme for International Student Assessment (PISA) 2022 indicate that Indonesian students' mathematics scores rank 67th out of 81 countries, with an average score of 366, far below the Organisation for Economic Co-operation and Development (OECD) average of 472 points (O.E.C.D., 2023). More critically, 68% of Indonesian students only reach Level 1 or below in mathematical proficiency, indicating fundamental difficulties in understanding and applying basic mathematical concepts. This phenomenon highlights the urgency of transforming pedagogical approaches to be more effective and contextual.

One of the root causes of low mathematical understanding is the tendency of instructional approaches to be decontextualized and to neglect students' socio-cultural realities (D'Ambrosio and Rosa, 2017). Conventional mathematics instruction often presents mathematics as a universal system of knowledge detached from students' lived experiences, creating cognitive dissonance between formal mathematical knowledge and the cognitive schemas formed through their cultural interactions (Rosa & Orey, 2021). This condition has the potential to increase unnecessary extraneous cognitive load, diverting limited cognitive resources away from essential conceptual understanding processes.

Cognitive Load Theory (CLT), developed by Sweller (1988), provides a powerful theoretical framework for understanding instructional effectiveness. CLT explains that human working memory has a limited capacity for processing new information; therefore, instructional design must optimize three types of cognitive load: intrinsic load (the inherent complexity of the material), extraneous load (the load imposed by poor instructional

design), and germane load (the productive load devoted to schema construction) (Sweller et al., 2019b). In the context of mathematics learning, managing cognitive load becomes crucial given the inherently abstract and cognitively demanding nature of mathematics. CLT has been widely supported by research as an instructional design framework that enhances learning effectiveness through the management of cognitive load (Paas & Renkl, 2003; Sweller et al., 2011).

Contextual Teaching and Learning (CTL) offers a learning paradigm that emphasizes connections between academic content and students' real-life contexts. Johnson (2002) defines CTL as a learning system that links academic content with students' everyday life contexts to construct meaning. The seven core components of CTL constructivism, inquiry, questioning, learning community, modeling, reflection, and authentic assessment are designed to activate and integrate students' prior knowledge with new information (Sears, 2003). Empirical research shows that CTL significantly improves conceptual understanding in mathematics compared to conventional instruction (Chotijah et al., 2019).

Ethnomathematics, as a research program that explores the relationships among mathematics, culture, and society, provides authentic and meaningful contextual resources for students (D'Ambrosio, 1985; Rosa & Orey, 2016). It recognizes that each cultural group develops unique ways of counting, measuring, designing, playing, and explaining natural phenomena, which implicitly contain mathematical concepts (Bishop, 1988). In the Indonesian context, with more than 300 ethnic groups and rich local wisdom, ethnomathematics offers learning contexts that are both culturally relevant and cognitively accessible. Several meta-analyses and recent studies indicate that the integration of ethnomathematics especially when combined with active learning models such as Problem-Based Learning (PBL) or STEM-Project-Based Learning (STEM-PjBL) consistently enhances learning motivation, mathematical reasoning abilities, and student engagement in solving authentic, real-life problems (Hartoyo et al., 2025).

The convergence of CTL, ethnomathematics, and CLT opens innovative opportunities for designing mathematics instruction that is both cognitively optimal and culturally relevant. When ethnomathematical practices are integrated within a CTL framework, students can access cognitive schemas formed through their cultural experiences, which theoretically reduces intrinsic load through contextual familiarity and lowers extraneous load by minimizing cognitive dissonance (Widada et al., 2018). Simultaneously, meaningful contexts can enhance germane load by facilitating deeper elaboration and organization of cognitive schemas.

Although research on CTL and ethnomathematics has developed independently, a significant gap still exists in the literature regarding how their systematic integration can optimize cognitive load management in mathematics learning. Systematic reviews indicate that, although dozens of ethnomathematics studies have been published, most are descriptive or implementation-oriented; studies that explicitly analyze cognitive mechanisms (e.g., changes in cognitive load, working memory processes) remain relatively limited (Rosa & Orey, 2016b; Roesdiana & Juandi, 2024). Similarly, while CTL has been widely studied in educational literature including its principles, applications, and impacts on learning outcomes most studies do not deeply explore internal cognitive processes or the dynamics of cognitive load experienced by students during learning. Within the CLT theoretical framework, intrinsic and extraneous cognitive loads play a critical role in learning effectiveness (Paas & Renkl, 2003; Sweller et al., 2011). This gap indicates the need for a more comprehensive theoretical and empirical synthesis.

Previous studies have tended to explore ethnomathematics and CTL in a partial or isolated manner. Khasanah et al. (2021) examined CTL-based mathematics learning without emphasizing the cultural dimension, while findings from systematic reviews indicate that research has focused more on cultural content and material validity rather than cognitive processes (Arvianto et al., 2025; Asnawati & Hasanah, 2025; B. A. Khasanah, 2023). However, these studies have not deeply analyzed the cognitive mechanisms underlying the effectiveness of these approaches.

The urgency of this research is further reinforced by global trends toward culturally responsive mathematics education and evidence-based instructional design. The National Council of Teachers of Mathematics (NCTM, 2020), in *Catalyzing Change in Early Childhood and Elementary Mathematics*, emphasizes the importance of "mathematizing cultural practices" to make mathematics more accessible and meaningful. Meanwhile, the European Association for Research on Learning and Instruction (EARLI), in its 2023 roadmap, identifies "cognitive load management in culturally diverse classrooms" as a key research priority in education (E.A.R.L.I., 2023). The convergence of these pedagogical and cognitive imperatives calls for a framework that integrates both perspectives.

The *Kurikulum Merdeka* promoted by the Indonesian Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) encourages flexibility in instructional design and adaptation to local contexts to make learning more relevant and meaningful (Virijai et al., 2025). The ministry also emphasizes the importance of fostering understanding and appreciation of national culture from an early age, as well as preserving culture through education, which can serve as a policy foundation for integrating cultural elements into subjects, including mathematics (Swastiastu et al., 2025). Empirical studies show that integrating local cultural elements into mathematics learning can enhance students' conceptual understanding and motivation, while connecting mathematics to real-life contexts (Hayati et al., 2024). However, implementation in practice remains limited due to constraints in instructional materials and teacher training.

The novelty of this study lies in the systematic integration of three theoretical frameworks ethnomathematics, Contextual Teaching and Learning (CTL), and Cognitive Load Theory (CLT) within a coherent analysis using a systematic literature review approach. This study is among the first to explicitly connect these three perspectives to explain how ethnomathematical practices can be operationalized both pedagogically and cognitively. Its main contribution is the development of a taxonomy of instructional strategies that links specific ethnomathematical practices with CTL components and the types of cognitive load they optimize. In addition, the synthesis of empirical evidence from diverse contexts enables more robust generalization of findings. Unlike previous studies that tend to separate cultural and cognitive dimensions, this study positions CTL as a pedagogical bridge between the two. By employing the PRISMA protocol, this review ensures transparency, replicability, and methodological rigor. The resulting framework not only synthesizes existing knowledge but also identifies patterns, tensions, and research gaps, while providing prescriptive guidance for practitioners in designing culturally grounded and cognitively efficient instruction.

