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Integrating ethnomathematics into challenge-based learning: A need assessment to enhance students' creative problem solving and scholarly zeal

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Abstract.
This study aims to conduct a comprehensive needs assessment as the foundational phase in the development of an ethnomathematics-integrated Challenge-Based Learning (CBL) model, designed to enhance students' creative problem-solving (CPS) abilities and scholarly interest in mathematics. A qualitative descriptive approach was employed, with data collected through student questionnaires, teacher interviews, and documentary analysis of curricular materials. The findings reveal a significant gap between the current state of instruction and desired learning outcomes. Students exhibited critical deficits in CPS, particularly in connecting concepts to real-world contexts and devising alternative strategies, alongside a pronounced lack of intrinsic motivation (scholarly enthusiasm). Teachers identified the dominance of procedural, routine-based instruction as a primary cause, while simultaneously expressing a strong demand (84.6%) for innovative, contextual pedagogical models. The analysis underscores the potent, yet underutilized, potential of local cultural elements (ethnomathematics) to serve as authentic contexts for meaningful challenges. The study conclusively establishes that the integration of ethnomathematics within a CBL framework is a theoretically sound and empirically warranted strategy to address the identified gaps. This integration is projected to foster a more engaging, relevant, and effective mathematics learning environment that cultivates essential 21st-century competencies.

Keywords:
Challenge-based learning; ethnomathematics; creative problem solving; scholarly zeal; needs assessment

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INTRODUCTION

Mathematics is a discipline that plays a strategic role in developing students' critical, logical, and creative thinking abilities (Nufus et al., 2025; Genç et al., 2025). Within the context of 21st-century learning, students are expected not only to master mathematical concepts but also to develop competencies in creative problem solving (CPS) and a scholarly zeal that drives them to continuously learn, explore, and innovate. Unfortunately, mathematics instruction in classrooms often remains procedurally oriented, teacher-centered, and provides limited opportunities for the exploration of ideas or the connection of concepts to real-world experiences (Nic Mhuirí & Twohill, 2025). This situation results in students' low proficiency in solving non-routine problems and a weak motivation to engage with mathematics in a meaningful manner. While various innovative learning models have been proposed to address these challenges, many of them do not sufficiently integrate authentic contexts, student agency, and sustained problem-solving processes within a single instructional framework.

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One approach deemed relevant to address this issue is Challenge-Based Learning (CBL). This model emphasizes student engagement in tackling authentic, real-life challenges, working collaboratively, and producing creative solutions. Nichols et al. (2016) explain that CBL consists of three main phases—engage, investigate, and act—designed to foster critical thinking, collaboration, and 21st-century skills. In mathematics learning, the CBL framework allows students to connect abstract concepts to contextual problems, thereby enabling them to perceive mathematics not merely as a set of symbols and procedures, but as a tool for solving real-world challenges.

In addition to CBL, ethnomathematics also offers significant potential for constructing contextual mathematics learning. D'Ambrosio (1985) defines ethnomathematics as an approach to understanding mathematics through the cultural practices of societies. Furthermore, Rosa and Orey (2016) elucidate that ethnomathematics provides a comprehensive perspective on mathematics, encompassing concepts, procedures, processes, methods, and practices that are deeply embedded within diverse cultural contexts. The integration of ethnomathematics into CBL has the potential to create meaningful learning experiences, as students not only learn mathematical concepts abstractly but also investigate traces of local culture as an integral part of their learning activities. The potential of integrating Challenge-Based Learning (CBL) and ethnomathematics is supported by empirical research in mathematics education. For instance, contextual learning that embeds ethnomathematics has been shown to significantly improve students' problem-solving abilities by connecting mathematics to local culture (Nur et al., 2020). Likewise, a recent meta-analysis indicates that ethnomathematics-based learning approaches have a strong positive effect on students' mathematical literacy when compared with conventional instruction (Pratama & Yanpar Yelken, 2024). Additionally, studies investigating problem-based contexts with ethnomathematics report enhanced conceptual understanding, further substantiating the value of culturally grounded, challenge-oriented pedagogies (Wikasari et al., 2025). This can strengthen the connection between mathematics and daily life while simultaneously fostering a sense of ownership, cultural identity, and students' intrinsic motivation.

