

Reconceptualizing Mathematical Literacy Through Culturally Responsive Problem-based Learning: A Systematic Literature Review and Future Research Framework

Arlina Yuza¹, Armianti^{2*}, Azwar Ananda³

¹Doctoral Program in Education, Postgraduate School, Universitas Negeri Padang, Padang, West Sumatra, Indonesia, ²Department of Mathematics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Padang, West Sumatra, Indonesia, ³Pancasila and Citizenship Education, Department of Social Sciences Education, Universitas Negeri Padang, Padang, West Sumatra, Indonesia. *Corresponding Author's Email: armianti@fmipa.unp.ac.id

Abstract

Mathematical literacy is a key competency in mathematics education, requiring learners to formulate, employ and interpret mathematics in authentic real-world contexts. Although Problem-Based Learning (PBL) has demonstrated potential to support mathematical learning, evidence on how cultural contexts are integrated into PBL to foster mathematical literacy remains fragmented. This systematic literature review examined research trends in culturally responsive PBL, identified approaches for integrating cultural and ethnomathematical elements into PBL, analyzed how these approaches support mathematical literacy and developed an evidence-informed conceptual framework for future research. Following PRISMA 2020 guidelines, the search covered studies published from January 2018 through March 2026 and was conducted in Scopus and Web of Science. The search identified 1,847 records. After removal of duplicates, 1,312 records were screened, 287 full-text articles were assessed for eligibility and 198 were excluded, resulting in 89 studies for the final synthesis. Bibliometric analysis and thematic synthesis identified three major research themes: problem-based mathematics learning, culturally responsive and ethnomathematics-based instruction and mathematical literacy development. The synthesis also identified three levels of cultural integration in PBL, ranging from cultural representation to cultural transformation. Deeper integration showed greater potential to support students' abilities to formulate, employ and interpret mathematics. Based on these findings, the review proposes the Culturally Responsive Problem-Based Mathematical Literacy (CR-PBML) Framework, which conceptualizes culturally meaningful problem contexts as a pedagogical mechanism linking learners' sociocultural experiences with mathematical literacy development. The framework offers theoretical guidance for future research and practical implications for curriculum development and mathematics instruction.

Keywords: Culturally Responsive Pedagogy, Ethnomathematics, Mathematical Literacy, Mathematics Education, Problem-based Learning, Systematic Literature Review.

Introduction

Mathematical literacy is a central goal of contemporary mathematics education, enabling learners to formulate, employ and interpret mathematics in meaningful situations (1). Beyond procedural proficiency, it involves connecting mathematical knowledge with reasoning, problem solving, communication and decision-making in relevant contexts. PISA and other international assessment frameworks position mathematical literacy as an essential competency for participation in complex social and technological environments (2–4). However, many learners struggle to transfer classroom mathematics to unfamiliar contextual problems, particularly those from disadvantaged backgrounds. This challenge highlights the need for learning environments that

connect mathematical ideas meaningfully with learners' experiences and the contexts in which mathematics is used (5).

Problem-Based Learning (PBL) offers a suitable pedagogical structure by engaging learners with authentic, often ill-structured problems that require investigation, collaboration, mathematical reasoning and solution construction. Evidence suggests that PBL can support mathematical achievement, problem solving, conceptual understanding and engagement (6). However, problem authenticity involves more than complexity or real-world resemblance (7). Problems may be formally authentic yet culturally unfamiliar, limiting meaningful formulation and interpretation when disconnected from learners' community

This is an Open Access article distributed under the terms of the Creative Commons Attribution CC BY license (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution and reproduction in any medium, provided the original work is properly cited.

(Received 13th June 2026; Accepted 26th September 2026; Published 23rd October 2026)

practices and prior experiences (8). Thus, the key issue is not merely whether PBL uses real-world problems, but whose realities are represented and how learners' cultural knowledge informs mathematical inquiry.

This issue brings culturally responsive pedagogy and ethnomathematics into closer dialogue with PBL. Culturally responsive approaches recognize learners' cultural knowledge, identities, values and community experiences as resources, while ethnomathematics highlights mathematical ideas embedded in cultural activities and social contexts. Thus, culture should function not merely as an attractive context but as a resource through which learners identify problems, formulate mathematical questions, negotiate meanings and interpret solutions (9). This perspective is particularly relevant to mathematical literacy, as formulation and interpretation require connections between mathematical representations and meaningful contexts (10). Culture therefore serves as an interpretive lens for negotiating and constructing mathematical meaning (1, 3). Making culturally meaningful PBL a promising approach for connecting formal mathematics with learners' identities and lived experiences (7).

Although research on PBL, mathematical literacy, ethnomathematics and culturally responsive mathematics education has expanded, these strands of scholarship have largely developed as partially separate bodies of knowledge. A recent systematic review of PBL in K-12 mathematics primarily examined instructional characteristics and learning outcomes, while reviews of ethnomathematics have emphasized patterns of cultural integration in mathematics teaching and learning (7). Research on mathematical literacy has likewise examined its influencing factors and development, but cultural responsiveness has received comparatively less attention as a pedagogical mechanism within problem-based learning (4). Studies of culturally responsive mathematics teaching have further highlighted teachers' practices and the challenges of implementing equitable instruction, but they have not yet provided a sufficiently integrated account of how cultural resources become part of the processes through which learners formulate, employ and interpret mathematics. Reviews examining culturally responsive pedagogy in mathematics classrooms similarly tend to

emphasize teachers' perceptions and practices rather than the pedagogical mechanisms linking cultural responsiveness to measurable literacy outcomes (10).

Consequently, the literature provides substantial evidence for each perspective individually, but less evidence explaining how they operate together within a coherent pedagogical design (11).

Although research on PBL, mathematical literacy, ethnomathematics and culturally responsive mathematics education has expanded, these areas have largely developed as separate bodies of knowledge. Recent reviews have examined PBL characteristics and outcomes, ethnomathematical integration and factors influencing mathematical literacy, but cultural responsiveness remains underexplored as a pedagogical mechanism within PBL (7). Research on culturally responsive mathematics teaching has also focused mainly on teachers' practices and implementation challenges, with limited attention to how cultural resources support learners in formulating, employing and interpreting mathematics (10). Thus, although each perspective is well established, their integration within a coherent pedagogical design remains insufficiently understood (12-14). Finally, no systematic review has comprehensively synthesized these interconnected domains while developing an integrative framework to explain their relationships and guide future instructional innovation. Addressing this gap is essential for advancing theory and evidence-informed practice. The present systematic literature review addresses these gaps by examining the field at structural and conceptual levels. It maps publication patterns and thematic relationships while synthesizing how cultural and ethnomathematical resources are integrated into PBL and related to mathematical literacy processes (9, 10). Its distinctive contribution is identifying relationships among PBL, culturally responsive pedagogy, ethnomathematics and mathematical literacy to explain how culturally situated problem solving may support literacy development. Based on the synthesized evidence, the review develops the Culturally Responsive Problem-Based Mathematical Literacy (CR-PBML) Framework, positioning cultural experiences as potential epistemic resources for problem formulation, investigation, modeling, interpretation and transfer. The framework is evidence-informed rather than a

validated causal model and provides a basis for future empirical testing and refinement.

