**Pedagogical Research**
2026, 11(3), em0280
e-ISSN: 2468-4929
https://www.pedagogicalresearch.com/

MODESTUM

**Research Article** **OPEN ACCESS**

# Critical mathematics education in Thai secondary classrooms: Barriers, opportunities, and implications for urban context-based instruction

Nattakarn Poomkornsan [1,2*], Pisith Nasee [1], Omsin Jatuporn [1], Jensamut Saengpun [1]

[1] Chiang Mai University, THAILAND
[2] Nareerat School Phrae, THAILAND
***Corresponding Author:** nattakarn@nareerat.ac.th

**Citation:** Poomkornsan, N., Nasee, P., Jatuporn, O., & Saengpun, J. (2026). Critical mathematics education in Thai secondary classrooms: Barriers, opportunities, and implications for urban context-based instruction. *Pedagogical Research, 11*(3), em0280. https://doi.org/10.29333/pr/19018

**ARTICLE INFO**

Received: 21 Jan. 2026

Accepted: 25 Jun. 2026

**ABSTRACT**

Critical mathematics education (CME) emerged in Western contexts that assume students will voice dissent and openly challenge mathematics as political. This qualitative phase 1 study examines how Thai secondary mathematics educators understand and enact CME in a hierarchical, examination-driven setting where those assumptions do not necessarily hold. Through semistructured interviews with five scholars and seven teachers, alongside observations of project-based instruction, thematic analysis produced three constructs. Depoliticization is the institutional process that removes political content from critical frameworks while retaining the language of critical thinking. Suppressed silence, inferred from teacher accounts and classroom observations rather than direct student data, describes critical awareness that students may hold but have learned not to voice. Gentle criticality describes critiques expressed through quiet questioning and community-oriented inquiry rather than open confrontation. As provisional constructs, they offer a vocabulary for theorizing CME in collectivist contexts not fully addressed by Western frameworks, grounding subsequent model development.

**Keywords:** critical pedagogy, mathematics teaching, teacher beliefs and practices, pedagogical barriers, professional development

## INTRODUCTION

Critical mathematics education (CME) emerged from intellectual and political struggles in distinct historical contexts. Paulo Freire developed his pedagogy under authoritarian rule in Brazil, Eric Gutstein articulated his work within the contested terrain of urban classrooms in the United States, and Ole Skovsmose developed mathematics education theory on the basis of the Scandinavian traditions of democracy and participation (Freire, 1970; Gutstein, 2006; Skovsmose, 1994). These origins matter because CME treats mathematics not as a neutral subject but as a site for exposing power relations, supporting critical consciousness, and enabling students to question social inequality. However, these assumptions are not necessarily generalizable to different cultural and institutional contexts.

In educational systems where silence is culturally valued and where authority structures shape classroom interactions, the dialogic ideals of CME fit uneasily with everyday norms. In Thailand, mathematics education has historically emphasized procedural competence, examination performance, and hierarchical transmission of knowledge (OECD, 2023; Taranet, 2017). Centralized curricula and high-stakes assessments continue to reinforce a view of mathematics as objective and apolitical. Moreover, classroom participation is shaped by *kreng jai*—a culturally embedded reluctance to impose one's views or challenge authority—which may constrain open critique even when teachers encourage discussion.

This raises both practical and theoretical questions. Much of the international literature has developed within Western traditions that assume the legitimacy of public critique, individual voice, and democratic participation (Stinson et al., 2024). When CME is interpreted within collectivist, examination-oriented contexts such as Thailand, not only are the possibilities of critical pedagogy revealed but the cultural assumptions embedded within the framework itself are also exposed. Examining CME within this context clarifies how far its assumptions extend and where they must be adapted.

This article forms part of an ongoing doctoral dissertation in Development Education at the Faculty of Education, Chiang Mai University. Preliminary findings from this research were presented at the 29th International Social Sciences and Business Research Conference, January 2025.

Recent scholarship recognizes that mathematics education is not politically neutral and that equity and social justice belong at the center of the field (Stinson et al., 2024), reflecting a wider turn toward social-justice concerns across educational research, including adjacent fields such as educational leadership (Karakose et al., 2023). Studies across diverse contexts demonstrate both the promise and the challenges of teaching mathematics in ways that engage structural inequality through critical inquiry (Khan & Rizvi, 2024; Wickstrom et al., 2024; Wright, 2020). However, empirical studies examining how CME is conceptualized and enacted in Southeast Asian contexts remain limited. In Thailand specifically, increasing attention has been given to socially responsive approaches to mathematics education, yet little research has explored Thai educators' understanding of the aims of CME and where it proves workable in practice.