Within the framework of developing mathematics instruction, two crucial aspects to optimize are creative problem solving and scholarly zeal. Torrance (1974) emphasizes that CPS involves the ability to generate diverse, flexible, original, and elaborate ideas in problem-solving, making it highly relevant for addressing non-routine challenges. The CPS model comprises problem clarification, opinion expression, evaluation and selection, and implementation (Sholihah et al., 2020). Meanwhile, scholarly zeal refers to an academic spirit characterized by intrinsic motivation, curiosity, enthusiasm, and perseverance in the pursuit of knowledge (Pintrich & De Groot, 1990). In contrast to general learning motivation, which primarily concerns the underlying reasons for students' engagement in learning activities, whether intrinsic or extrinsic (Ryan & Deci, 2000), scholarly zeal emphasizes a more enduring dispositional orientation toward intellectual inquiry. It reflects a profound commitment to knowledge construction, critical engagement, and the autonomous pursuit of understanding beyond immediate instructional objectives or performance outcomes. In this regard, scholarly zeal aligns conceptually with notions of intellectual curiosity and academic engagement that emphasize sustained cognitive investment, epistemic interest, and responsibility toward learning as a scholarly practice (Schiefele, 1991; Fredricks et al., 2004). Consequently, scholarly zeal should be understood not merely as a motivational state, but as a stable academic disposition that shapes how students value, approach, and persist in learning over time. These two aspects are not merely cognitive competencies but also affective ones, which determine the quality of students' mathematics learning experiences.

However, various studies indicate that the problem-solving abilities and scholarly zeal of Indonesian students remain at a concerning level. Results from the PISA survey (OECD, 2016; 2018; Schleicher, 2019; 2023) show that Indonesian students' performance in mathematical problem-solving has consistently been below the OECD average. This condition is illustrated in Figure 1, which depicts the mathematics scores of Indonesian students in PISA over several periods. Research by Isnawan et al. (2023), Surya et al. (2017), and Mariano-Dolesh et al. (2022)

also confirms the low level of student problem-solving in the classroom. Furthermore, a systematic literature review (Hadi et al., 2023) found a declining trend in problem-solving research in Indonesia in recent years, indicating an increasing urgency to focus on this aspect.

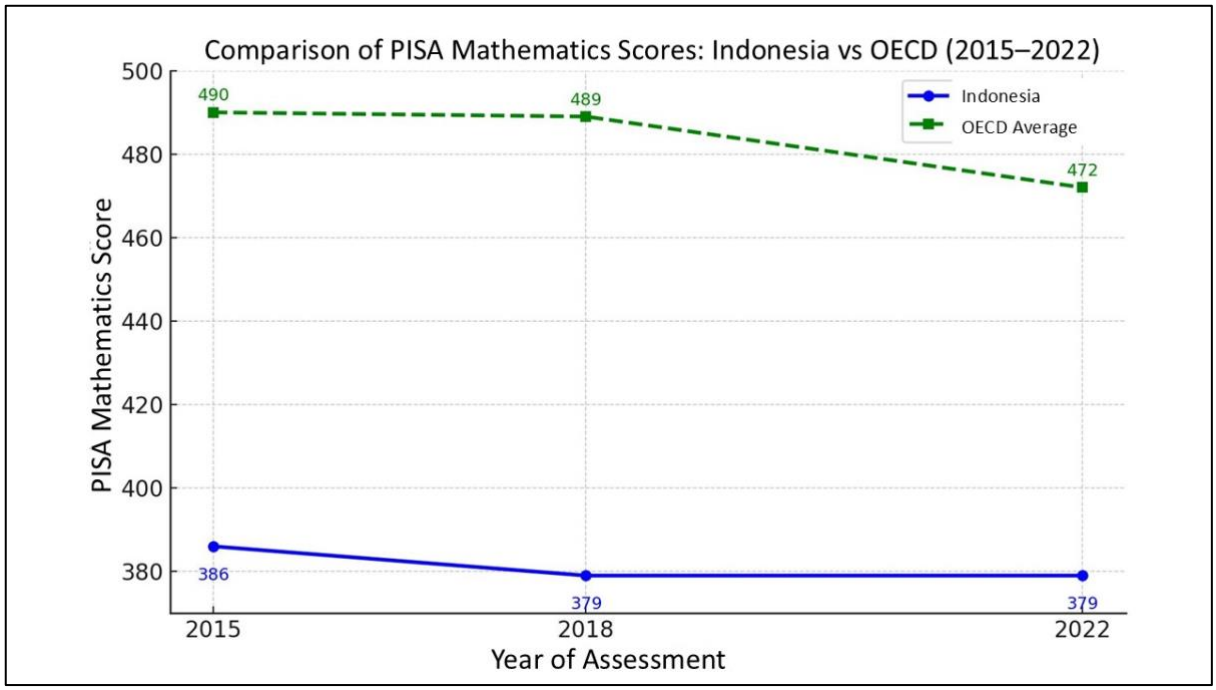

Figure 1. Mathematics scores of Indonesian students based on the programme for international student assessment (PISA) results