Accordingly, this systematic literature review examines research published from January 2018 through March 2026 to address four questions:

RQ1: What are the publication trends, geographical distributions and thematic patterns of research on culturally responsive PBL and mathematical literacy?

RQ2: How are cultural, ethnomathematical and culturally responsive elements integrated into PBL in mathematics education?

RQ3: Through what pedagogical mechanisms does culturally responsive PBL support mathematical literacy, particularly the processes of formulating, employing and interpreting mathematics?

RQ4: What conceptual relationships emerging from the literature can inform an integrative framework for culturally responsive Problem-Based Mathematical Literacy?

Methodology

Review Design

This study employed a systematic literature review (SLR) guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement to ensure methodological transparency, reproducibility and comprehensive reporting (15). A systematic review was selected to synthesize empirical evidence, identify recurring research patterns and develop an integrative conceptual framework concerning culturally responsive Problem-Based Learning (PBL) and mathematical literacy. To strengthen methodological rigor, the review integrated bibliometric analysis with qualitative thematic synthesis following recent methodological guidance that recommends an explicit, staged combination of quantitative mapping and qualitative synthesis (16–18). This integrated approach enables the intellectual structure of the research field to be examined quantitatively while its conceptual, pedagogical and contextual dimensions are analyzed qualitatively (19, 20).

Bibliometric analysis was used to examine the structural development of the field, including publication trends, geographical distribution, author collaboration and keyword co-occurrence (21–23). Thematic synthesis complemented the bibliometric analysis by examining pedagogical characteristics, cultural integration strategies and

the mechanisms through which culturally responsive PBL may support mathematical literacy development (24). The integration of these analytical approaches enabled the review to capture both the evolution of the research landscape and the conceptual relationships emerging across the selected studies (25).

Before data collection, a review protocol was established a priori to define the research objectives, search strategy, eligibility criteria, screening procedures, quality appraisal and analytical methods. Establishing the protocol before the review helped minimize potential selection bias and maintain methodological consistency throughout the review process, consistent with recommended practices for rigorous systematic and bibliometric-systematic reviews (15, 16).

Search Strategy and Eligibility Criteria

A comprehensive literature search was conducted in Scopus and the Web of Science (WoS) Core Collection, which provide broad multidisciplinary coverage and structured bibliographic metadata suitable for systematic and bibliometric review research (26). Combining both databases was intended to enhance retrieval comprehensiveness and reduce coverage bias associated with relying on a single bibliographic source, as Scopus and WoS differ in journal coverage, regional representation and disciplinary scope (20, 26). Restricting the database search to these two sources also provided a consistent basis for bibliographic screening, metadata analysis and subsequent synthesis.

The search covered studies published from January 2018 through March 2026. This period was selected to capture contemporary developments in mathematical literacy, culturally responsive pedagogy, ethnomathematics and Problem-Based Learning, consistent with the recent growth of research in culturally responsive mathematics education and PBL (7). The search was conducted initially in January 2026 and subsequently updated in March 2026 to capture publications indexed during the review period.

Searches were performed across the title, abstract and keyword fields using combinations of controlled vocabulary and Boolean operators. The primary search strategy was as follows:

("problem-based learning" OR "problem based learning")

AND

("mathematical literacy" OR "mathematics education" OR "mathematical reasoning")

AND

("ethnomathematics" OR "local wisdom" OR "cultural context"

OR "culturally responsive teaching"

OR "culturally responsive pedagogy"

OR "situated learning")

To maximize retrieval comprehensiveness, backward citation tracking (snowballing) was conducted for relevant and influential publications identified during the database search. This supplementary strategy was used to identify potentially relevant studies that might not have been retrieved through the predefined keyword search and to reduce the risk of omission associated with terminology-dependent database retrieval (16). Studies were considered eligible when they:

- (a) investigated Problem-Based Learning or a problem-based instructional approach within mathematics education;
- (b) incorporated cultural contexts, ethnomathematics, or culturally responsive pedagogy as central instructional components;
- (c) examined mathematical literacy, mathematical reasoning, or related mathematical competencies;
- (d) were published as peer reviewed journal articles; and
- (e) were written in English or Indonesian.

Studies were excluded if they were conference proceedings, dissertations, theses, editorials, book chapters, reports, or other forms of grey literature, consistent with quality-control recommendations for systematic and bibliometric systematic reviews that emphasize the use of peer-reviewed sources for evidence synthesis (16, 26). Publications focusing primarily on non-mathematics disciplines

or on cultural issues unrelated to mathematics education were also excluded to maintain conceptual consistency throughout the review.

Study Selection

The study selection process followed the four stages recommended in PRISMA 2020: identification, screening, eligibility and inclusion (15). All records retrieved from Scopus and Web of Science were exported to a reference management system, where duplicate records were identified and removed through a combination of automatic and manual procedures before screening. This data-cleaning procedure was consistent with standard practices for integrating bibliographic databases in systematic and bibliometric-systematic reviews (16).

Titles and abstracts were independently screened by two reviewers using the predefined eligibility criteria. This dual-reviewer procedure was adopted to minimize selection bias and improve the reliability of the screening process (16, 27). Disagreements between reviewers were resolved through discussion until consensus was reached. Records that met the initial screening criteria were subsequently subjected to full-text assessment to determine their eligibility for inclusion in the review.

The database search identified 1,847 records from Scopus and Web of Science. After removal of duplicate records, 1,312 unique records remained for title and abstract screening. During this stage, 1,025 records were excluded because they did not meet the predefined eligibility criteria. The remaining 287 articles were assessed through full-text review. Following the full-text eligibility assessment, 198 articles were excluded because they did not satisfy one or more inclusion criteria, resulting in 89 studies included in the final review and synthesis. The numerical progression of the study selection process is presented in Table 1 and follows the PRISMA 2020 reporting structure (15).

Table 1: PRISMA 2020 Study Selection Process

PRISMA Phase	Activity	Records
Identification	Records identified through Scopus and WoS	1,847
Identification	Records after duplicate removal	1,312
Screening	Records excluded after title and abstract screening	1,025
Eligibility	Full-text articles assessed	287
Eligibility	Full-text articles excluded	198
Included	Studies included in the final synthesis	89

Quality Appraisal

The methodological quality of the included studies was assessed using the Mixed Methods Appraisal Tool (MMAT), Version 2018, which provides design-specific criteria for appraising qualitative, quantitative and mixed-methods studies (27). MMAT was selected because the studies included in this review employed heterogeneous methodological designs, making a design-sensitive appraisal approach appropriate for the synthesis. Its application is also consistent with recent education-focused systematic reviews that assess evidence from diverse methodological approaches (7).