Phase 1 of this study examines how Thai secondary mathematics educators conceptualize and navigate CME within their professional and institutional realities. It focuses on urban contexts because provincial cities in Thailand present socially meaningful issues—waste management, public-space allocation, and unequal access to resources—that are mathematically analyzable yet politically and socially consequential, functioning as generative themes for critical inquiry that let mathematics serve as a means of examining the social conditions under which those problems emerge.

Accordingly, this study addresses two research questions. First, how do Thai mathematics educators conceptualize CME, particularly its social justice orientation and critical consciousness goals? Second, what facilitating factors, structural barriers, and future directions shape CME implementation in secondary mathematics classrooms in Thailand? By addressing these questions, this study aims to provide empirical and conceptual grounding for contextually responsive CME approaches attentive to both the transformative goals of critical pedagogy and the educational realities in Thailand.

## LITERATURE REVIEW AND THEORETICAL FRAMEWORK

### Critical Pedagogy: From Banking Education to Critical Consciousness

The philosophical foundation of critical mathematics education lies in Paulo Freire's critical pedagogy (Freire, 1970, 1973). Freire criticized the "banking model" in which students passively receive knowledge from teachers as unquestioned authorities, discouraging critical inquiry and reproducing existing power relations. He instead proposed education as liberation, centered on critical consciousness (conscientização)—the capacity to perceive social contradictions and act upon them. This consciousness emerges through praxis, the interplay of reflection and action, facilitated by dialog in which teachers and students engage as coinvestigators of reality.

Freire also stressed that critical pedagogy is not a fixed doctrine; it must be adapted to learners' lived realities and cultural contexts (Frankenstein, 1983).

### Critical Mathematics Education: Reading and Writing the World through Mathematics

Critical mathematics education (CME) extends Freirean philosophy into mathematics instruction by challenging the assumption that mathematics is neutral and value-free (Skovsmose, 2023). CME scholars argue that mathematics is deeply involved in structuring social, economic, and political systems and can either obscure or illuminate inequities (Frankenstein, 1983).

Gutstein's (2006) framework of "reading and writing the world with mathematics" articulates two complementary pedagogical goals. First, students must develop a proficiency in mathematics that is aligned with conventional academic standards. Second, students must cultivate a social justice orientation, where mathematics is used to analyze inequities ("reading the world") and to propose informed actions for change ("writing the world"). Skovsmose (1994, 2023) further conceptualized "landscapes of investigation," which are learning environments where students engage in open-ended inquiry around meaningful social problems, connecting mathematical reasoning with real-world contexts.

CME does not prescribe universal teaching methods; rather, it requires adaptation to local cultural values, institutional structures, and community realities (Frankenstein, 1983; Gutstein, 2006; Skovsmose, 2023). This adaptability is both the strength of CME and its main implementation challenge.

Recent extensions include Skovsmose's (2023) argument that mathematical knowledge increasingly operates as power through algorithmic decision-making and data-driven governance and Penteado and Skovsmose's (2022) development of "landscapes of investigation" to examine how shifts between exercise-based and open-ended inquiry affect students' agency. More broadly, recent scholarship places equity at the center of curriculum and teaching (Skovsmose, 2023; Stinson et al., 2024).

### International Research on CME Implementation

Empirical research in Western contexts shows the transformative potential of CME alongside persistent challenges. Gutstein's (2006) work in urban U.S. classrooms demonstrated that students could develop mathematical competence while engaging in social-justice inquiry, but studies also report tensions between rigor and social analysis, limited teacher preparedness, and institutional constraints (Bartell, 2013; Brantlinger, 2013; Wright, 2017). These implementation challenges are not unique to CME. Research on instructional reform more broadly finds that sustained change depends on professional development, supportive curricula, and school leadership—for example, Papadakis et al.'s (2024) meta-analysis links leadership for learning to student outcomes through teacher performance—conditions that apply to CME even though that work does not address it directly.

Wickstrom et al. (2024) reported that effective CME teaching moves past surface-level real-world connections toward tasks where students analyze structural inequalities mathematically, with lessons that integrate content and social-justice ideas rather than separating them.

Working with five English secondary teachers, Wright (2020) reported that collaborative participatory action research helped teachers question procedural instruction and develop more engaging curricula—a structured route for changing tradition-bound settings.

Geiger et al. (2023) argued that mathematical and statistical literacy are essential for democratic participation, preparing students for civic as well as economic roles—aligning with the transformative goals of CME. Similarly, Suh et al. (2024) reported that when teacher scaffolding is performed carefully, interdisciplinary problem-based learning that combines mathematical analysis with social issues builds both competence and critical awareness.