On the other hand, studies by Rone et al. (2023), Abramovich et al. (2019), and Lestari et al. (2019) reveal that students' enthusiasm for learning mathematics remains low; they tend to be less persistent, quick to give up, and demonstrate minimal enthusiasm. This evidence reinforces the need for instructional strategies capable of fostering both CPS skills and scholarly zeal.

In this context, Challenge-Based Learning integrated with ethnomathematics is believed to be a promising innovative alternative. This approach not only places students in challenging situations that demand creative thinking (Fitri & Mustika, 2022; Christersson et al., 2022; Beattie, 2024) but also encourages them to be persistent, active, and enthusiastic in exploring knowledge (Doulougeri et al., 2024; Membrillo-Hernández, 2019; Vilalta-Perdomo, 2020). Integration with ethnomathematics brings learning closer to local culture, making students feel more connected to the subject matter (Mustika et al., 2022; Prahmana et al., 2021; Tampubolon et al., 2023; Shahbari & Daher, 2020; Turmuzi et al., 2023). With the additional support of the theory of didactical situations, the concepts constructed through learning can be more focused (Sridana et al., 2025; Sukarma et al., 2024). The conceptual framework of this model is presented in Figure 2, which illustrates the integration of CBL with ethnomathematics in mathematics learning.

To design such a learning model, a strong foundation built upon a needs assessment is required. Dick and Carey (2009) assert that needs assessment is a critical initial stage in development research, as it serves to identify the gap between actual and ideal conditions. This analysis not only provides an overview of student and teacher readiness but also maps the potential for integrating local cultural contexts into instruction. Therefore, this article aims to explore the findings of a needs assessment related to the development of an ethnomathematics-integrated Challenge-Based Learning model in mathematics instruction, focusing on efforts to optimize creative problem-solving and foster students' scholarly zeal.

METHOD

This study represents the initial phase of a larger Research and Development (R&D) project

aimed at designing and developing an ethnomathematics-integrated Challenge-Based Learning (CBL) model for mathematics instruction. The focus of this article is on the needs assessment stage, which functions as a critical foundation for the entire development process. As Dick, Carey, and Carey (2015) emphasize, conducting a comprehensive needs assessment is essential for identifying the performance gap between the current state of learning and the desired future condition, ensuring that the product developed is relevant and responsive to authentic educational challenges. To achieve this purpose, the study adopted a qualitative descriptive design that allowed for an in-depth exploration of existing learning conditions, obstacles faced in classroom practice, and opportunities for integrating ethnomathematical elements into the CBL framework.