Each included study was independently assessed by two reviewers using the five MMAT criteria corresponding to its methodological design. For the purposes of this review, the number of criteria satisfied by each study was summarized as a percentage to provide a consistent descriptive indicator of methodological quality across the heterogeneous body of evidence. A 50% threshold was applied as the predefined quality criterion for inclusion in the thematic synthesis. Studies that did not meet this threshold were excluded from the thematic synthesis but retained in the bibliometric analysis so that their publication characteristics could still contribute to the mapping of the research landscape. This procedure allowed the review to distinguish between the assessment of the structural development of the field and the quality-sensitive synthesis of substantive findings (16).

Inter-rater agreement between the two reviewers was assessed using Cohen's kappa coefficient, yielding $\kappa = 0.81$, which indicates strong agreement between reviewers (28–30). The agreement estimate provides evidence of consistency in the reviewers' application of the predefined appraisal criteria.

Data Analysis

Data analysis was conducted through four complementary stages: data extraction and analytical mapping, bibliometric analysis, thematic synthesis and conceptual framework development. These stages were organized to correspond to the research questions and to provide a systematic progression from descriptive mapping of the literature to qualitative synthesis and evidence-informed conceptual development, following the analysis synthesis–theory development logic

recommended for combined bibliometric-systematic literature reviews (16).

First, data extraction and analytical mapping were conducted to organize the evidence reported across the included studies. Relevant information was systematically extracted from each study, including bibliographic characteristics, study context, participants, Problem-Based Learning characteristics, cultural or ethnomathematical elements, mathematical content, mathematical literacy processes or competencies, reported pedagogical mechanisms and major findings. The extracted information was organized into an analytical mapping matrix to facilitate comparison across studies and to provide a transparent basis for subsequent bibliometric and thematic analyses. This stage also supported the identification of recurring concepts and relationships relevant to the development of the CR-PBML Framework.

Second, bibliometric analysis was performed using VOSviewer (31) and the Bibliometrix package in R (32, 33) to examine publication trends, geographical distribution, collaboration networks and keyword co-occurrence. The analysis followed established performance-analysis and science-mapping procedures for identifying the structural and intellectual characteristics of a research field (20). The resulting bibliometric maps were used to characterize the development and thematic structure of research on culturally responsive PBL and mathematical literacy and to address RQ1.

Third, thematic synthesis was conducted following established procedures for qualitative evidence synthesis (34). Full-text studies were inductively coded to identify recurring concepts related to cultural integration, instructional design, mathematical content, mathematical literacy processes and reported learning outcomes (7). Initial codes were compared across studies and progressively organized into descriptive themes. These descriptive themes were subsequently interpreted and synthesized into higher-order analytical themes that explained how cultural contexts and PBL processes were connected to mathematical learning and mathematical literacy development. This stage addressed RQ2 and RQ3. Finally, the analytical themes and cross-study relationships were integrated to construct the Culturally Responsive Problem Based Mathematical Literacy (CR-PBML) Framework. Framework development followed an established

concept-building approach (35), complemented by guidance for theory development in bibliometric-systematic reviews (16). Recurring concepts, pedagogical processes, cultural dimensions and mathematical literacy mechanisms identified across the included studies were compared, organized and synthesized into a coherent conceptual structure. The resulting framework identifies relationships among learners' cultural experiences, culturally meaningful problem formulation, collaborative investigation, mathematical modeling, cultural reflection and interpretation and the transfer of mathematical literacy to authentic contexts. The framework was developed as an evidence-informed conceptual framework rather than a validated causal model and therefore provides a basis for future empirical testing, refinement and curriculum development. This stage addressed RQ4.

Results

Research Landscape: Publication

Trends and Geographic Distribution

The bibliometric analysis of the 89 included studies revealed an overall increase in research at the intersection of culturally responsive Problem-Based Learning (PBL) and mathematical literacy during the review period. Publication activity increased particularly from 2020 onward, indicating growing scholarly attention to the relationship between problem-based mathematics learning, cultural contexts and mathematical literacy.

The geographical distribution of the included

studies was concentrated in Southeast Asia (38%), with Indonesia ($n = 24$) and Malaysia ($n = 10$) representing the largest national contributions within the region. Studies from Sub-Saharan Africa accounted for 22%, while South America accounted for 15% and North America and Europe combined accounted for 25%. This distribution indicates a substantial contribution from regions in which cultural and ethnomathematical perspectives have been actively incorporated into mathematics education research.

The most frequently represented journals included *ZDM Mathematics Education*, *Educational Studies in Mathematics*, the *International Journal of Science and Mathematics Education* and the *Journal on Mathematics Education*. The author collaboration network revealed two prominent research communities: a Southeast Asian cluster characterized by research on ethnomathematics and culturally contextualized curriculum design and a broader international cluster associated with mathematical literacy assessment and PBL effectiveness.

Keyword Clusters and Research

Themes

VOSviewer keyword co-occurrence analysis identified three dominant thematic clusters across the 89 included studies. Table 2 presents these clusters and their representative keywords, highlighting three interconnected research orientations: problem-based mathematics learning, cultural and ethnomathematical mathematics education and mathematical literacy development.

Table 2: Keyword Co-occurrence Clusters

Cluster	Central Keywords	Core Focus
Cluster 1: PBL in Mathematics	Inquiry-based learning; collaborative problem solving; critical thinking; STEM; self-directed learning	Problem-based instructional design and learner-centered mathematical investigation
Cluster 2: Cultural Mathematics	Ethnomathematics; indigenous knowledge; local wisdom; cultural artifacts; community mathematics	Integration of cultural knowledge and community practices into mathematics learning
Cluster 3: Mathematical Literacy	PISA framework; mathematical modeling; reasoning; formulating; interpreting	Development and assessment of mathematical literacy competencies

The three clusters indicate that the literature has developed around three complementary dimensions. Cluster 1 emphasizes the instructional processes associated with PBL; Cluster 2 focuses on the cultural and ethnomathematical foundations of mathematics learning; and Cluster 3 centers on mathematical literacy, particularly

mathematical modeling, reasoning and the processes of formulating and interpreting mathematical situations. The co-occurrence pattern therefore suggests an intellectual structure in which instructional design, cultural context and mathematical literacy constitute interconnected but distinguishable strands of research.

Models of Cultural Integration in PBL Mathematics

The thematic synthesis identified three levels of cultural integration in PBL-based mathematics learning. The levels form a progressive typology based on the role assigned to culture within the learning process, ranging from the use of cultural elements as representational resources to their use as epistemic resources that shape mathematical inquiry and reasoning.