Stinson et al. (2024) argue that mathematics education is never politically neutral and that equity research must examine structural inequities embedded in institutions across Western and postcolonial contexts—underscoring a recurring challenge: translating philosophical acceptance of equity into practice that confronts rather than reproduces structural inequity.

### CME in Asian and Thai Educational Contexts

CME research in Asian contexts remains limited, although emerging work—such as Khan and Rizvi's (2024) action research in Pakistani classrooms—signals growing interest in critical approaches within non-Western systems. Education in Asia often emphasizes hierarchical teacher–student relationships and high-stakes examinations, conditions that may conflict with dialogic, inquiry-based pedagogies. In Thailand, mathematics education research has largely centered on cognitive skill development and test performance (OECD, 2023; Taranet, 2017), and empirical studies on CME implementation are scarce, although scholars have begun calling for critical, socially responsive approaches (Nokkaew & Chuechote, 2022). Understanding how Thai educators interpret and enact CME is therefore a necessary precursor to culturally responsive critical pedagogies.

Roberts et al. (2024) examined mathematics education across global contexts, including South and Southeast Asia, documenting how local cultural values, colonial educational legacies, and current policy environments shape what is possible for critical pedagogical approaches. Asian contexts pose particular challenges—hierarchical traditions and examination-driven accountability—but also offer distinctive resources such as strong community ties that can support collaborative inquiry.

In their study of ethnomathematics across Indonesia and Thailand, Payadnya et al. (2024) reported that educators valued practices that connect mathematics with local culture to deepen engagement and foster appreciation of cultural heritage, while noting the complexity of integration—work that supports culturally responsive mathematics education but centers on cultural integration rather than explicit social-justice analysis.

In South Asia, Panthi et al. (2021) reported that while Nepali mathematics teachers valued connecting mathematics with social realities, prescribed curricula, nonparticipatory teaching norms, and limited support constrained implementation—patterns that mirror challenges in Thailand and point to shared Asian dynamics that call for cross-national study.

### Urban Contexts as Pedagogical Resources

Urbanization generates complex social, economic, and environmental challenges that are both mathematically analyzable and socially meaningful (Hirsch, 1973; Royal Institute, 2013). Issues such as waste management, public-space allocation, and unequal access to resources provide authentic, data-rich contexts for mathematical inquiry—aligning with Skovsmose's landscapes of investigation and Gutstein's emphasis on students' lived experiences and building engagement, conceptual understanding, and agency through community-based problem analysis.

Takona (2025) argues that critical pedagogy retains its emancipatory force when teaching is grounded in students' social realities, making communities and their problems active sites of learning rather than backdrops—this supports the use of urban municipal contexts as settings for building both mathematical ability and critical awareness.

### Synthesis of Research Gaps

The reviewed literature reveals five key gaps.

1. CME implementation remains challenging even in Western contexts, as extensive teacher support and institutional flexibility are needed.
2. Asian and Thai contexts remain underrepresented in CME research; Western frameworks developed in settings where the legitimacy of critical pedagogy is at least open to debate and public critique is a recognized mode of student expression cannot be assumed to transfer to hierarchical, examination-driven, collectivist contexts—sharpening the need for context-sensitive empirical work.
3. Urban contexts remain underutilized as integrated pedagogical resources in CME scholarship.
4. Although international work has given increasing attention to equity in mathematics education (Stinson et al., 2024; Wickstrom et al., 2024), empirical studies in non-Western classrooms remain limited. Karakose et al. (2023) bibliometric analysis (2003–2022) documents growth concentrated in Western institutional contexts. Scholars consistently note that critical frameworks require cultural adaptation when applied in contexts with educational traditions with different assumptions about authority, knowledge, and social relations (Roberts et al., 2024; Skovsmose, 2023).
5. CME increasingly connects with broader concerns—sustainability (Geiger & Schmid, 2024; Makramalla et al., 2025), democratic citizenship (Geiger et al., 2023), community-based inquiry (Takona, 2025), and technology-enhanced

instruction (Uğraş et al., 2024)—widening its scope and underscoring the relevance of investigating CME implementation in diverse cultural contexts while addressing locally meaningful social issues.

These gaps point to the need to investigate how mathematics educators in Thailand currently understand and practice CME before any instructional model is designed. Phase 1 of this study therefore provides foundational empirical knowledge for developing urban context-based CME approaches suited to the educational and cultural realities in Thailand.