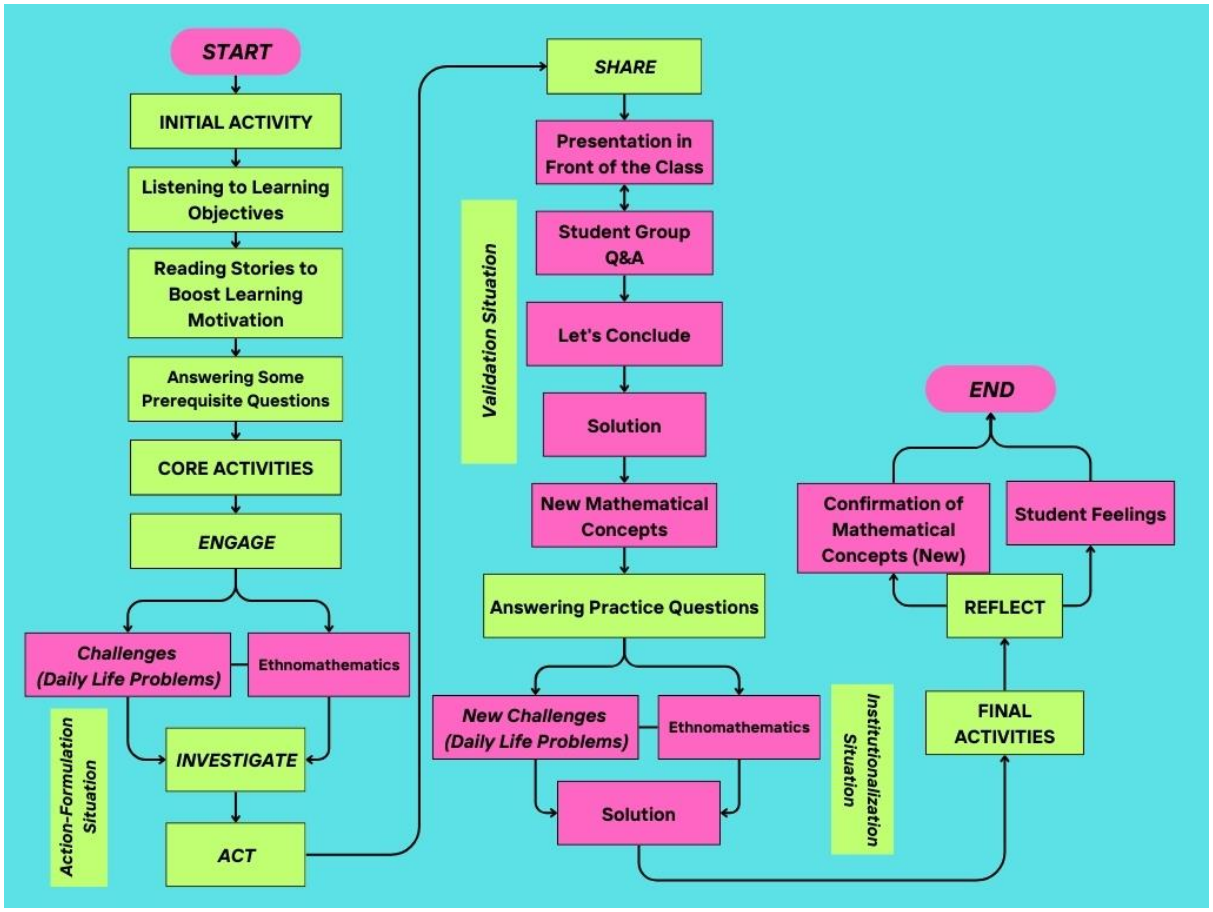

Figure 2. Conceptual framework of ethnomathematics-integrated challenge-based learning in mathematics instruction

The participants of the study were purposively selected to capture perspectives central to the envisioned intervention (Creswell & Poth, 2018). Two groups were involved: students and teachers. Secondary school students, as the intended end-users of the learning model, provided data concerning their learning perceptions, difficulties, and motivational orientations. Mathematics teachers, meanwhile, served as key informants due to their direct role in facilitating classroom instruction. Their insights were particularly valuable in understanding prevailing pedagogical practices, students' learning struggles, and the practical feasibility of embedding CBL with ethnomathematics into mathematics lessons.

To ensure triangulation and strengthen the credibility of findings, data were collected using multiple techniques and instruments (Patton, 2015). A structured student questionnaire was administered to identify perceptions, needs, and challenges in learning mathematics, particularly in relation to creative problem-solving and intrinsic motivation (scholarly zeal). The instrument combined Likert-scale items with open-ended responses to capture both quantitative trends and qualitative nuances. In addition, semi-structured interviews were conducted with mathematics

teachers to obtain in-depth information about current instructional strategies, difficulties in fostering higher-order thinking skills, and their perspectives on the opportunities and challenges of implementing CBL enriched with cultural contexts. Complementing these instruments, a documentary analysis of relevant educational materials—including the national curriculum, school syllabi, lesson plans (RPP), and textbooks—was performed. This analysis aimed to examine the alignment of existing curricular documents with CBL principles and to identify potential points of entry for ethnomathematical integration (Bishop, 1988; Rosa & Orey, 2016).

The data obtained through questionnaires, interviews, and documents were analyzed using the interactive model of qualitative data analysis developed by Miles, Huberman, and Saldaña (2014). The analysis involved three concurrent flows of activity. First, data reduction was carried out by coding and categorizing raw data into themes directly related to the research objectives, namely students' needs, teachers' readiness, and contextual opportunities for integration. Second, data display was conducted through matrices, tables, and descriptive narratives to facilitate the identification of emerging patterns and themes. Finally, conclusion drawing and verification were performed iteratively, with preliminary interpretations constantly checked against reduced and raw data to ensure their accuracy, consistency, and validity.