Specifically, this study aims to: (1) identify and analyze how ethnomathematics-based CTL strategies can optimize the management of intrinsic and extraneous cognitive load in mathematics learning; (2) map the cognitive mechanisms underlying the effectiveness of ethnomathematics–CTL integration; (3) develop a systematic and evidence-based instructional design framework; and (4) identify research gaps and directions for future studies. Through these objectives, this research is expected to contribute to both theoretical advancement and practical application in the domain of mathematics education that is inclusive, effective, and culturally responsive.

2. METHOD

This study was conducted using a Systematic Literature Review approach with the PRISMA protocol to ensure transparency and replicability. Articles were searched in the Scopus, Web of Science, ERIC, Google Scholar, and Garuda Portal databases using Boolean operator combinations of keywords related to ethnomathematics, Contextual Teaching and Learning (CTL), cognitive load, and mathematics education within the 2015–2024 period. From 1,247 identified articles, a stepwise screening process resulted in 47 articles that met the inclusion criteria. The analysis was carried out using thematic analysis with categories based on Cognitive Load Theory (intrinsic, extraneous, germane), CTL components, and ethnomathematical dimensions.

3. RESULTS AND DISCUSSION

Ethnomathematics-Based CTL Strategies and Intrinsic Load

The literature analysis indicates that ethnomathematics-based Contextual Teaching and Learning (CTL) consistently contributes to the reduction of intrinsic cognitive load through the activation of students' existing cognitive schemas. According to Cognitive Load Theory (Sweller et al., 2011), linking instructional material to prior knowledge enables more effective management of intrinsic element complexity. The integration of cultural contexts in ethnomathematics functions as an advance organizer (Ausubel, 1968), bridging abstract mathematical concepts with students' cultural experiences. Thus, ethnomathematics-based CTL not only enhances meaningful learning (Johnson, 2002; D'Ambrosio, 2001), but also creates more optimal cognitive conditions for conceptual understanding in mathematics.

A study by Rahmawati et al. (2025) shows that the use of the traditional congklak game within an ethnomathematics approach can improve students' understanding of mathematical concepts while strengthening motivation and cultural context. Moreover, congklak has proven effective as a learning medium for introducing and reinforcing basic arithmetic operations (addition and subtraction) as well as number patterns. The study reports that integrating congklak makes the material more contextual, easier to understand, and more engaging for students. Think-aloud protocol analysis reveals that students' familiarity with the game facilitates the chunking of mathematical information into meaningful units. According to Cognitive Load Theory, schema formation through

chunking directly reduces the number of elements that must be processed simultaneously in working memory, thereby lowering intrinsic cognitive load (Sweller et al., 2011).

Another finding from Waralangi et al. (2025) reveals that the carvings of traditional Asei houses in Papua contain various school-level mathematical concepts, particularly in geometry and transformations. These include plane shapes, reflection symmetry, translation, and rotation, which are visually manifested in carving patterns. These findings confirm that local cultural artifacts can be utilized as contextual learning resources that bridge abstract mathematical concepts with students’ cultural experiences, while also supporting contextual and ethnomathematics-based learning approaches.

Ethnomathematics-Based CTL Strategies and Extraneous Load

According to Cognitive Load Theory, extraneous load arises from instructional designs that are not aligned with learners’ cognitive structures (Sweller et al., 2011). The integration of cultural contexts within the CTL approach enables the presentation of mathematical concepts in a more natural and meaningful way, thereby minimizing the need for additional, irrelevant processing (Johnson, 2002; D’Ambrosio, 2001). Thus, ethnomathematics-based CTL creates a more cognitively efficient learning environment by reducing extraneous cognitive load and directing students’ mental resources toward conceptual understanding. Several meta-analyses in ethnomathematics show that culturally grounded approaches have a strong effect on mathematics learning outcomes and students’ thinking abilities (Calista et al., 2023; Turmuzi, 2022). Other meta-analyses in the domain of cognitive load generally indicate that well-designed instruction can significantly reduce cognitive load and improve learning retention (e.g., cueing in multimedia learning).

First, the elimination of cognitive dissonance between mathematical knowledge and lived experience. A study by Arisetyawan et al., (2014) shows that learning volume concepts through realistic contexts such as rice storage in traditional granaries enables natural cognitive integration between students’ experiences and mathematical representations. In contrast, the use of decontextualized representations such as abstract cubes and rectangular prisms requires students to perform simultaneous mental integration, a condition consistent with the split-attention effect in Cognitive Load Theory (Sweller et al., 2011). These findings indicate that meaningful cultural contexts have significant potential to reduce unproductive extraneous cognitive load.

Second, an ethnomathematics study by Charitas and Prahmana (2018) shows that batik motifs contain geometric structures such as symmetry, transformations, dilation, and pattern repetition, which can be utilized as meaningful learning contexts that provide concrete referents for students. This cultural context allows direct integration between the visual representation of motifs and mathematical concepts, thereby theoretically reducing the need for mental translation from abstract symbols to real experiences a condition that can lower extraneous cognitive load in accordance with principles of efficient instructional design.

Third, various studies show that mathematics learning rooted in meaningful cultural contexts (e.g., number systems in local agricultural practices), combined with progressive scaffolding, helps students integrate real-life experiences with formal representations. Cognitive Load Theory suggests that such instructional design reduces unnecessary cognitive processing (extraneous load) while enabling the allocation of cognitive resources for schema construction (germane load). Models such as 4C/ID and scaffolding in inquiry-based learning have been used to design task sequences that support this integration from observation to collaborative mathematical modeling—although specific numerical measurements vary across studies. This reflects the importance of progressively structured, culturally grounded scaffolding.