## METHODS

### Research Design

This Phase 1 study employed an exploratory qualitative research design to investigate how Thai secondary mathematics educators understand and enact Critical Mathematics Education (CME). Guided by an interpretivist paradigm, the study sought to explore participants' perspectives within their educational and cultural contexts. It follows the Standards for Reporting Qualitative Research (SRQR; O'Brien et al., 2014) to support transparency in design, sampling, data collection, analysis, and interpretation. Data were collected through semistructured interviews, classroom observations, and document analysis. Data analysis followed a thematic approach informed by grounded-theory coding procedures, allowing recurring patterns and conceptual categories to emerge through iterative comparison across data sources. The resulting constructs are presented as provisional concepts intended for further empirical examination rather than as established theory.

### Participants

Participants were selected through purposive and snowball sampling to ensure representation of both theoretical and practical perspectives on mathematics education. Two participant groups were involved:

Mathematics education scholars (n = 5) from higher education institutions were identified through expert referrals; all had research experience in mathematics education, critical pedagogy, or related fields and had published or conducted research related to CME.

Secondary mathematics teachers (n = 7) with experience implementing project-based or inquiry-oriented instruction were identified through professional networks; these teachers needed experience connecting mathematics with real-world or community issues while engaging students in questioning and dialog.

This dual-source sampling enabled triangulation between academic conceptions of CME and classroom practices. All participants consented voluntarily after being informed of the study's purposes and procedures.

During recruitment, the researcher invited ten individuals to participate in each group. Five academics and seven teachers agreed to participate. Some who declined indicated time constraints or uncertainty about whether their work aligned with CME, which remains relatively unfamiliar in the Thai educational context. The final sample comprised twelve participants who met the approved study criteria.

In qualitative research, sample size is guided by the depth and quality of data rather than statistical representativeness (Patton, 2015). Guest et al. (2006) reported that thematic saturation often occurs within six to twelve interviews when participants share similar professional backgrounds. Saturation in this study was assessed during coding rather than assumed in advance. The same core themes—including cognitive interpretations of CME, examination pressure, and hierarchical classroom relations—recurred across both participant groups, with few codes unique to individual participants. According to the later interviews, additional data contributed only minor elaborations rather than genuinely new insights, indicating sufficient thematic redundancy for the exploratory aims of the study.

Although small and not intended for statistical generalization, the sample offers conceptual insights that may transfer to similar educational contexts (Lincoln & Guba, 1985). Studies involving more diverse participants across regions would extend these findings.

### Data Collection

Data were collected between September 2024 and September 2025 using three complementary qualitative methods.

(1) **Semistructured interviews:** In-depth interviews with all twelve participants explored their understanding and perspectives on CME across four domains: theoretical foundations, current instructional practices, facilitators and obstacles, and future directions. Each interview lasted 45–60 minutes, was conducted in Thai, was audio-recorded with permission, and was transcribed verbatim.

(2) **Classroom observations:** Nonparticipant classroom observations were conducted in project-based mathematics classes taught by the seven teacher participants. Each teacher was observed once, in a Grade 10 or Grade 11 class, with each observation lasting approximately 90–120 minutes and focusing on instructional strategies, questioning practices, student participation, connections between mathematical content and real-world contexts, and evidence of critical inquiry in classroom activities. Each teacher chose the session to be observed, selecting a class period they felt comfortable with rather than one assigned by the researcher or fixed to a particular topic; this was intended to reduce pressure on participating teachers. Detailed field notes were recorded during and immediately after each session.

(3) **Document review:** Teaching materials, student project artifacts, lesson plans, and curricular documents provided contextual evidence; document analysis complemented the interview and observation data by revealing how critical or social orientations were reflected in the planned activities and assessment tasks.

### Data Analysis

Data were analyzed through a coding process informed by grounded-theory techniques (Corbin & Strauss, 2015). The interview transcripts, observation notes, and documents were examined through three stages of coding: open coding to identify meaningful units, axial coding to establish relationships among categories, and selective coding to refine categories into overarching themes. The analysis involved iterative comparisons across data sources and participant groups to identify recurring patterns. Peer debriefing with research collaborators was conducted throughout the analysis process to challenge interpretations and strengthen analytic rigor.

### Trustworthiness

To enhance credibility and trustworthiness, multiple validation strategies were employed (Creswell & Poth, 2018). Data triangulation across interviews, observations, and documents enabled cross-verification of emerging interpretations. Investigator triangulation through peer debriefing provided opportunities to refine analytic insights. Member checking with participants was employed to verify the accuracy of interpretations. An audit trail documented analytic decisions and theme development to ensure the transparency of the research process. These procedures helped ensure that the findings reflected the participants' perspectives and classroom realities.