RESULTS AND DISCUSSION

The results of the needs analysis demonstrate a significant discrepancy between the current condition of mathematics instruction and the expectations for developing 21st-century competencies, particularly in the areas of creative problem solving (CPS) and scholarly zeal (SZ). This section discusses the findings from three primary sources—student responses, teacher insights, and documentary analysis—supported by both quantitative data and qualitative excerpts, thereby offering a nuanced picture of the needs and opportunities for pedagogical innovation.

Student competencies: Persistent deficits in CPS and SZ

The student questionnaire reveals that the majority of students experience substantial difficulties when confronted with non-routine problems. As summarized in Table 1, more than two-thirds of the respondents reported challenges in connecting mathematical problems to real-world contexts (72.1%). A similarly high proportion of students struggled to generate alternative solving strategies (67.5%) and to produce creative ideas in constructing solutions (64.8%).

Table 1. Student difficulties in creative problem solving (CPS)

Aspect Assessed	% of Students Reporting Difficulty
Connecting problems to real-world contexts	72.1
Discovering alternative solving strategies	67.5
Generating creative ideas in solutions	64.8

These numbers suggest that students' engagement with mathematics remains largely procedural rather than conceptual. This tendency was corroborated by teachers during interviews. One teacher stated:

> *"Students are accustomed to memorizing steps; when a problem is slightly modified, they immediately become confused and give up."*

Such testimony illustrates a classroom culture that overemphasizes rote learning and algorithmic repetition, leaving little room for exploration or creativity. This is consistent with Polya's (1973) assertion that true problem solving requires the application of heuristics and divergent thinking, rather than the mechanical execution of procedures.

In addition, motivational aspects emerge as another critical challenge. Teachers observed that students' learning is primarily driven by extrinsic motives, such as the pursuit of grades, rather than by intrinsic curiosity or enjoyment. This condition reflects a lack of scholarly zeal, which

Pintrich and De Groot (1990) define as persistence, intrinsic motivation, and active engagement with knowledge. As one teacher remarked:

"They study only to pass exams, not because they are truly interested."

This overreliance on extrinsic motivation creates a cyclical problem: students avoid engaging with more demanding tasks, thereby limiting opportunities to develop problem-solving competence and the intrinsic interest that might sustain deeper learning.

Teacher practices and readiness for change

While students' struggles are apparent, teacher responses shed light on the structural and pedagogical factors contributing to these outcomes. Teachers identified the prevalence of routine exercises, a lack of student curiosity, and distractions from digital devices and the surrounding environment as major inhibitors of CPS development. For SZ, they pointed to the dominance of extrinsic motivation, weak perseverance, and permissive parenting practices. These insights are summarized in Table 2.

Table 2. Teacher-identified causes of low CPS and scholarly zeal

Aspect	Main Contributing Factors
CPS	• Prevalence of routine exercises, rare use of non-routine problems • Students lack curiosity and inquiry skills • Distractions from gadgets and environment
SZ	• Dominance of extrinsic motivation (grades) • Lack of perseverance and enthusiasm • Permissive parenting styles

The alignment between student data (Table 1) and teacher diagnoses (Table 2) reinforces the validity of these findings. Teachers are fully aware of the shortcomings of existing practices and the urgent need for change. As shown in Table 3, although 81.3% of teachers admitted that their current instruction is dominated by lectures and routine practice, an even larger proportion (84.6%) explicitly expressed the need for innovative models grounded in real-world contexts.

Table 3. Teacher practices and perceived needs

Aspect Assessed	% of Teachers Agreeing
Instruction is dominated by lecture and routine practice	81.3
Difficulty in facilitating higher-order thinking skills	76.9
Need for innovative models based on real-world contexts	84.6

The qualitative data provides further insight into teachers' recognition of the problem. One teacher confessed:

"Children can do routine problems, but when the question changes slightly, they get lost. We need new ways to train them to think."

Another reflected on the potential of cultural resources:

"Actually, there are many cultural elements around us that could be used, like weaving patterns or traditional houses, but we haven't tried to make them into teaching material."

These reflections suggest that teachers are not resistant to innovation; rather, they are seeking pedagogical tools that can help bridge the gap between abstract mathematical concepts and meaningful, contextualized learning experiences. Furthermore, teachers proposed concrete solutions, as summarized in Table 4, which include embedding challenging and contextual problems, fostering collaboration and communication, strengthening intrinsic motivation, and linking mathematics to daily life.