Table 1. Effects of Ethnomathematics-Integrated CTL on Cognitive Load Components

No	Learning Context	CTL Components	Ethnomathematical Context	Intrinsic Load	Extraneous Load	Germane Load	References
1	Batik Motifs for Geometric Transformation	Constructivism, Modeling, Authentic Assessment	Yogyakarta Batik Textile Art	Reduced through activation of culturally familiar visual schemas	Reduced through structured and familiar visual context	Increased through meaningful construction of geometric transformation concepts	Prahmana & D’Ambrosio (2020)

2	Batik Motifs for Geometry Concepts	Modeling, Reflection, Questioning	Indonesian Geometric Batik Ornaments	Reduced through automatic pattern recognition	Reduced through elimination of unnecessary abstraction	Increased through strengthened conceptual understanding	Khasanah (2023)
3	Kawung Batik for Rotation	Constructivism, Learning Community	Traditional Kawung Batik	Reduced through chunking in symmetrical patterns	Reduced through relevant concrete visual representation	Increased through schema construction processes	Charitas & Prahmana (2018)
4	Congklak Game for Number Operations	Learning Community, Inquiry, Authentic Assessment	Traditional Congklak Game	Reduced through activation of familiar gameplay schema	Reduced through hands-on manipulation activities	Increased through integration of mathematical understanding and social values	Rahmawati et al. (2025)
5	Bengkulu Local Context	Constructivism, Modeling, Questioning	Local Culture (architecture, agriculture)	Reduced through meaningful contextualization	Reduced through culturally relevant scaffolding	Increased through cognitive level enhancement	Widada et al. (2018)
6	Systematic Batik-Based Learning	Modeling, Reflection, Learning Community	Multi-regional Batik Context	Reduced through enhanced pattern recognition	Reduced through structured visual support	Increased through development of mathematical literacy	Roesdiana & Juandi (2024)
7	Multicultural Geometric Ornaments	Constructivism, Modeling, Authentic Assessment	Cross-cultural geometric ornaments	Reduced through cross-cultural schema activation	Reduced through integrated multiple representations	Increased through multicultural awareness and conceptual connections	Massarwe et al. (2016)
8	Comprehensive Ethnomathematics Practice	Inquiry, Questioning, Reflection, Learning Community	Indonesian Cultural Practices (meta-analysis)	Reduced through contextualized learning	Reduced through minimization of irrelevant abstraction	Increased through mathematical thinking and cultural identity development	Hartoyo et al. (2025)
9	Integration of Local Cultural Values	Constructivism, Modeling, Authentic Assessment	Contextual Local Culture	Reduced through high cultural relevance	Reduced through use of authentic learning materials	Increased through integration of cultural values in conceptual understanding	Hayati et al. (2024)

10	General CTL-Based Mathematics Learning	Constructivism, Inquiry, Questioning, Learning Community	Real-life Contexts	Reduced through real-world connections	Reduced through clear contextual support	Increased through strengthened conceptual understanding	Chotijah et al. (2019)
----	--	--	--------------------	--	--	---	------------------------

Instructional Design Strategies for Ethnomathematics-Based CTL in Reducing Intrinsic and Extraneous Load

The integration of ethnomathematics within the Contextual Teaching and Learning (CTL) approach requires well-planned instructional design strategies to optimize students’ cognitive load. Effective instructional design must be able to reduce excessive intrinsic load and minimize extraneous load, so that students’ cognitive capacity can be maximally allocated to germane load, which supports the construction of mathematical knowledge schemas.

1. Segmentation of Mathematical Concepts through Local Cultural Contexts

The first strategy to reduce intrinsic load is to segment complex mathematical concepts into smaller, meaningful learning units through local cultural contexts. Sweller et al. (2011), in Cognitive Load Theory, emphasize that breaking down complex information into manageable parts (chunking) is a fundamental principle for reducing intrinsic cognitive load. This structuring of information optimizes instructional design by aligning content complexity with learners’ prior knowledge, supporting the need to divide complex information into smaller components (Clark & Kimmons, 2023). In the context of ethnomathematics, this segmentation can be achieved by identifying mathematical elements within cultural practices that exhibit varying levels of complexity.

Research by Lidia (2023) and Nugraha (2019) shows that the use of cultural artifacts can facilitate the gradual understanding of geometric transformation concepts. For example, learning about reflection, rotation, and translation can begin with observing simple patterns in woven fabrics, then progress to analyzing more complex patterns, and ultimately lead to mathematical formalization. This gradual approach enables students to build cognitive schemas progressively without experiencing cognitive overload.

The CTL approach strengthens this segmentation strategy through the components of relating and experiencing. According to Johnson (2002) the principle of relating in CTL helps students connect abstract concepts with their prior concrete experiences, thereby reducing high element interactivity. A study by Widada et al. (2018) on ethnomathematics-based mathematics learning in Bengkulu demonstrates that students who learned solid geometry concepts through the context of traditional houses showed improvements in mathematical cognition after classroom implementation. Data from students’ cognitive assessments increased significantly from one instructional cycle to the next.

2. The Use of Worked Examples Based on Cultural Practices

The second strategy is the use of worked examples derived from authentic cultural practices to reduce extraneous load. Worked examples are one of the most effective techniques in Cognitive Load Theory for minimizing unnecessary cognitive load (Yeo & Tzeng, 2019). In traditional mathematics instruction, worked examples are often presented in abstract formats, which can increase cognitive load because students must interpret unfamiliar contexts.

Ethnomathematics provides a rich source of worked examples through cultural practices that are already familiar to students, thereby helping bridge formal mathematical concepts with their real-life experiences. Instructional approaches that connect mathematical concepts with students’ cultural contexts tend to make the material easier to understand, as they link abstract ideas to familiar real-life situations. This, in turn, can reduce unnecessary cognitive load and increase engagement. This aligns with the worked example effect in Cognitive Load Theory (Sweller et al., 2019a), where structured examples reduce extraneous cognitive load and facilitate the understanding of new concepts.

Within the Contextual Teaching and Learning (CTL) framework, ethnomathematics-based worked examples can be integrated through the *modeling* component to support the understanding of complex mathematical concepts. Worked examples themselves are an instructional strategy proven effective in reducing cognitive load by providing step-by-step demonstrations of procedures or solutions, allowing students to focus their cognitive resources on understanding underlying principles rather than relying on trial-and-error problem solving. Cognitive Load Theory literature shows that the use of worked examples can reduce extraneous cognitive load and improve learning efficiency, especially in the early stages of mathematical skill acquisition. This is

because well-designed examples help direct students' attention to essential elements without splitting their focus across multiple sources of information (worked example effect).

However, the design of ethnomathematics-based worked examples must consider the principle of fading guidance. Kalyuga (2007) warns about the expertise reversal effect, where overly explicit guidance can hinder learning for students who already possess sufficient prior knowledge. Therefore, worked examples should be designed adaptively, beginning with highly structured examples accompanied by detailed explanations, and gradually reducing the level of guidance as students' understanding increases.

3. Cultural Scaffolding in Collaborative Learning

The third strategy is the implementation of cultural scaffolding through collaborative learning, which is central to the *learning community* component in CTL. Vygotsky (1978) through the concept of the Zone of Proximal Development (ZPD), explains that optimal learning occurs when students receive support from more competent individuals to complete tasks beyond their independent capabilities. In the context of ethnomathematics, "more competent individuals" are not limited to teachers, but also include cultural practitioners, parents, and community members.

From a theoretical perspective, distributed cognition explains that thinking processes do not occur solely within an individual, but are distributed across group members and the resources they use. Thus, collaboration within groups can reduce individual cognitive load when dealing with complex tasks. This aligns with research by Kirschner et al. (2009), which states that well-structured collaborative learning can reduce cognitive load by distributing information processing among group members. However, collaborative learning must be carefully designed to avoid collaborative overload. Kirschner et al. (2009) warn that unstructured collaboration can increase extraneous load, as students must allocate cognitive resources to social coordination, communication, and meaning negotiation. Therefore, cultural scaffolding should include clear collaboration protocols, explicit role distribution, and effective monitoring mechanisms.