### Researcher Positionality and Power Dynamics

The researcher occupied multiple positions—a doctoral candidate, a practicing secondary mathematics teacher, and the investigator—creating different power dynamics across participant groups.

In interviews with academics, the researcher was a junior scholar speaking with more senior colleagues, which may have limited candid reflection on institutional constraints. In interviews with and observations of teachers, the researcher occupied a more collegial role within overlapping professional networks, creating the possibility of receiving socially desirable responses. Classroom observation introduced an additional dynamic, as participants may present idealized versions of practice when being observed.

Several steps were taken to reduce these influences. The participants selected the time and setting for the interviews, and informal conversation preceded the recording to establish rapport. Member checking of interpretations was employed, and the researcher maintained a reflexive journal throughout to document assumptions and how positionality might shape interpretation (Berger, 2015).

### Ethical Considerations

This study received institutional Research Ethics Committee approval prior to data collection (approval details are provided on the title page). All the participants received an explanation of the study's purpose, procedures, and use of the data and provided written informed consent before their participation. Participation was voluntary, and participants were informed that they could decline any question or withdraw at any time without consequence. To protect confidentiality, identifying information was removed, pseudonyms were used throughout, and audio recordings, transcripts, and field notes were stored securely and accessed only by the researcher.

## RESULTS

### Conceptualizations of Critical Mathematics Education: Depoliticization as a Structural Process (RQ1)

Analysis revealed considerable variation in how participants understood Critical Mathematics Education (CME). Across both academic and teacher participants, however, a common pattern emerged: discussions of CME focused primarily on critical thinking, problem solving, and real-world applications, while explicit references to social justice, power, inequality, and political dimensions were largely absent.

Most participants described mathematics as a neutral and objective discipline and emphasized its role in developing students' procedural skills and conceptual understanding. Several participants associated CME with encouraging students to think critically and apply mathematics to everyday situations, but few connected mathematics to broader social concerns.

These findings suggest that participants tended to emphasize the cognitive aspects of CME while giving relatively little attention to its social and political dimensions. This pattern was observed across both groups of participants, although the degree of familiarity with CME varied considerably among individuals.

#### *Academic perspectives*

Two academic participants described CME as more than a pedagogical approach, emphasizing its potential to help students examine social structures through mathematics. One participant explained:

> "Critical mathematics should help students question structures in society, not only solve mathematical tasks. Students need to see how mathematics can reveal or hide inequalities."

The remaining three academic participants understood CME primarily in cognitive terms, emphasizing higher-order thinking, analytical reasoning, and problem solving, with relatively little reference to social transformation or critical consciousness. Several participants associated critical approaches with constructivist and inquiry-based pedagogies, highlighting student-centered learning, active participation, and the development of reasoning skills.

Although participants differed in their understandings of CME, most discussions focused on pedagogical approaches and cognitive development rather than on issues of social justice, power, or inequality.

### *Teacher perspectives*

The teacher participants exhibited a similar pattern, although the emphasis on cognitive and pedagogical aspects was more pronounced. Most teachers described CME as encouraging students to think independently, solve problems analytically, and connect mathematics to everyday life. One teacher explained:

> "It is about connecting mathematics to students' daily lives so they see relevance."

These descriptions emphasized critical thinking, problem solving, and the practical application of mathematics, with little reference to issues of power, inequality, or social transformation.

When the researcher introduced the theoretical foundations of CME during the interviews, several teachers expressed surprise at the possibility that mathematics could be used to address broader social issues. One teacher remarked:

> "I never thought mathematics could address inequality or fairness—I always saw it as a neutral subject focused on calculations and formulas."

Rather than rejecting the social justice orientation of CME, participants generally responded with curiosity and interest. Their responses suggested that many teachers had previously understood mathematics primarily as a neutral and technical subject. Similar views were observed across several participants, although the degree of familiarity with CME varied considerably.

### *Mathematics as a gatekeeper: The ideological function of neutrality*

The findings presented in Section *Conceptualizations of Critical Mathematics Education: Depoliticization as a Structural Process (RQ1)* suggest that participants generally understood mathematics as neutral, objective, and value-free. From a critical perspective, this understanding may serve important institutional functions within Thai education. Mathematics occupies a central role in determining educational opportunities, with examination results influencing students' access to academic tracks, institutions, and future careers. Such arrangements depend, at least in part, on the widespread perception that mathematical knowledge and assessment are objective and impartial (Apple, 2004; D'Ambrosio, 1985).

Viewed through this lens, questioning the neutrality of mathematics raises broader questions about what forms of knowledge are valued and rewarded within educational systems. Critical scholars have argued that examination systems may contribute to maintaining meritocratic legitimacy by presenting educational outcomes as the product of ability and effort, while giving less attention to differences in resources, preparation, and access to cultural capital (Apple, 2004).