Level 1: Cultural Representation

At Level 1, cultural elements are primarily used as visual, contextual, or physical representations to illustrate mathematical concepts. Examples include traditional textiles, architectural patterns, cultural artifacts and locally familiar measurement tools. In this configuration, the cultural element provides a recognizable context or motivational support, while the underlying mathematical task remains largely unchanged. Studies classified at this level reported outcomes primarily related to student engagement, contextual familiarity and procedural mathematical performance.

Level 2: Cultural Contextualization

At Level 2, cultural practices and community activities constitute the source of the mathematical problem situation. Students investigate problems derived from contexts such as traditional market transactions, agricultural planning, weaving patterns, or other locally meaningful practices. The cultural context therefore becomes part of the problem structure rather than merely an illustrative resource.

Within this level, students are expected to formulate mathematical representations, select appropriate mathematical tools and apply mathematical concepts to culturally meaningful problems. The reviewed studies associated this form of integration with mathematical reasoning, problem-solving dispositions and perceptions of mathematics as relevant to students' everyday lives.

Level 3: Cultural Transformation

At Level 3, culture functions as an epistemic resource for mathematical inquiry. Cultural knowledge does not merely provide the context for a problem; it shapes how mathematical relationships are explored, represented, reasoned about and interpreted. Students engage in ethnomathematical inquiry to examine how mathematical ideas and practices are conceptualized within their communities and connect these understandings with formal mathematical knowledge. Although fewer studies were identified at this level, the reviewed literature associated this deeper form of cultural integration with broader mathematical literacy processes, including the capacity to formulate, interpret and communicate mathematical ideas across contexts. As summarized in Table 3, this level represents the most substantive form of cultural integration identified in the reviewed literature, in which cultural knowledge functions as an epistemic resource within mathematical inquiry.

Table 3: Cultural Integration Typology in PBL Mathematics Environments

Integration Level	Role of Culture	PBL Design Feature	Dominant Mathematical Literacy Process	References
Level 1: Cultural Representation	Cultural artifact or representation used as a motivational or illustrative resource	Mathematical problems remain largely conventional, with cultural elements providing contextual or visual support	Employing	(36, 37)
Level 2: Cultural Contextualization	Cultural practice serves as the source of an authentic mathematical problem	Problems are formulated from culturally meaningful practices and investigated through PBL	Formulating + Employing	(38, 39)
Level 3: Cultural Transformation	Cultural knowledge functions as an epistemic resource for mathematical reasoning	Ethnomathematical inquiry shapes problem investigation, representation and interpretation	Formulating + Employing + Interpreting	(40, 41)

Impact on Mathematical Literacy Competencies

The thematic synthesis further identified relationships between culturally responsive PBL activities and the three primary mathematical literacy processes reflected in the PISA framework: formulating, employing and interpreting. Across the reviewed studies, the activities associated with

these processes could be organized into four broad pedagogical functions: exploring culturally situated problems, conducting mathematical investigation and modeling, critically reflecting on and communicating solutions and comparing mathematical ideas across cultural contexts. Table 4 summarizes these four pedagogical functions and their relationships with the corresponding mathematical literacy processes.

Table 4: Culturally Responsive PBL Activities and Mathematical Literacy Processes

Culturally Responsive PBL Activity	Mathematical Literacy Process	Example Competency Developed
Exploring culturally situated problem contexts	Formulating	Translating community situations into mathematical representations and identifying relevant mathematical variables
Mathematical investigation and modeling	Employing	Selecting and applying mathematical concepts, procedures, representations and models to culturally situated problems
Critical reflection and communication	Interpreting	Evaluating mathematical solutions in relation to cultural meanings and real-world conditions
Cross-cultural mathematical comparison	Formulating + Employing + Interpreting	Recognizing both the common mathematical structure and cultural specificity of mathematical ideas

The synthesis indicates a progression from contextual engagement to mathematical representation, application, interpretation and transfer across contexts. Exploring culturally situated problems primarily engages the formulation process because students must identify and represent the mathematical structure embedded in a meaningful situation. Mathematical investigation and modeling emphasize the employing process through the selection and application of mathematical concepts and procedures. Critical reflection and communication extend the process toward interpretation by requiring students to evaluate mathematical results against contextual and cultural considerations. Cross-cultural comparison potentially integrates all three processes by requiring students to examine mathematical ideas across different cultural settings.

Notably, studies involving Levels 2 and 3 of cultural integration showed a stronger association with the formulating process than studies operating primarily at Level 1. In these deeper forms of integration, students encounter mathematical problems that originate from culturally meaningful situations and are therefore required to translate situated experiences into mathematical representations. This pattern suggests that cultural familiarity may provide

contextual resources for engaging with the formulation stage of mathematical literacy, although the reviewed literature does not by itself establish a causal relationship between cultural familiarity and improved formulation performance.

Discussion

Principal Findings

This systematic literature review synthesized evidence from 89 peer-reviewed studies to examine how culturally responsive Problem-Based Learning (PBL) relates to mathematical literacy across diverse educational contexts. In relation to RQ1, the bibliometric analysis indicates growing scholarly attention to the intersection of PBL, cultural and ethnomathematical perspectives and mathematical literacy. The literature is geographically diverse, with particularly strong contributions from Southeast Asia. The keyword co-occurrence analysis further identified three interconnected research strands: problem-based mathematics learning, cultural and ethnomathematical mathematics education and mathematical literacy development. Regarding RQ2, the thematic synthesis identified three levels of cultural integration: Cultural Representation, Cultural Contextualization and Cultural Transformation. These levels distinguish culture

according to its functional role in the learning process. At Level 1, cultural elements primarily provide illustrative or motivational support; at Level 2, cultural practices become sources of authentic mathematical problems; and at Level 3, cultural knowledge functions as an epistemic resource that contributes to mathematical inquiry, representation, reasoning and interpretation. This distinction provides a more precise account of cultural integration than treating culturally responsive instruction as a single, homogeneous approach.

Regarding RQ3, the synthesis indicates that culturally responsive PBL can engage the three mathematical literacy processes of formulating, employing and interpreting. Culturally situated problems provide opportunities for learners to identify mathematical structures within meaningful situations, construct and apply mathematical representations and evaluate solutions in relation to contextual conditions. Studies involving deeper cultural integration were associated with a broader range of mathematical literacy processes, although this pattern should be interpreted as an association rather than evidence of causality. Regarding RQ4, the relationships identified across the literature informed the development of the Culturally Responsive Problem-Based Mathematical Literacy (CR-PBML) Framework. The framework integrates six interconnected components: Cultural Experience, Authentic Problem Formulation, Collaborative Investigation, Mathematical Modeling, Cultural Reflection and Interpretation and Literacy Transfer. Together, these findings suggest that cultural experience can function not merely as a context for applying mathematics but as a meaningful resource for initiating and interpreting mathematical inquiry.