4. Visualization and Multimodality in Concept Representation

The fourth strategy is the use of visualization and multimodal representations based on cultural artifacts to reduce extraneous load. Dual Coding Theory proposed by Paivio (1986) and further developed by Mayer (2014) in the Cognitive Theory of Multimedia Learning, states that information presented simultaneously in visual and verbal forms can enhance understanding and retention, provided that the design follows appropriate multimedia principles.

Ethnomathematics offers rich visual representations through cultural artifacts such as batik patterns, weaving, carvings, and traditional architecture. Research by Prahmana and D'Ambrosio (2020) shows that students who learn symmetry concepts through visual analysis of batik fabrics demonstrate deeper conceptual understanding compared to those taught using abstract geometric diagrams. These culturally based visualizations reduce extraneous load because students do not need to expend cognitive resources interpreting artificial representations that lack meaning in their lived experiences.

However, the principles of coherence and redundancy in the Cognitive Theory of Multimedia Learning must be carefully considered. Mayer (2014) cautions that adding non-essential visual or verbal elements can increase extraneous load, even if they appear attractive. In the context of ethnomathematics, this means that the selection of cultural artifacts should prioritize those that are mathematically relevant, rather than those that are merely aesthetically appealing or popular.

The CTL approach reinforces this strategy through the *experiencing* component, which emphasizes hands-on and minds-on learning. Instructional approaches that involve visual, verbal, and kinesthetic representations—known as multimodal or multisensory learning can enrich learning experiences and strengthen information processing (Ernst, 2008). In cultural contexts, the exploration of batik motifs as a medium for mathematics learning has been shown to enrich learning contexts and help students connect geometric concepts with cultural artifacts (Yolanda & Putra, 2022). According to Cognitive Load Theory, effective instructional design should enhance germane load while minimizing extraneous load.

5. Sequencing Learning from Concrete to Abstract

The fifth strategy is the systematic sequencing of learning from concrete cultural contexts toward the formalization of abstract mathematics. In his enactive iconic symbolic learning theory, explains that optimal learning begins with concrete experiences (enactive), progresses to visual representations (iconic), and ultimately reaches abstract symbolic representations. This principle is highly relevant for managing intrinsic load, especially for mathematical concepts with high element interactivity.

Within the ethnomathematics – CTL framework, this sequencing can be implemented through the following cycle: (1) exploration of authentic cultural practices (enactive–experiencing), (2) identification and representation of mathematical patterns (iconic–modeling), (3) formalization of mathematical concepts (symbolic–applying), and (4) reflection on the relationship between culture and formal mathematics (reflecting). Research indicates that instructional sequences beginning with concrete representations and gradually progressing to abstract representations contribute to improved knowledge transfer. Fyfe et al. (2014) assert that such sequencing helps learners build more stable conceptual structures, enabling them to apply knowledge in new situations.

Van Merriënboer and Kester (2005), in the Four-Component Instructional Design Model (4C/ID), emphasize the importance of using authentic whole tasks organized by increasing levels of complexity to teach complex skills or concepts. In the context of ethnomathematics, this means that learning should begin with complete but simple cultural practices, then gradually progress to more complex practices while explicitly extracting the mathematical concepts involved. This approach aligns with Cognitive Load Theory, which suggests that intrinsic load should be managed through structured task sequencing so that learners are not cognitively overloaded at the early stages of learning (van Merriënboer et al., 2002; van Merriënboer & Ayres, 2005; van Merriënboer & Kester, 2005).

In addition, a meta-analysis by Harding et al. (2021) shows that ethnomathematics provides strong contextual opportunities for mathematics learning only when the relationships between cultural practices and formal concepts are presented explicitly and systematically. Without such explicit connections, students may struggle to transfer understanding from ethnomathematical contexts to formal mathematical situations, which may ultimately increase cognitive load in the long term. Therefore, each phase of instruction should include bridging activities that help students recognize the structural relationships between cultural practices and formal mathematical structures.

6. Differentiated Instruction Based on Cultural Prior Knowledge

The sixth strategy is differentiated instruction that takes into account variations in students' cultural prior knowledge. Kalyuga (2017), in his study on the expertise reversal effect, shows that instructional strategies effective for novices may hinder learning for students with higher prior knowledge. In the context of ethnomathematics, prior knowledge includes not only formal mathematical knowledge but also familiarity with the cultural practices used as learning contexts.

Tandililing (2013) found that students' experiences and familiarity with local cultural artifacts vary greatly and represent a potential resource for enriching mathematics learning in schools. This aligns with ethnomathematics studies showing that students' cultural backgrounds influence how they understand the relationship between cultural practices and formal mathematical concepts. Therefore, explicit efforts are needed to bridge cultural contexts with school mathematics to ensure effective knowledge transfer. Students who are already familiar with cultural practices are likely to experience reduced intrinsic load, as they do not need to allocate cognitive resources to understanding the cultural context and can instead focus directly on extracting mathematical concepts.

Within the CTL framework, this differentiation can be implemented through the *inquiry* component, adjusted to students' levels of knowledge. For students with low cultural prior knowledge, inquiry can begin with structured guided discovery supported by strong scaffolding. In contrast, students with high cultural prior knowledge can engage directly in open inquiry that challenges them to explore more complex mathematical relationships.

The principle of adaptive expertise proposed by Kapur (2014) can be applied by providing productive failure tasks to students who already possess strong foundational knowledge. In the context of ethnomathematics, this means that students familiar with cultural practices can be challenged to identify more advanced mathematical concepts or make generalizations across cultural contexts. This strategy optimizes germane load without excessively increasing intrinsic or extraneous load.

7. Integrated Formative Assessment as a Cognitive Load Regulator

The seventh strategy is the implementation of formative assessment integrated into instruction as a mechanism for regulating cognitive load. Black and Wiliam (2009) argue that effective assessment for learning helps teachers and students identify gaps in understanding in real time, enabling instructional adjustments before cognitive overload occurs.

In ethnomathematics-based CTL learning, formative assessment can be integrated through the *authentic assessment* component, using cultural contexts as the medium for evaluation. Fauzi et al. (2024) developed an ethnomathematics-based mathematical literacy instrument that incorporates local cultural contexts into assessment

items to measure students' mathematical literacy in a valid and reliable manner. Meanwhile, Ulya et al. (2024) developed a culture-based project performance assessment that effectively evaluates mathematical thinking skills within an ethnomathematics context. These instruments assess students' conceptual, procedural, and mathematical connection skills through meaningful tasks.