The present findings do not permit conclusions about whether processes of depoliticization are intentional or explicitly designed. Rather, they suggest that understandings of mathematics as neutral are widely shared among participants and appear to extend beyond individual teachers' beliefs or preferences. Consequently, the limited attention given to the social and political dimensions of CME may reflect broader institutional and cultural conditions rather than simply a lack of familiarity with the literature.

At the same time, the predominance of cognitive interpretations should not necessarily be viewed as evidence of an absence of criticality. Participants' understandings may represent culturally situated forms of critique that differ from those emphasized within Freirean traditions. This possibility is explored further through the concept of gentle criticality discussed later in the paper.

### *Evidence from classroom observations*

Classroom observations supported the patterns identified in the interviews. All seven observed teachers employed collaborative group work, project-based activities, and open-ended questioning, demonstrating the use of student-centered instructional approaches. Teachers frequently encouraged mathematical reasoning through questions such as, *"How did you arrive at this answer?"* and *"Can you show your thinking process?"*

Across the observed lessons, instructional activities focused primarily on mathematical accuracy, procedural competence, and task completion. In one lesson, students analyzed survey data on spending patterns by calculating means, constructing graphs, and interpreting percentages. Students successfully completed the mathematical tasks and discussed their results, but classroom interactions remained focused on the accuracy of calculations and the interpretation of numerical findings.

Similarly, in another lesson, students investigated parking space allocation at their school by measuring areas, calculating optimization ratios, and proposing more efficient layouts. Students demonstrated sophisticated mathematical reasoning and generated several alternative designs. Discussion centered on efficiency and practical solutions, with little attention given to broader social or ethical considerations.

Field notes consistently indicated that teachers emphasized mathematical rigor and correct procedures. One observation note stated:

> "Teachers consistently emphasized mathematical rigor and correct procedures but rarely extended discussions beyond the mathematical results."

Overall, the observations suggested that student-centered and inquiry-oriented approaches were present in classrooms, but classroom discussions remained primarily focused on mathematical understanding and the completion of curricular tasks.

#### *Synthesis*

Across academic participants, teacher interviews, and classroom observations, a consistent pattern emerged. Participants generally associated Critical Mathematics Education with critical thinking, problem solving, and real-world applications, while explicit references to social justice, inequality, and broader social issues were relatively uncommon. Similarly, classroom observations revealed that although student-centered and inquiry-oriented approaches were widely used, discussions remained primarily focused on mathematical understanding, procedural competence, and task completion. Taken together, these findings suggest that participants tended to emphasize the cognitive and pedagogical dimensions of CME more strongly than its social and political aspects.

### Structural and Cultural Barriers to CME Implementation: From Obstacles to Ideology (RQ2)

The participants consistently identified overlapping structural and cultural constraints. Taken individually, these barriers—centralized curricula, time limitations, examination pressures, hierarchical relationships, and student silence—look like practical challenges. Taken together, they form a connected set of institutional arrangements in which each element reinforces the others, sustaining a mathematics education that remains politically bounded and tends to reproduce existing social arrangements.

#### *The examination system as a sorting mechanism: The political economy of mathematics education*

Examination pressure emerged as one of the most consistently reported barriers across participants. Teachers described tensions between their instructional aspirations and the demands of preparing students for high-stakes assessments. One teacher explained:

> "Exams test whether students can solve problems correctly and quickly. They don't assess critical thinking about society or understanding of inequalities. So, if I focus on social justice, am I really helping students succeed?"

Rather than indicating resistance to CME, this concern reflects the institutional realities within which teachers work. Participants consistently emphasized that examination performance remains a central priority for students, parents, and schools, creating limited opportunities for extended inquiry into broader social issues.

From a critical perspective, the prominence of examinations may be understood as serving functions that extend beyond assessment alone. Mathematics examinations play an important role in shaping educational opportunities, influencing students' access to academic tracks, institutions, and future careers. Such arrangements rely, at least in part, on the perception that mathematical achievement represents objective and impartial measures of ability and effort (Apple, 2004).

Critical scholars have argued that examination systems may also contribute to maintaining meritocratic legitimacy by framing educational outcomes primarily in terms of individual achievement, while giving less attention to differences in resources, preparation, and forms of cultural capital (Apple, 2004). In addition, the emphasis on procedural fluency and efficiency may encourage narrower conceptions of mathematical competence, leaving relatively little room for forms of inquiry that involve open-ended investigation or critical analysis.