These solutions strongly resonate with the pedagogical recommendations articulated by Hmelo-Silver (2004) and Hiebert and Grouws (2007). Hmelo-Silver underscores that problem-

based learning environments, where students are actively engaged in investigating authentic and complex problems, cultivate not only content knowledge but also the essential processes of inquiry, reasoning, and reflection. Such approaches position students as active constructors of knowledge rather than passive recipients of information, thereby fostering deeper understanding and the ability to transfer skills to novel situations. Similarly, Hiebert and Grouws highlight that teaching methods which encourage students to grapple with meaningful problems, explore multiple strategies, and engage in mathematical discourse are far more effective in promoting higher-order thinking skills than traditional lecture-based practices. In this context, the teachers' call for more contextual and challenge-oriented models can be interpreted as a practical demand that aligns with these theoretical insights. By shifting away from routine exercises and moving toward problem-centered and student-driven instruction, the classroom can become a space where creative problem solving and scholarly zeal are not only encouraged but systematically developed through carefully designed learning experiences.

Table 4. Teacher-proposed solutions for enhancement

Competency	Primary Solutions Proposed by Teachers
CPS	• Providing challenging and contextual problems • Training communication and collaboration skills • Developing problem-based learning
SZ	• Fostering intrinsic motivation • Building teacher-student-parent collaboration • Linking mathematics to everyday life

Ethnomathematics and challenge-based learning: A convergent opportunity

Documentary analysis and teacher interviews further underscore the strong potential of integrating ethnomathematics into classroom practice, revealing that cultural contexts are not merely supplementary but can serve as central resources for meaningful mathematical learning. Teachers articulated that element of local culture—such as the intricate geometry of batik patterns, the strategic reasoning embedded in traditional games, the proportional and spatial concepts inherent in local architecture, and the arithmetic practices reflected in everyday market activities—could be transformed into authentic mathematical challenges. As one teacher insightfully remarked, *"If we can make challenges from daily life—like traditional crafts or market activities—students will surely be more engaged."* This statement reflects a recognition that mathematics is not an isolated discipline but deeply interwoven with the lived experiences of students.

This finding strongly resonates with D'Ambrosio's (1985) seminal perspective, which situates ethnomathematics as a bridge between cultural practices and formal mathematical structures, enabling learners to see mathematics as both meaningful and accessible. Rosa and Orey (2016) further affirm that embedding cultural elements in classroom instruction not only enhances motivation but also strengthens students' sense of identity, as they encounter mathematics through familiar and valued aspects of their heritage. Such integration supports intrinsic motivation, allowing students to pursue mathematical inquiry with genuine interest rather than external pressure.

The alignment with Nichols et al. (2016) is equally significant, as they emphasize that authentic engagement arises when challenges are rooted in real-world contexts that students perceive as relevant and worthwhile. From this perspective, ethnomathematics offers not just "contextual flavor," but a transformative medium for designing challenges that matter to students. It responds directly to the critical needs identified in earlier findings: it helps students bridge the gap between abstract mathematics and lived reality (Table 1), provides authentic and contextually rich problems to enhance creative problem solving (Table 4), and answers teachers' call for innovative and meaningful pedagogical models (Table 3).

In this way, ethnomathematics emerges as a pivotal component of Challenge-Based Learning. It situates mathematical exploration within cultural narratives and practices, thereby fostering deeper engagement, stronger cultural relevance, and the intrinsic motivation necessary for sustaining scholarly zeal. Rather than being an optional enrichment, the integration of ethnomathematics can be seen as a powerful and essential strategy for reorienting mathematics education toward the holistic development of 21st-century learners.

Synthesis: Toward an ethnomathematics-integrated CBL model

The presented needs analysis reveals a clear and consistent narrative, highlighting a significant gap between the current state of mathematics instruction and the desired outcomes for 21st-century learning. A synthesis of the data from students, teachers, and contextual analysis provides a compelling rationale for developing an innovative pedagogical model.