The think-aloud protocol technique recommended by Van Gog and Paas (2008) can be used to directly measure cognitive load during ethnomathematics learning. By asking students to verbalize their thinking processes while analyzing cultural artifacts or solving ethnomathematics-based problems, teachers can identify sources of cognitive overload and implement targeted interventions.

The integration of these instructional design strategies within an ethnomathematics-based CTL approach requires comprehensive planning and adaptive implementation. Teachers need a deep understanding not only of Cognitive Load Theory and CTL principles, but also of local cultural practices and how these can be leveraged for optimal mathematics learning.

The findings of this systematic review confirm and extend the theoretical understanding of how the integration of ethnomathematics within the CTL framework can optimize cognitive load management in mathematics learning. The main results show that ethnomathematics-based CTL strategies consistently and significantly reduce intrinsic and extraneous load, while increasing germane load. These findings have substantial theoretical and practical implications for mathematics instructional design, particularly in multicultural and culturally diverse contexts.

From a theoretical perspective, these findings strengthen and extend Cognitive Load Theory in several ways. First, they demonstrate the importance of cultural schemas as a form of prior knowledge that can significantly reduce intrinsic load. Sweller et al. (2019a), in the latest reformulation of CLT, emphasize that the expertise reversal effect occurs when learners possess extensive prior knowledge in a particular domain. Ethnomathematics provides precisely this form of domain-specific prior knowledge rooted in cultural practices, activating what Bartlett refers to as cultural schemas, which facilitate faster and more efficient information processing. The novelty of this finding lies in understanding cultural familiarity as a powerful form of cognitive expertise, comparable to academic expertise in reducing the perceived complexity of learning materials.

Second, the findings on the reduction of extraneous load through the elimination of cognitive dissonance enrich the understanding of various sources that may trigger extraneous load beyond traditional instructional design factors. Traditional Cognitive Load Theory literature focuses on presentation format, split-attention effects, and redundancy as the primary sources of extraneous load (Mayer & Fiorella, 2021). However, the results of this review indicate that cultural-cognitive mismatch arising when mathematical content is presented in ways that are unfamiliar or disconnected from students' real-life contexts can also be a significant source of extraneous load that has received relatively little attention. Ethnomathematics studies show that cultural contexts influence students' mathematical thinking processes through diverse cultural experiences (Rosa & Orey, 2011). The concept of "culturally induced cognitive load" thus emerges as a distinct construct, although it has not yet been fully developed within the mainstream CLT literature.

Third, the findings regarding the enhancement of germane load through meaningful cultural contextualization provide empirical support for the frameworks of connected learning (Ito et al., 2014) and funds of knowledge (Moll et al., 1992). Both perspectives emphasize that learning becomes more effective when it is connected to the cultural resources, lived experiences, and social practices already possessed by students and their families. This connectedness produces a qualitatively different form of cognitive engagement, characterized by deeper processing, richer conceptual elaboration, and stronger schema construction. In this context, cultural integration functions not only as a motivational context but also as a mechanism that facilitates productive cognitive load through processes such as progressive contextualization, multimodal representation, collaborative inquiry, and structured reflection.

A comparison with previous research findings reveals patterns of both convergence and divergence. The results of this review align with the ethnomathematics meta-analysis by Massarwe et al. (2016), which reported positive effects on mathematics learning outcomes, particularly through increased student motivation and affective attitudes. However, this study differs in its emphasis on mechanisms, demonstrating that cognitive mechanisms play an equally important if not more decisive role in explaining how cultural relevance influences learning outcomes. This finding is consistent with the perspective of Cognitive Load Theory, which emphasizes that cognitive processing efficiency and schema construction are primary prerequisites for meaningful learning (Sweller et al., 2019a). Although affective factors such as reduced mathematics anxiety and increased self-efficacy have also been identified in several studies (Ramirez et al., 2018; Rozgonjuk et al., 2020), this review indicates

that these factors primarily function as supporting conditions, while improvements in cognitive efficiency act as the mediating mechanism linking cultural relevance to enhanced mathematical learning outcomes.

Consistent with the meta-analysis by Satriani et al. (2012), which reported the superiority of Contextual Teaching and Learning (CTL) over conventional instruction, the findings of this review confirm this advantage while also offering important conceptual extensions. Specifically, when CTL is implemented through an ethnomathematics approach grounded in students' cultural contexts, its effectiveness appears to increase more substantially. This suggests that cultural grounding acts as a cognitive mechanism that strengthens the effectiveness of CTL. This finding is particularly relevant in addressing criticisms of inquiry and discovery based approaches, which are often considered inefficient due to their potential to generate excessive cognitive load (Kirschner et al., 2006). By leveraging cultural familiarity, the ethnomathematics approach helps reduce extraneous load through the activation of existing schemas, thereby preserving the benefits of inquiry-based learning without increasing unnecessary cognitive burden.

The novelty of this study lies in the development of an integrated framework Culturally Grounded Cognitive Load Management (CG-CLM) which synthesizes three theoretical perspectives that have previously been examined separately. This framework operationalizes the integration of ethnomathematical practices with the components of Contextual Teaching and Learning (CTL) to strategically manage different types of cognitive load. This approach goes beyond general notions of cultural relevance in mathematics learning by offering more operational strategies grounded in clear cognitive rationales. For example, the use of cultural artifacts as modeling tools can reduce extraneous load through concrete representation, while collaborative ethnomathematical inquiry within a learning community contributes to distributed cognitive processing and increased germane load through peer explanation. The strength of this approach lies in its ecological validity and cultural sustainability, as it utilizes local resources familiar to learners, making it particularly relevant for resource-limited contexts such as many regions in Indonesia, while also supporting cultural preservation and intergenerational knowledge transmission.

Nevertheless, several limitations are identified in this review. First, most of the studies reviewed focus on specific domains of mathematics, particularly geometry and measurement, while exploration in other domains such as algebra, calculus, and statistical reasoning remains relatively limited. This limits the generalizability of the findings across the full mathematics curriculum. Second, there is variability in implementation fidelity across studies, making it difficult to determine the optimal level and intensity of cultural contextualization. Third, nearly all studies were conducted in contexts where students had some degree of familiarity with the cultural practices used as learning resources; therefore, the effectiveness of this approach in entirely unfamiliar cultural contexts, or among transient and highly heterogeneous student populations, remains uncertain and requires further empirical investigation.

There is also an interesting tension between the goal of abstraction in mathematics and the specificity of cultural contexts. Mathematics derives much of its power from its abstract nature and its capacity for generalization across contexts (Devlin, 1998), whereas ethnomathematics is inherently contextual and culturally bound. Some researchers argue that excessive focus on cultural context may hinder the development of abstract mathematical thinking (Rowlands & Carson, 2002). However, the findings of this review suggest that this tension can be effectively managed through gradual decontextualization strategies, in which cultural context serves as an initial cognitive scaffold that is progressively reduced as students' abstract understanding develops. Nonetheless, the optimal balance and pathways for decontextualization still require further empirical validation.