Viewed in this way, the examination pressures described by participants may represent more than practical obstacles to implementing CME. They suggest that the priorities embedded within assessment systems may not always align with the broader goals of critical mathematics education. Consequently, efforts to promote CME may require consideration not only of classroom practices but also of the institutional structures and educational priorities that shape what counts as valued mathematical knowledge.

#### *Centralized curriculum and time constraints: Institutional priorities and structural constraints*

Teachers consistently identified the prescribed national curriculum and limited instructional time as major barriers to implementing extended forms of critical inquiry. One teacher captured this tension succinctly:

> "We barely have time to complete required content. If we spend class periods discussing social issues, students won't be prepared for examinations, and parents will complain."

Participants frequently described pressure to complete required content and prepare students for examinations. These demands were experienced as practical constraints that limited opportunities for broader discussions and inquiry-oriented activities.

From a critical perspective, however, such constraints may be understood as reflecting broader institutional priorities. Centralized curricula do more than specify content; they also shape what forms of mathematical activity are emphasized within classrooms and what purposes mathematics education is expected to serve. Within these conditions, teachers may perceive mathematical learning primarily in terms of content coverage, procedural competence, and examination preparation.

Similarly, the time pressures described by participants appear to reflect the competing demands placed upon teachers rather than merely individual circumstances. The urgency teachers expressed was genuine, but it arose within educational structures

organized around priorities that may differ from those proposed by Critical Mathematics Education. Consequently, opportunities for sustained social inquiry may become difficult to realize within existing curricular and assessment arrangements.

Taken together, these findings suggest that the barriers described by teachers extend beyond issues of individual willingness or pedagogical knowledge. They point to broader institutional conditions that shape how mathematics is understood and practiced and that may influence the possibilities for implementing CME within the Thai context.

### *Hierarchical classroom relationships and student silence: Institutional reproduction through cultural norms*

Participants consistently identified hierarchical teacher–student relationships and student deference as important challenges to dialogic teaching. One academic explained:

> "Students are taught from an early age to respect elders and not question authority. In classrooms, this means that students hesitate to challenge ideas, disagree with teachers, or voice controversial opinions—especially about sensitive topics like inequality."

Teachers described similar experiences. One participant noted:

> "Even when I encourage students to share different viewpoints, they wait to hear what I think first. They want to know the right answer rather than explore multiple possibilities."

Another teacher highlighted the difficulties involved in changing established classroom norms:

> "Many students still won't share what they think or disagree with the teacher, even when they see it differently. For this kind of learning to work, the classroom has to feel safe and open—and that's hard, because changing how both teachers and students are used to behaving takes time."

These patterns were also reflected in classroom observations, which showed that students generally participated in group activities and procedural discussions but rarely engaged in open disagreement or debate. Participants frequently associated such patterns with cultural values emphasizing respect, harmony, and *kreng jai*.

Because these interpretations are based primarily on teachers' accounts and classroom observations rather than on students' own perspectives, caution is required in drawing conclusions about students' intentions or beliefs. Nevertheless, the findings suggest that student silence may not be uniform and that different forms of silence may exist within mathematics classrooms. Some forms of silence may reflect culturally valued norms of respect and harmony, whereas others may represent what we term suppressed silence—a reluctance to express disagreement or controversial views publicly despite holding them. Understanding these differences may be important for designing forms of critical mathematics education that are responsive to local cultural contexts and classroom relationships.

### *Teacher preparation gaps: Conceptual formation, not just skills deficit*

Several teachers expressed uncertainty about how to connect mathematics with social issues. Participants frequently reported limited exposure to examples of Critical Mathematics Education during their own professional preparation and indicated that they lacked practical models for implementing such approaches within the Thai context. One teacher explained:

> "I don't know how to link quadratic equations or trigonometry with social justice. I wasn't taught this way myself, and I have no models to follow in Thai contexts."

These responses suggested that teachers' difficulties extended beyond a lack of instructional resources or specific pedagogical techniques. Although participants described using student-centered approaches such as questioning, group work, and collaborative learning, they often viewed mathematics primarily as a technical and procedural subject. Several teachers indicated that they had received little preparation for connecting mathematics with broader social issues or for facilitating discussions involving questions of inequality, fairness, or social responsibility.

Overall, participants expressed interest in learning more about CME and emphasized the need for practical examples and contextually relevant models that could support its implementation in Thai classrooms.

### *Synthesis: Structural barriers as interconnected systems*

Viewed together, the barriers identified in this study appear to form an interconnected set of institutional and cultural conditions rather than a series of isolated obstacles. Examination demands encourage content coverage, which contributes to time pressures and limits opportunities for extended inquiry. At the same time, teachers' limited exposure to CME and established classroom norms emphasizing deference and harmony may further constrain dialogic practices. These conditions appear to reinforce one another, making it difficult to address any single barrier independently.