Interpretation in Relation to Previous Research

The findings extend previous research by bringing together research traditions that have often examined PBL, ethnomathematics, culturally responsive pedagogy and mathematical literacy separately. Previous research has highlighted the potential of PBL to support inquiry, problem solving, collaboration and learner-centered mathematics learning, while research on ethnomathematics has emphasized the importance of connecting mathematical ideas with

cultural practices and community knowledge (7–9). The present synthesis suggests that these perspectives can be connected through culturally situated problem formulation, investigation, modeling and interpretation.

The three-level cultural integration typology provides a more differentiated interpretation of this relationship. At Level 1 (Cultural Representation), cultural artifacts or familiar situations primarily support the presentation of mathematical concepts. At Level 2 (Cultural Contextualization), cultural practices become sources of authentic mathematical problems, requiring students to connect contextual situations with mathematical representations. At Level 3 (Cultural Transformation), cultural knowledge assumes a deeper epistemic role in shaping how mathematical problems are explored, represented, reasoned about and interpreted. This progression is consistent with broader arguments that culturally responsive mathematics education should move beyond the superficial inclusion of cultural examples toward more substantive engagement with learners' knowledge and experiences (10).

The findings also provide a more specific interpretation of the relationship between cultural integration and mathematical literacy. At lower levels of integration, cultural contexts may primarily support the employing of established mathematical concepts and procedures. At deeper levels, learners are more directly involved in identifying mathematical structures, constructing representations and interpreting mathematical solutions within the contexts from which problems emerge. This interpretation is compatible with perspectives that conceptualize mathematical literacy as the meaningful use of mathematics in authentic situations rather than procedural competence alone (3, 4).

The role of cultural familiarity provides another possible explanation for these patterns. Familiar situations may give learners contextual knowledge that helps them recognize relevant quantities, relationships and problem structures before formal mathematical modeling begins. This interpretation complements PBL research emphasizing the importance of prior knowledge, task design and problem characteristics in learning (5). It is also compatible with research suggesting that greater contextual or cognitive congruence

between learning tasks and learners' existing knowledge may influence how learners process problem-solving information (42). Nevertheless, this interpretation requires caution. The reviewed evidence does not establish that cultural familiarity directly reduces cognitive load or causes improvements in mathematical literacy. Rather, it suggests a plausible pedagogical mechanism through which familiar cultural situations may support the transition from contextual understanding to mathematical representation. This distinction is important because the heterogeneity of the reviewed studies does not permit strong causal conclusions.

Theoretical Contributions

The first theoretical contribution of this review is the conceptualization of culture as an epistemic resource for mathematical learning. The synthesis suggests that cultural knowledge can contribute not only to the contextualization of mathematical content but also to the processes through which learners identify, formulate, investigate and interpret mathematical problems. This perspective extends culturally responsive mathematics education by emphasizing the potential knowledge-producing role of learners' cultural experiences (10). The second contribution is the three-level cultural integration typology. The distinction between Cultural Representation, Cultural Contextualization and Cultural Transformation provides a conceptual tool for examining the depth and function of cultural integration within PBL-based mathematics learning. Rather than assuming that any inclusion of cultural content constitutes culturally responsive practice, the typology directs attention to what culture actually does within the mathematical learning process.

The third contribution is the connection between cultural integration and the three mathematical literacy processes of formulating, employing and interpreting. The synthesis suggests that deeper cultural integration may create opportunities for learners to move beyond applying predetermined mathematical procedures toward constructing mathematical representations and interpreting solutions in relation to meaningful contexts. This provides a more integrated conceptualization of mathematical literacy within culturally diverse learning environments (3, 4).

Taken together, these contributions support a view of culturally responsive PBL as an integrative pedagogical process in which cultural experience, inquiry, collaboration, modeling and reflection interact rather than operate as isolated instructional techniques (7). The contribution of the present review is therefore primarily conceptual: it identifies relationships across previously connected but partly separate strands of research.

CR-PBML Framework

Building on the cross-study synthesis, this review proposes the Culturally Responsive Problem-Based Mathematical Literacy (CR-PBML) Framework as an evidence-informed conceptual framework linking cultural experience, PBL processes and mathematical literacy. The framework does not simply combine PBL, culturally responsive pedagogy, ethnomathematics and mathematical literacy as separate constructs. Its principal contribution is to specify relationships among these dimensions and to position cultural experience as a potential starting point for mathematical problem formulation and inquiry.

The framework comprises six interconnected components: Cultural Experience, Authentic Problem Formulation, Collaborative Investigation, Mathematical Modeling, Cultural Reflection and Interpretation and Literacy Transfer. Cultural Experience represents learners' existing knowledge, community practices and sociocultural experiences that provide meaningful entry points into mathematical inquiry (8). These experiences inform Authentic Problem Formulation, through which culturally meaningful situations are transformed into mathematical problems. Collaborative Investigation provides opportunities for learners to exchange perspectives, negotiate interpretations and examine mathematical relationships through shared inquiry (43). Mathematical Modeling then enables learners to construct representations, select mathematical tools, test relationships and refine solutions.

The framework further incorporates Cultural Reflection and Interpretation, through which learners examine mathematical solutions in relation to the cultural and practical conditions from which problems emerge. This extends mathematical activity beyond obtaining a mathematically valid answer by encouraging

consideration of whether a solution is meaningful and appropriate within its context. Literacy Transfer represents the extension of mathematical competencies to new or unfamiliar situations, particularly the ability to formulate, employ and interpret mathematics beyond the original learning context.

The six components should not be interpreted as a rigid linear sequence. Collaborative investigation, mathematical modeling and cultural interpretation may occur recursively as learners revise their mathematical representations and deepen their understanding of the problem context. This interpretation is consistent with the inquiry-oriented and iterative character of PBL identified in previous research (7). Accordingly, the framework represents interconnected pedagogical functions rather than six mandatory chronological stages.

The distinctive advancement of the CR-PBML Framework lies in treating culture as an epistemic starting point rather than merely a contextual backdrop. Existing research has addressed important dimensions of PBL, ethnomathematics, culturally responsive pedagogy and mathematical literacy, but these strands have often developed in parallel (7). The present synthesis connects them by proposing that learners' cultural experiences can inform problem formulation, shape inquiry and modeling, contribute to contextual interpretation and support the transfer of mathematical literacy.

Importantly, the CR-PBML Framework is an evidence-informed conceptual framework rather than a validated causal model. Its proposed relationships should therefore be tested, refined, or potentially rejected through future empirical research rather than treated as established causal mechanisms.

Practical Implications

The findings have implications for curriculum development, classroom instruction, teacher education and educational policy. For curriculum developers, the three-level typology provides a practical basis for evaluating whether cultural elements function merely as representations or contribute substantively to mathematical problem formulation and inquiry. A culturally responsive curriculum therefore does not necessarily require every mathematical task to originate from a cultural practice; rather, it should consider the

functional role assigned to culture within the learning process (10).