The practical implications of this review are substantial and multi-layered. For practitioners, the CG-CLM framework provides a decision-making tool for selecting and sequencing ethnomathematical activities based on desired cognitive effects. For example, when the instructional goal is to reduce mathematics anxiety and initial resistance (forms of extraneous load), teachers can begin with highly familiar cultural practices; whereas when the goal is to promote deep elaboration and schema construction (germane load), collaborative ethnomathematical inquiry is more appropriate. For curriculum developers, these findings highlight the need for systematic integration of culturally based mathematical practices across the curriculum, rather than treating them as occasional add-ons or cultural notes.

For teacher education programs, these findings indicate the need to develop dual competencies: ethnomathematical awareness the ability to identify mathematical concepts embedded in cultural practices and cognitive load management skills for designing instruction that optimizes working memory use. Both competencies remain underemphasized in pre-service and in-service teacher education in Indonesia, creating a gap that must be addressed through professional development initiatives. For policymakers, these findings support the allocation of resources for documenting and systematizing ethnomathematical practices across cultures,

developing culturally responsive mathematics curriculum materials, implementing culturally responsive teacher professional development programs, and strengthening research infrastructure to investigate cultural–cognitive dynamics in mathematics education. In the context of Indonesia’s commitment to the Sustainable Development Goals, particularly Goal 4 on quality education, and the growing recognition of indigenous knowledge systems, ethnomathematics-based approaches align with both educational improvement and cultural preservation agendas.

From an equity and access perspective, these findings are particularly significant, as students from marginalized cultural groups often experience mathematics as a culturally alien and exclusive domain (Gutiérrez, 2013). By centering students’ cultural knowledge and experiences, ethnomathematics-based CTL has the potential to function as an equity-oriented pedagogy that reduces achievement gaps caused by cultural disconnection. Evidence from studies involving indigenous communities, such as in Papua and Kalimantan, shows significant improvements in student engagement and mathematical achievement when cultural practices are valued and strategically integrated. However, the limitations of this review must be acknowledged, including potential publication bias that may inflate reported effects, limited geographical generalizability due to the dominance of studies from Indonesia and surrounding regions, and the scarcity of studies employing rigorous experimental designs and random assignment. Therefore, cross-cultural replication and research with stronger methodological designs are needed to strengthen causal inferences and the validity of findings.

4. CONCLUSION

Based on the systematic literature review, the findings indicate that the integration of ethnomathematics within the Contextual Teaching and Learning (CTL) framework is effective in optimizing cognitive load management in mathematics learning. The synthesis results show a reduction in intrinsic load through the activation of culture-based schemas, a decrease in extraneous load through the use of familiar contexts, and an increase in germane load through deeper meaning construction. The implementation effects further confirm that ethnomathematics can function as a bridge between concrete learning experiences and the abstraction of mathematical concepts. From this synthesis, the Culturally Grounded Cognitive Load Management (CG-CLM) framework was developed, formulating four core strategies: progressive contextualization, multimodal cultural representation, collaborative ethnomathematical inquiry, and reflective ethnomathematical documentation, which can serve as practical guidelines for designing culturally responsive and cognitively efficient instruction.

The contribution of this study lies in integrating the perspectives of ethnomathematics, CTL, and Cognitive Load Theory into a single analytical framework, identifying the cognitive mechanisms underlying the effectiveness of the approach, and developing a taxonomy of instructional strategies applicable in classroom contexts. The implications for Indonesia are particularly significant given its rich cultural diversity, as the integration of ethnomathematics has the potential to improve mathematics learning outcomes while simultaneously strengthening cultural preservation. Future research directions include experimental studies with larger samples, the development of more precise cognitive load measurement instruments, longitudinal studies on concept retention and transfer, and the exploration of technology as a medium to support the documentation and implementation of ethnomathematics. Thus, the integration of ethnomathematics within a CTL framework oriented toward cognitive load management offers a promising pathway toward mathematics learning that is high-quality, inclusive, and culturally sustainable.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to all parties who have provided support, insights, and contributions in the preparation of this article. Appreciation is also extended to the lecturers for their valuable feedback, colleagues for their support, and previous researchers whose work has served as important references for this study.

REFERENCES

- [1] Arisetyawan, A., Suryadi, D., Herman, T., & Rahmat, C. (2014). Study of ethnomathematics: A lesson from the Baduy culture. *International Journal of Education and Research*, 2(10), 681–688.
- [2] Arvianto, I. R., Fadila, A., Nurcahyo, A., & Farizqi, M. L. (2025). Ethnomathematics : An Exploration of Mathematical Concepts in Yogyakarta ’ s Ox Cart. 15(2).
- [3] Asnawati, N. A., & Hasanah, R. U. (2025). Development of Ethnomathematics-Based Student Worksheets to Improve Conceptual Understanding. 4(3), 919–930.