The quantitative and qualitative data from students (Table 1) consistently demonstrate a critical deficit in two core competencies: Creative Problem Solving (CPS) and Scholarly Zeal (SZ). Students' primary struggle lies in connecting abstract mathematical concepts to real-world contexts, devising alternative solving strategies, and generating original ideas. This challenge is not merely an internal student deficit but is fundamentally exacerbated by an instructional environment that remains predominantly procedural and focused on routine practice. This is corroborated by teacher interviews, with one noting that students are accustomed to *"memorizing steps; when a problem is slightly modified, they immediately become confused and give up."* This observation aligns with established literature which posits that a focus on procedural knowledge without conceptual understanding severely limits students' ability to transfer and adapt their skills to novel situations (Hiebert & Grouws, 2007; Rittle-Johnson & Schneider, 2015).

Furthermore, the teacher perspective (Tables 2 and 3) offers a deeper diagnostic layer, identifying the root causes of these student deficiencies. Teachers attribute the limitations in CPS and SZ to a curriculum overloaded with routine problems, a lack of cultivated curiosity, and external factors such as digital distractions and permissive parenting styles. Crucially, however, teachers demonstrate critical self-awareness, acknowledging that the traditional, teacher-centered methods they predominantly use (81.3% agreement) are insufficient. A significant majority (over 84%) expressed a clear demand for innovative, contextual models that can effectively develop higher-order thinking skills. As one teacher insightfully stated, *"We know these old methods are no longer enough; students need real challenges that make them think and ask questions."* This teacher readiness for change is a vital factor for the successful implementation of any new educational intervention (Fullan, 2007).

The solutions proposed by teachers (Table 4) precisely chart the course for development. To enhance CPS, they emphasize the need for challenging, contextual problems, improved communication and collaboration, and problem-based learning approaches. To foster SZ, they highlight the importance of building intrinsic motivation, strengthening teacher-student-parent collaboration, and linking mathematics to daily life. A teacher's comment that *"children are more enthusiastic when they feel mathematics is related to their own lives or culture"* is particularly salient. Collectively, these proposed solutions converge on a single, powerful theme: the imperative for contextualization.

This need for contextualization finds its perfect counterpart in the identified potential of ethnomathematics. Teachers suggested concrete examples, such as using batik patterns or traditional games, as authentic contexts for learning. This is not merely an optional add-on but a strategic solution. Ethnomathematics, defined as the mathematics inherent in cultural practices (D'Ambrosio, 1985; Rosa & Orey, 2016), bridges the gap between abstract formal mathematics and the learner's lived experience. It transforms mathematics from a distant, alienating set of rules into a meaningful exploration of one's own cultural heritage. When integrated with Challenge-Based Learning (CBL)—a framework engaging students in collaborative problem-solving of real-world challenges (Nichols et al., 2016)—ethnomathematics provides the authentic, culturally-

grounded "challenge." This synergy moves learning beyond procedural execution, demanding and fostering creativity, collaboration, and intrinsic motivation (Johnson et al., 2021).

Thus, a robust synthesis emerges: the low levels of student CPS and SZ (Table 1), the causative factors identified by teachers (Table 2), their critical awareness of methodological limitations (Table 3), and their proposed solutions (Table 4) all converge on the same imperative—the need for an innovative, contextual, and culturally relevant learning model. The integration of ethnomathematics within a CBL framework is not a coincidental choice but a logical and empirically grounded response to the authentic needs of the field. This model is designed to provide meaningful, culturally-rooted challenges that can ignite students' intrinsic motivation, strengthen their scholarly zeal, and cultivate the creative problem-solving competencies essential for the 21st century.

CONCLUSIONS

Based on the comprehensive needs assessment conducted, this study concludes that a significant gap exists between the current state of mathematics instruction and the demands for developing 21st-century competencies. The findings reveal fundamental weaknesses in students' creative problem-solving abilities, particularly in connecting mathematical concepts to real-world contexts and generating alternative and creative solution strategies. Furthermore, student motivation remains predominantly extrinsic, indicating a lack of scholarly zeal. Analysis from the teachers' perspective identifies the root of these issues in the dominance of procedural, routine-based approaches in current classroom practices. Importantly, teachers demonstrate critical awareness of these limitations and explicitly express a need for innovative, contextually relevant teaching models. Within this context, ethnomathematics emerges as a strategic yet underutilized resource. Its integration into the Challenge-Based Learning framework presents a logical and empirically grounded response to the identified gaps. This hybrid model is proposed to create an authentic, meaningful, and culturally relevant learning environment that is anticipated to simultaneously foster scholarly zeal and holistically develop students' creative problem-solving capacities. Thus, this needs assessment successfully establishes a robust foundation for the subsequent design and development of the proposed model.

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