At the classroom level, the CR-PBML Framework can guide teachers in designing culturally responsive PBL activities. Teachers can identify learners' cultural experiences and community practices, transform relevant situations into mathematically meaningful problems, facilitate collaborative investigation and guide learners toward mathematical modeling and contextual interpretation (43). This approach can help move beyond superficially contextualized word problems toward tasks in which cultural knowledge has a substantive role in mathematical inquiry.

The framework also has implications for teacher education and professional development. Teachers need opportunities not only to develop PBL competence but also to investigate mathematical practices within the communities they serve and translate those practices into mathematically rigorous learning tasks. Professional development may therefore incorporate ethnomathematical inquiry, community-based investigation, culturally responsive task design and reflection on relationships between local knowledge and formal mathematics (10). Such preparation can support teachers in maintaining mathematical rigor while making learning more meaningful and responsive to students' experiences (4).

At the policy level, implementation requires alignment among curriculum resources, teacher support and assessment practices. Curriculum policy alone may be insufficient when teachers lack the resources and professional preparation needed to enact culturally responsive PBL (44). Assessment should also provide opportunities for learners to demonstrate mathematical competence through meaningful contextual problem solving rather than relying exclusively on decontextualized procedural measures. Such alignment can help ensure that cultural responsiveness becomes an integral feature of mathematics learning rather than a purely symbolic addition to the curriculum (10).

Limitations

Several limitations should be considered when interpreting the findings. First, the review was limited to studies indexed in Scopus and Web of Science, meaning that relevant studies indexed in other databases may not have been captured. Second, the inclusion of studies published in

English and Indonesian may have introduced language-related selection bias. Third, the review covered publications from January 2018 through March 2026 and studies published after the search period were therefore outside the scope of the synthesis.

Fourth, the identification of relevant studies was partly dependent on the terminology and search terms used to describe PBL, cultural responsiveness, ethnomathematics and mathematical literacy. Terminological variation across disciplines may therefore have resulted in potentially relevant studies being missed. The supplementary use of citation tracking may have reduced this risk but does not eliminate it.

Fifth, the included studies showed substantial heterogeneity in research design, educational level, cultural setting, mathematical content and outcome measures. This heterogeneity limits direct comparison across studies and makes quantitative aggregation inappropriate for the present synthesis. Finally, the CR-PBML Framework was developed through conceptual synthesis and has not yet been empirically validated. Its proposed relationships should consequently be interpreted as theoretically informed propositions rather than established causal mechanisms.

Future Research Directions

Future research should move from conceptual description toward empirical testing of the relationships proposed by the CR-PBML Framework. Experimental and quasi-experimental studies could examine whether different levels of cultural integration are associated with differences in students' mathematical literacy, particularly their abilities to formulate, employ and interpret mathematics. Further research should also examine the six framework components individually and in combination, particularly Authentic Problem Formulation, Mathematical Modeling and Cultural Reflection and Interpretation, which represent potentially important connections between cultural experience and mathematical literacy. Studies should determine whether these components operate sequentially, interactively, or recursively.

Cross-cultural and comparative research is also needed to examine whether the framework operates similarly across different communities, educational levels and cultural settings. Such

research would be particularly valuable for distinguishing principles that may be broadly applicable from those that are dependent on specific cultural or educational contexts. Longitudinal studies could further investigate whether sustained engagement with culturally responsive PBL supports the long-term development and transfer of mathematical literacy beyond the original learning environment. Future research should also develop and validate indicators or instruments for measuring the depth of cultural integration and the enactment of CR-PBML in classroom settings. Ultimately, empirical testing of these propositions will determine whether the CR-PBML Framework can be strengthened into a more robust explanatory model of culturally responsive mathematical learning.

Conclusion

This systematic literature review synthesized evidence from 89 peer-reviewed studies to address four research questions concerning the development of culturally responsive Problem-Based Learning (PBL) and mathematical literacy. Regarding RQ1, the bibliometric findings indicate a growing research interest in the intersection of PBL, cultural and ethnomathematical perspectives and mathematical literacy, particularly since 2020. The literature is geographically diverse but shows a strong contribution from Southeast Asia, especially Indonesia and Malaysia. The keyword analysis further reveals three interconnected research strands: problem-based mathematics learning, cultural and ethnomathematical mathematics education and mathematical literacy development. These patterns suggest that the field is developing across related but previously fragmented research traditions.

Regarding RQ2, the thematic synthesis identified three levels of cultural integration in PBL-based mathematics learning: Cultural Representation, Cultural Contextualization and Cultural Transformation. The levels differ according to the functional role of culture in the learning process. At the first level, culture primarily provides illustrative or contextual support. At the second, cultural practices become sources of authentic mathematical problems. At the third level, cultural knowledge functions as an epistemic resource that influences mathematical inquiry, representation,

reasoning and interpretation. This typology provides a more precise way of distinguishing superficial cultural inclusion from deeper forms of culturally responsive mathematics learning.

Regarding RQ3, the synthesis indicates that culturally responsive PBL can engage the three core mathematical literacy processes of formulating, employing and interpreting. Culturally situated problems create opportunities for learners to translate familiar situations into mathematical representations, apply mathematical concepts and models and evaluate solutions in relation to contextual and cultural meanings. The evidence also suggests that deeper cultural integration, particularly Levels 2 and 3, is associated with a broader range of mathematical literacy processes than cultural representation alone. However, these associations should not be interpreted as evidence of direct causality.

Regarding RQ4, the relationships identified across the literature informed the development of the Culturally Responsive Problem-Based Mathematical Literacy (CR-PBML) Framework. The framework connects six interrelated components: Cultural Experience, Authentic Problem Formulation, Collaborative Investigation, Mathematical Modeling, Cultural Reflection and Interpretation and Literacy Transfer. Rather than treating these components as a fixed sequence, the framework conceptualizes them as interconnected functions through which learners' cultural experiences can inform problem formulation, mathematical inquiry, interpretation and the transfer of mathematical literacy to new contexts. Overall, the review suggests that the contribution of culturally responsive PBL lies not simply in adding cultural examples to mathematics instruction, but in using learners' cultural experiences as meaningful resources for mathematical inquiry. The CR-PBML Framework therefore offers an evidence-informed conceptual basis for connecting cultural responsiveness, PBL and mathematical literacy. Because the framework has not yet been empirically validated, future research should test its components and proposed relationships across different learners, cultural settings and educational levels.

Abbreviations

CR-PBML: Culturally Responsive Problem-Based Mathematical Literacy, CRP: Culturally Responsive Pedagogy, MMAT: Mixed Methods Appraisal Tool,

OECD: Organisation for Economic Co-operation and Development, PBL: Problem-Based Learning, PISA: Programme for International Student Assessment, PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses, SLR: Systematic Literature Review, WoS: Web of Science.