-
- [4] Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. Holt, Rinehart and Winston.
- [5] Bishop, A. J. (1988). *Mathematical enculturation. A cultural perspective on mathematics education*. Kluwer Academic Publishers. <https://doi.org/10.1007/978-94-009-2657-8>
- [6] Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment Evaluation and Accountability*, 5–31. <https://doi.org/10.1007/s11092-008-9068-5>
- [7] Calista, N., Susanto, P., Purnamasari, H., & Wahjuningtyas, S. (2023). Meta-analysis of the effectiveness of ethnomathematics learning on the mathematical thinking ability of Indonesian students. *JP2M (Journal of Mathematics Education and Learning)*, 9(2), 191–199.
- [8] Charitas, R., & Prahmana, I. (2018). Hypothetical Learning Trajectory Design in Rotational Learning Using Kawung Batik Motif. *Prima Journal of Mathematics Education*, 2(1), 19–32. <https://doi.org/10.31000/prima.v2i1.411>
- [9] Chotijah, S., Susanto, A. (2019). The Effectiveness of Contextual Teaching and Learning (CTL) in Improving Students' Understanding of Concepts. *Journal of Mathematics* 2(2), 2(November), 195–206. <https://doi.org/10.21274/jtm.2019.2.2.195-206>
- [10] Clark, C., & Kimmons, R. (2023). Cognitive Load Theory. *EdTechnica*, 109–114. <https://doi.org/10.59668/371.12980>
- [11] D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics*, 5(1), 44–48. <https://doi.org/https://www.jstor.org/stable/40247876>
- [12] D'Ambrosio, U. (2001). *Ethnomathematics: Link between traditions and modernity*. Sense Publishers.
- [13] D'Ambrosio, U., & Rosa, M. (2017). Ethnomathematics and Its Pedagogical Action in Mathematics Education BT - Ethnomathematics and its Diverse Approaches for Mathematics Education (M. Rosa, L. Shirley, M. E. Gavarrete, & W. V Alangui (eds.); pp. 285–305). Springer International Publishing. https://doi.org/10.1007/978-3-319-59220-6_12
- [14] Devlin, K. J. (1998). *The Language of Mathematics: Making the Invisible Visible*. W.H. Freeman. https://books.google.co.id/books?id=_lCwQgAACAAJ
- [15] E.A.R.L.I. (2023). EARLI 2023 conference: Programme and abstracts. European Association for Research on Learning and Instruction. <https://www.earli.org/events/earli2023>
- [16] Ernst, M. O. (2008). Multisensory Integration : A Late Bloomer. 1, 519–521. <https://doi.org/10.1016/j.cub.2008.05.003>
- [17] Fauzi, A., Rahmatih, A. N., Ermiana, I. da, & Nurmawanti, I. (2024). Development of ethnomathematics-based mathematical literacy instruments for elementary school students. *JUPIKA: Journal of Mathematics Education of the University of Flores* Volume, 7(2), 153–167.
- [18] Fyfe, E. R., McNeil, N. M., Son, J. Y., & Goldstone, R. L. (2014). Concreteness Fading in Mathematics and Science Instruction: a Systematic Review. *Educational Psychology Review*, 26(1), 9–25. <https://doi.org/10.1007/s10648-014-9249-3>
- [19] Gutiérrez, R. (2013). The Sociopolitical Turn in Mathematics Education. *Journal for Research in Mathematics Education*, 44(1), 37–68.
- [20] Harding, J. L., Pettit, J., & Becker, D. (2021). Ethnomathematics Defined: A Literature Meta-Analysis. *Journal of Mathematics and Culture*, 15(June 2021), 33–65.
- [21] Hartoyo, A., Fitriawan, D., Siregar, N., & Ganda, F. (2025). Connecting cultural roots with mathematical thinking : A comprehensive meta-analysis of ethnomathematics practices in indonesian classrooms. *Al-Jabar: Jurnal Pendidikan Matematika*, 16(02), 673–689. <https://doi.org/10.24042/ajpm.v16i2.28734>
- [22] Hayati, R., Karim, A., Fachrurazi, Rohantizani, & Marzuki. (2024). Integration of Local Cultural Values in Mathematics Learning: A Case Study of the Application of Ethnomathematics. *KADIKMA : Journal of Mathematics and Mathematics Education*, 15(03), 99–107.
- [23] Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., Schor, J., Sefton-, J., Watkins, C. S., Livingstone, S., & Rhodes, J. (2014). *Connected Learning: An Agenda for Research and Design*. Digital Media and Learning Research Hub, Irvine, CA, USA.
- [24] Johnson, E. B. (2002). *Contextual teaching and learning: What it is and why it's here to stay*. Corwin Press.
- [25] Kalyuga, S. (2007). Expertise Reversal Effect and Its Implications for Learner-Tailored Instruction. *Educ Psychol Rev*. <https://doi.org/10.1007/s10648-007-9054-3>
- [26] Kalyuga, S. (2017). Expertise Reversal Effect and Its Implications for Learner-Tailored Instruction. *Educational Psychology Review*, 19(4), 509–539. <https://doi.org/10.1007/s10648-007-9054-3>
- [27] Kapur, M. (2014). Productive Failure in Learning Math. *Cognitive Science*, 38, 1008–1022. <https://doi.org/10.1111/cogs.12107>
- [28] Khasanah, B. A. (2023). The geometric contents and the values of local batik in Indonesia. *Jurnal Elemen*, 9(January), 211–226.
- [29] Khasanah, U., Rahayu, W., & Rohimah, S. R. (2021). Development of Android-Based Mathematics Learning Modules with Contextual Teaching and Learning (CTL) Approach on Two-Variable Linear Equation System Material. *JOURNAL OF SCHOOL MATHEMATICS LEARNING RESEARCH*, 5(2), 85–93. <https://doi.org/10.21009/jrpms.052.10>
- [30] Kirschner, F., Paas, F., & Kirschner, P. A. (2009). A Cognitive Load Approach to Collaborative Learning: United Brains for Complex Tasks. *Educational Psychology Review*, 21(1), 31–42. <https://doi.org/10.1007/s10648-008-9095-2>
- [31] Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, 41(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1
- [32] Kirschner, P. A., Sweller, J., Kirschner, F., & Zambrano, J. (2018). From Cognitive Load Theory to Collaborative Cognitive Load Theory. *International Journal of Computer-Supported Collaborative Learning*, 213–233.
- [33] Lidia, W. S. (2023). ETHNOMATHEMATICS IN STRUCTURE AND CARVING PATTERNS OF. 4(2), 132–148.
- [34] Massarwe, K., Verner, I., & Bshouty, D. (2016). Ethnomathematics and multicultural education: Analysis and Construction of Geometric Ornaments. *Journal of Mathematics & Culture*, 4, 344–360.
- [35] Mayer, R. E. (2014). *The Cambridge Handbook of Multimedia Learning (edisi terbaru)*. Cambridge University Press.
- [36] Mayer, R. E., & Fiorella, L. (2021). *The Cambridge Handbook of Multimedia Learning*. In *Cambridge Handbooks in Psychology* (3rd ed.). Cambridge University Press. <https://doi.org/10.1017/9781108894333>
- [37] Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory Into Practice*, 31(2), 132–141. <https://doi.org/10.1080/00405849209543534>
- [38] NCTM. (2020). *Standards for the Preparation of Secondary Mathematics Teachers*. May.
- [39] Nugraha, J. . (2019). Ethnomathematical review of Toraja ' s typical carving design in geometry transformation learning
Ethnomathematical review of Toraja ' s typical carving design in geometry transformation learning. <https://doi.org/10.1088/1742->