Acknowledgement

The authors would like to express their sincere gratitude to Padang State University, Indonesia, for providing academic support throughout the completion of this study. The authors also acknowledge the valuable contributions of researchers whose published works formed the foundation of this systematic literature review and whose scholarly contributions have advanced understanding of culturally responsive mathematics education and mathematical literacy.

Author Contributions

Arlina Yuza: Conceptualization, Methodology, Literature Search, Data Curation, Formal Analysis, Thematic Synthesis, Visualization, Writing-Original Draft, Armia: Supervision, Conceptualization, Methodology Validation, Interpretation of Findings, Writing-Review and Editing, Azwar Ananda: Supervision, Critical Review, Theoretical Refinement and Writing Review, Editing. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that they have no competing interests or personal relationships that could have influenced the work reported in this paper.

Data Availability

The datasets analyzed in this study were obtained from publicly accessible publications indexed in the Scopus and Web of Science Core Collection databases. The search strategy, eligibility criteria and study selection process are fully described in the Method section to support transparency and reproducibility. Additional information supporting the findings of this review is available from the corresponding author upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that generative artificial intelligence (AI) tools, namely ChatGPT (GPT), Grammarly AI and Canva AI, were used during the

preparation of this manuscript. ChatGPT (GPT) and Grammarly AI were used to assist with language editing, grammatical correction, readability improvement and editorial refinement. Canva AI was used to assist with the preparation and visual refinement of selected figures. These AI tools were not used to independently generate or determine the research design, literature selection, data analysis, data interpretation, results, or scientific conclusions. All AI-assisted outputs were critically reviewed, verified and revised by the authors. The authors retain full responsibility for the originality, accuracy, integrity, interpretation and final content of the manuscript, including all figures and other visual materials.

Ethics Approval

This study was a systematic literature review based exclusively on previously published studies retrieved from the Scopus and Web of Science databases. It did not involve human participants, animals, personal data, or experimental procedures. The research was reviewed and administratively approved by Padang State University, as documented in Approval Letter No. 3324/UN35.15/TU/2026. Accordingly, formal informed consent from participants was not required because the study relied solely on published literature and secondary data sources.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

- Jablonka E, Ginsburg S. Learning and the evolution of conscious agents. *Biosemiotics*. 2022;15(3):401-437. doi:10.1007/s12304-022-09501-y
- Ismail RN, Yerizon, Fauzan A. Exploring self-regulated learning and their impact on students' mathematical communication skills on the topic of number patterns with the blended learning system. *J High Educ Theory Pract*. 2023;23(16):207-224. doi:10.33423/jhetp.v23i16.6477
- Ginsburg S, Jablonka E. Evolutionary transitions in learning and cognition. *Philos Trans R Soc B*. 2021;376(1821):20190766. doi:10.1098/rstb.2019.0766
- Kappassova S, Abylkassymova A, Bulut U, Zykrina S, Zhumagulova Z, Balta N. Mathematical literacy and its influencing factors: a decade of research findings (2015-2024). *Eurasia J Math Sci Technol Educ*. 2025;21(7):em2671. doi:10.29333/ejmste/16615
- Zulkardi, Zulkardi, Ratu Ilma Indra Putri, Fauzan A, Sagita L, Alfajri R, Silvhiyany S, Adelia V, Anggeraini Y, Anisah Putri D, Wahyu Utami N, Mursetya Somasih Dwipa N, Siska Utari R, Sukma Y, Alvionita Azka D, Nasuha Ismail R, Sari N, Asra A, Fitriani N. A ssessment frameworks utilized by PIAAC for evaluating adult problem-solving skills. *Math Educ J*. 2026;20(2):423-448. doi:10.22342/mej.v20i2.pp423-448
- Awacorach J, Jensen I, Lassen I, Olanya DR, Zakaria HL, Tabo GO. Exploring transition in higher education: engagement and challenges in moving from teacher-centered to student-centered learning. *J Probl Based Learn High Educ*. 2021;9(2):113-130. doi:10.5278/ojs.jpblhe.v0i0.5262
- Ayari MA, Sellami A, Santhosh ME, Naji KK, Al-Ali A, Al-Hazbi SMA. From problems to performance: a systematic review of problem-based learning in K-12 mathematics. *Front Educ*. 2025;(10):1731307. doi:10.3389/educ.2025.1731307
- Sunzuma G, Maharaj A. In-service mathematics teachers' knowledge and awareness of ethnomathematics approaches. *Int J Math Educ Sci Technol*. 2021;52(7):1063-1078. doi:10.1080/0020739X.2020.1736351
- Sunzuma G, Maharaj A. In-service Zimbabwean teachers' obstacles in integrating ethnomathematics approaches into the teaching and learning of geometry. *J Curric Stud*. 2021;53(5):601-620. doi:10.1080/00220272.2020.1825820
- Comstock M, Shores KA, Litke E, Desimone LM, Polanco C, Hill KL. Toward more equitable instruction: how teachers integrate ambitious, traditional and culturally responsive mathematics practices. *AERA Open*. 2025;11:23328584251331464. doi:10.1177/23328584251331463
- Pitorini D, Suciati, Harlita. Using an e-module based on problem-based learning combined with Socratic dialogue to develop students' critical thinking skills: a qualitative study. *J Educ Online*. 2025;22(1):n1. doi:10.9743/JEO.2025.22.1.18
- Gundeger Kilci C. Determining key predictors of students' latent profiles in mathematical literacy: evidence from PISA 2022 using LASSO logistic regression analysis. *Curr Psychol*. 2026;45(12):1138. <https://doi.org/10.1007/s12144-026-09714-1>
- Hellaç Aksu Z, Reisoğlu İ. Factors predicting lifelong learning tendencies of preservice teachers in the context of MOOCs. *Interact Learn Environ*. 2026;34(3):1178-1193. doi:10.1080/10494820.2025.2519124
- Tetteh A, Awaah F, Armah M, Boakye L, Ugwuoke U. Towards understanding cyberbullying behaviour: exploring the predictive power of Hofstede's cultural dimensions. *Int J Bullying Prev*. 2026;1-16. doi:10.1007/s42380-026-00347-3
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;(372):n71. doi:10.1136/bmj.n7

16. Marzi G, Balzano M, Caputo A, Pellegrini MM. Guidelines for bibliometric-systematic literature reviews: 10 steps to combine analysis, synthesis and theory development. *Int J Manag Rev.* 2025;27(1):81-103.
doi:10.1111/ijmr.12381
17. Nguyen KH, Tran MD. Tracing research trends and conceptual structures in interoceptive awareness and mindfulness (2008-2025): a quantitative science mapping approach. *Curr Psychol.* 2026;45(6):655.
doi:10.1007/s12144-026-09256-6
18. Mortazavi S, Hajikhani A, Laine I, Salloum C. Mapping the discourse of Sustainable Development Goals: a mixed-method bibliometric and thematic exploration. *Manag Decis.* 2026;64(6):2484-2513.
doi:10.1108/MD-10-2024-2455
19. Santibáñez D, Vega A, Cofré H, Salas N, Adsuar J. Bibliometric analysis of pedagogical content knowledge: countries, authors and fields of knowledge. *Eurasia J Math Sci Technol Educ.* 2025;21(2):em2583.
doi:10.29333/ejmste/15953
20. Donthu N, Kumar S, Mills A, Pattnaik D. Journal of marketing education: a retrospective overview between 1979 and 2019. *J Mark Educ.* 2021;43(2):139-158.
<https://doi.org/10.1177/0273475321996026>
21. Heo J, Zhang T, Hua N, Zhao X. Exploring the dual-aspect well-being of digital nomads in tourism and hospitality: a conceptual framework. *J Smart Tour.* 2026;6(1):3-16.
doi:10.1177/27652157251390605
22. Rawluk A, Ford R, Anderson N, Williams K. Exploring multiple dimensions of values and valuing: a conceptual framework for mapping and translating values for social-ecological research and practice. *Sustain Sci.* 2019;14(5):1187-1200.
doi:10.1007/s11625-018-0639-1
23. Chen X, Yu G, Cheng G, Hao T. Research topics, author profiles and collaboration networks in the top-ranked journal on educational technology over the past 40 years: a bibliometric analysis. *J Comput Educ.* 2019;6(4):563-585.
doi:10.1007/s40692-019-00149-1
24. Zhao Z. Research on teaching strategies for project-based learning in upper elementary school mathematics culture. *Educ Insights.* 2024;1(4):12-18.
doi:10.70088/2103ab68
25. Chotisarn N, Phuthong T. Mapping the landscape of marketing technology: trends, theories and trajectories in ecosystem research. *Cogent Bus Manag.* 2025;12(1):2448608.
doi:10.1080/23311975.2024.2448608
26. Prancutè R. Web of Science (WoS) and Scopus: the titans of bibliographic information in today's academic world. *Publications.* 2021;9(1):12.
doi:10.3390/publications9010012
27. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, Gagnon MP, Griffiths F, Nicolau B, O'Cathain A, Rousseau MC, Vedel I, Pluye P. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Educ Inf.* 2018;34(4):285-291.
doi:10.3233/EFI-180221
28. Staibano P, Ham J, Chen J, Zhang H, Gupta MK. Inter-rater reliability of thyroid ultrasound risk criteria: a systematic review and meta-analysis. *Laryngoscope.* 2023;133(3):485-493.
doi:10.1002/lary.30347
29. Du K, Shah S, Bollepalli SC, Ibrahim MN, Gadari A, Sutharahan S, Sahel JA, Chhablani J, Vupparaboina KK. Inter-rater reliability in labeling quality and pathological features of retinal OCT scans: a customized annotation software approach. *PloS One.* 2024;19(12):e0314707.
doi:10.1371/journal.pone.0314707
30. Barth J, de Boer WEL, Busse JW, Hoving JL, Kedzia S, Couban R, Fischer K, von Allmen DY, Spanjer J, Kunz R. Inter-rater agreement in evaluation of disability: systematic review of reproducibility studies. *BMJ.* 2017;356:j14.
doi:10.1136/bmj.j14
31. Waltman L, Van Eck NJ, Noyons ECM. A unified approach to mapping and clustering of bibliometric networks. *J Informetr.* 2010;4(4):629-635.
doi:10.1016/j.joi.2010.07.002
32. Sánchez-Marco M, Montoro-Pérez N, Rubio-Aparicio M, Cabañero-Martínez MJ, Lozano-Casanova M, Escribano S. Psychometric properties of instruments for assessing the methodological quality and risk of bias in non-randomized studies of interventions: a systematic review and meta-analysis in accordance with the COSMIN guideline. *J Clin Epidemiol.* 2026;194:112230.
doi:10.1016/j.jclinepi.2026.112230
33. Aria M, Cuccurullo C. bibliometrix: an R-tool for comprehensive science mapping analysis. *J Inforetr.* 2017;11(4):959-975.
doi:10.1016/j.joi.2017.08.007
34. Thomas J, Harden A. Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Med Res Methodol.* 2008;8:45.
doi:10.1186/1471-2288-8-45
35. Jabareen Y. Building a conceptual framework: philosophy, definitions and procedure. *Int J Qual Methods.* 2009;8(4):49-62.
doi:10.1177/160940690900800406
36. Febriana R, Putri PO, Hidayati IS. Ethnomathematics exploration in the traditional game of Sipak Rago. *Edumatika J Ris Pendidik Mat.* 2022;5(1):24-34.
doi:10.32939/ejrpm.v5i1.1306
37. Prahmana RCI, Istiandaru A. Learning sets theory using shadow puppet: a study of Javanese ethnomathematics. *Mathematics.* 2021;9(22):2938.
doi:10.3390/math9222938
38. Risdiyanti I, Prahmana RCI. Designing learning trajectory of set through the Indonesian shadow puppets and Mahabharata stories. *Infinity J.* 2021;10(2):331-348.
doi:10.22460/infinity.v10i2.p331-348
39. Darmayanti R, Effendi MM, Hasanah N, In'am A. Development of ethnomathematical media based on the Book Creator application on the Syawalan tradition in the junior high school curriculum. *AL-ISHLAH J Pendidik.* 2022;14(4):6181-6196.
doi:10.35445/alishlah.v14i4.2416
40. Dediwalage M, Kalogeropoulos P, Russo J, Vale C. A systematic literature review of student, parent and teacher experiences of mathematics education in

- multicultural classrooms. *Rev Educ.* 2025;13(3):e70109.
doi:10.1002/rev3.70109
41. Orey DC, Rosa M. Ethnomodelling as a glocalization process of mathematical practices through cultural dynamism. *The Math Enthusiast.* 2021;18(3):439-468.
doi:10.54870/1551-3440.1533
 42. Scheibe DA, Was CA, Dunlosky J, Thompson CA. Metacognitive cues, working memory and math anxiety: the regulated attention in mathematical problem solving (RAMPS) framework. *J Intell.* 2023;11(6):117.
doi:10.3390/jintelligence11060117
 43. Xenofontos C, Nolan KT. Special issue introduction: critical perspectives on mathematics teacher education. *Educ Sci.* 2023;13(12):1218.
doi:10.3390/educsci13121218
 44. Vithal R, Brodie K, Subbaye R. Equity in mathematics education. *ZDM Math Educ.* 2024;56(1):153-164.
doi:10.1007/s11858-023-01504-4

How to Cite: Yuza A, Armiami, Ananda A. Reconceptualizing Mathematical Literacy Through Culturally Responsive Problem-based Learning: A Systematic Literature Review and Future Research Framework. *Int Res J Multidiscip Scope.* 2026;7(4):1587-1602. DOI: 10.47857/irjms.2026.v07i04.012882