- 6596/1280/4/042020
- [40] O.E.C.D. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. <https://doi.org/10.1787/31e1fcb1-en>
- [41] Paas, F., & Renkl, A. (2003). Cognitive Load Theory and Instructional Design : Recent Developments. 38(1), 1–4.
- [42] Paivio, A. (1986). Mental representations: A dual-coding approach. Oxford University Press.
- [43] Prahmana, R. C. I., & D'Ambrosio, U. (2020). LEARNING GEOMETRY AND VALUES FROM PATTERNS : ETHNOMATHEMATICS ON THE BATIK PATTERNS OF YOGYAKARTA , INDONESIA. *Journal on Mathematics Education*, 11(3), 439–456.
- [44] Rahmawati, E., Zulfiati, H. M., & Wijayanto, Z. (2025). Ethnomathematics Based on the Congklak Game as a Mathematics Learning Strategy to Improve the Social and Cultural Values of Elementary School Students. *Journal of Basicedu*, 9(4), 934–944. <https://doi.org/10.31004/basicedu.v9i4.10041>
- [45] Ramirez, G., Shaw, S. T., Maloney, E. A., Ramirez, G., Shaw, S. T., Maloney, E. A., Anxiety, M., Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math Anxiety : Past Research , Promising Interventions , and a New Interpretation Framework Math Anxiety : Past Research , Promising Interventions , and a New Interpretation Framework. 1520. <https://doi.org/10.1080/00461520.2018.1447384>
- [46] Roesdiana, L., & Juandi, D. (2024). Systematic Literature Review : Ethnomathematical Context of Batik Motifs in Mathematics Learning. *SJME (Supremum Journal of Mathematics Education)*, 08(02), 335–345. <https://doi.org/10.35706/sjme.v8i2.11370>
- [47] Rosa, M., & Orey, D. C. (2016a). Innovative Approaches in Ethnomathematics. In *Current and Future Perspectives of Ethnomathematics as a Program*. <http://www.springer.com/series/14352>
- [48] Rosa, M., & Orey, D. C. (2021). An Ethnomathematical Perspective of STEM Education in a Glocalized World Uma Perspectiva Etnomatemática para a Educação STEM em um Mundo Glocalizado. *Bolema Boletim de Educação Matemática*, 840–876
- [49] Rosa, M., & Orey, D. C. (2011). Ethnomathematics: The Cultural Aspects of Mathematics. *Revista Latinoamericana de Etnomatemática*, 4(2), 32–54.
- [50] Rosa, M., & Orey, D. C. (2016b). State of the Art in Ethnomathematics. In M. Rosa, U. D'Ambrosio, D. C. Orey, L. Shirley, W. V. Alanguí, P. Palhares, & M. E. Gavarrete (Eds.), *Current and future perspectives of ethnomathematics as a program* (pp. 11–37). Springer. https://doi.org/10.1007/978-3-319-30120-4_3
- [51] Rowlands, S., & Carson, R. (2002). Where would formal, academic mathematics stand in a curriculum informed by ethnomathematics? a critical review of ethnomathematics. *Educational Studies in Mathematics*, 1, 79–102. <https://doi.org/10.1023/A:1020532926983>
- [52] Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-puurand, K., & Täht, K. (2020). Mathematics anxiety among STEM and social sciences students : the roles of mathematics self-efficacy , and deep and surface approach to learning.
- [53] Satriani, I., Emilia, E., & Gunawan, M. H. (2012). Contextual teaching and learning approach to teaching writing. *Lndonaion Journal Af Applied Unguristics*, 2(1), 20.
- [54] Sears, S. J. (2003). *Introduction to Contextual Teaching and Learning*. Phi Delta Kappa Educational Foundation.
- [55] Swastiastu, O., Buddhaya, N., Education, K. K., Regulation, B., Education, M., Culture, K., Swastiastu, O., & Buddhaya, N. (2025). Performance Report of the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) in 2024.
- [56] Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. 285, 257–285. <https://doi.org/10.1207/s15516709cog1202>
- [57] Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Springer. <https://doi.org/10.1007/978-1-4419-8126-4>
- [58] Sweller, J., Merriënboer, J. J. G., & Paas, F. (2019a). Cognitive Architecture and Instructional Design : 20 Years Later. *Educational Psychology Review*, 261–292. <https://doi.org/10.1007/s10648-019-09465-5>
- [59] Sweller, J., Merriënboer, J. J. G., & Paas, F. (2019b). Cognitive Architecture and Instructional Design : 20 Years Later Content courtesy of Springer Nature , terms of use apply . Rights reserved . Content courtesy of Springer Nature , terms of use apply . Rights reserved . *Educational Psychology Review*, 261–292. <https://doi.org/10.1007/s10648-019-09465-5>
- [60] Tandililing, E. (2013). The development of school mathematics learning with an ethnomathematics approach based on local culture as an effort to improve the quality of mathematics learning in schools. *Proceedings of the National Seminar on Mathematics and Mathematics Education*, 1992, 193–202.
- [61] Turmuzi, M. (2022). Meta-analisis: Pengaruh Pembelajaran Berbasis etnomatematika Terhadap Hasil Belajar Matematika Siswa. *Jurnal Pembelajaran Matematika Inovatif*, 5(5), 1525–1534. <https://doi.org/10.22460/jpmi.v5i5.1525-1534>
- [62] Ulya, H., Rahayu, R., Sa'dijah, C., Qohar, A., Ikhwan, M., & Saad, M. (2024). Designing Performance Assessment for Ethnomathematics Project-Based Learning to Assess University Students' Mathematical Thinking Skills. *JOURNAL OF MATHEMATICS AND NATURAL SCIENCES EDUCATION*, 25(October), 1281–1296. <https://doi.org/http://dx.doi.org/10.23960/jpmipa.v25i3.pp1281-1296>
- [63] Van Gog, T., & Paas, F. (2008). Instructional Efficiency: Revisiting the Original Construct in Educational Research. *Educational Psychologist*, 43(1), 16–26. <https://doi.org/10.1080/00461520701756248>
- [64] van Merriënboer, J. J. G., & Ayres, P. (2005). Research on cognitive load theory and its design implications for e-learning. *Educational Technology Research and Development*, 53(3), 5–13. <https://doi.org/10.1007/BF02504793>
- [65] van Merriënboer, J. J. G., Clark, R. E., & de Croock, M. B. M. (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology Research and Development*, 50(2), 39–61. <https://doi.org/10.1007/BF02504993>
- [66] van Merriënboer, J. J. G., & Kester, L. (2005). The Four-Component Instructional Design Model : Multimedia Principles in Environments for Complex Learning. In R. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 71–94). Cambridge University Press. <https://doi.org/10.1017/CBO9780511816819.006>
- [67] Virijai, F., Indonesia, P., Malikussaleh, U., & Utara, A. (2025). The Merdeka Curriculum and P5: A Review of Teachers' Understanding and Students' Experiences I. *Journal of Educational Vehicles*, 12(1), 123-140, J, 12(1), 123–140.
- [68] Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes.
- [69] Waralangi, A. D., Kho, R., Tandililing, P., Sirampun, E., & Marthinus, Y. (2025). Ethnomathematics Exploration of Carvings in Asei Community Houses as a Source of School Mathematics Learning. *JUPE: Journal of Mandala Education*, 10(2), 651–657.
- [70] Widada, W., Herawaty, D., & Lubis, A. N. M. T. (2018). Realistic mathematics learning based on the ethnomathematics in Bengkulu to improve students ' cognitive level Realistic mathematics learning based on the ethnomathematics in Bengkulu to improve students '

- cognitive level. Journal of Physics Conference Series 1088:012028. <https://doi.org/10.1088/1742-6596/1088/1/012028>
- [71] Yeo, L., & Tzeng, Y.-T. (2019). Tracing Effect in the Worked Examples-based Learning : An Exploration of Individual Differences in Working Memory Capacity. *Eurasia Journal of Mathematics*, 15(10).
- [72] Yolanda, F. O., & Putra, A. (2022). Systematic Literature Review: An Ethnomathematical Exploration of Batik Motifs. *Prima Magistra: Scientific Journal of Education*, 3 (April), 188–195. <https://doi.org/https://doi.org/10.37478/jpm.v3i2.1533>