From a critical perspective, such patterns suggest that supporting CME may require approaches that address multiple dimensions simultaneously. Professional learning communities, context-based inquiry, and alternative forms of assessment may provide opportunities for expanding teachers' capacities while creating spaces for critical dialogue and mathematical investigation. Rather than treating structural constraints as fixed or insurmountable, these approaches may offer ways of working within existing educational contexts while gradually broadening the purposes and possibilities of mathematics education.

### Facilitating Factors and Emerging Opportunities

Despite the reported barriers, participants identified enabling conditions and promising foundations for future CME development.

#### *Teacher capacity and professional learning*

The participants emphasized teacher capacity as the most important factor for successful CME implementation. Teachers expressed openness toward CME approaches when provided with concrete support. One teacher provided the following explanation:

> "If someone could show me step-by-step examples—how to teach specific topics while addressing social issues relevant to our students—I would definitely try it. I need models, not just theory."

Teachers identified the support they would need—concrete lesson examples adapted to the Thai curriculum, guidance for facilitating difficult discussions, sustained professional learning, and administrative backing—while academics stressed that effective CME also requires conviction about social-justice purposes, knowledge of critical frameworks, and the ability to create psychologically safe classrooms where students feel empowered to voice diverse perspectives.

#### *Contextualized learning through local issues*

The participants repeatedly highlighted the potential of contextualized learning, particularly through community-based and urban issues, to meaningfully engage students. Several teachers noted that using local problems increased student motivation and participation. One teacher provided the following description:

> "When students investigate issues they see in their own communities—like waste management or traffic problems—they become much more engaged. Mathematics suddenly feels relevant and useful rather than abstract."

Drawing on Dewey's learning-by-doing and cooperative learning, one teacher described how this played out in practice:

> "I have them work in groups with real numbers from the community—income from local products, visitor numbers, economic figures for the area—and then analyze it and present it as a project."

Here the critical work travels through the data rather than through direct claims, an early instance of the gentle criticality examined in the discussion: students examine questions of livelihood and local economy by way of figures they gather themselves, without being asked to take an open position.

Classroom observations documented this heightened engagement. In project-based lessons addressing community issues, students engaged in active collaboration and animated discussion and demonstrated personal investment in the findings. For example, students investigating school cafeteria pricing demonstrated intense engagement by measuring portions, calculating costs, comparing across vendors, and discussing results with peers.

Although these lessons stopped short of explicit social-justice analysis, they showed students' readiness to investigate real-world applications when content was connected to immediate experience, suggesting that existing project-based practices could be expanded toward critical dimensions with appropriate scaffolding.

Participants' reflections pointed to something deeper than heightened engagement: the urban problems they described functioned as what Freire (1970) called generative themes—real situations containing social contradictions that provoked questioning. Urban issues such as waste management, inadequate school restrooms, and billboard encroachment were not neutral mathematical contexts. Each involved resource allocation decisions, competing interests, and consequences felt unevenly across groups—which goes beyond what Wickstrom et al. (2024) called surface-level real-world connections toward structural inequalities that mathematical analysis can make visible. Three mechanisms connecting urban contexts to critical awareness, not just motivation, emerged from the data.

First, urban problems help students do what Gutstein (2006) calls "reading the world with mathematics". When students calculated the ratio of restroom facilities to the student population at their school, the numbers carried social meaning—the data were used to show a disparity they experienced daily but that had never been examined. One teacher reflected that "The numbers told a story students already felt but couldn't articulate. Once they had data, they wanted to know why the school had not addressed this." This is what Geiger et al. (2023) describe as mathematical literacy for democratic participation: using mathematics to question conditions in one's own life, not merely to compute.

Second, urban contexts positioned students as stakeholders rather than outside observers. Issues from within the school and surrounding municipality carried what participants called "authentic stakes"—problems whose outcomes affected students' daily lives. Academic 004 noted, "Students become different when the problem is theirs, not something from a textbook. They argue more, they question more, they care about whether the answer is fair—not just correct." That shift—from caring about correctness to caring about fairness—captures the movement from mathematical engagement to critical mathematical engagement, which Freire's (1973) conscientização requires.

Third, urban settings created what Skovsmose (1994) called "landscapes of investigation"—open-ended problems with no single correct answer. Billboard regulation, drainage planning, and parking allocation all require the balancing of economic interests against community welfare and equitable access. When students worked through these problems, they reported that different calculations led to different conclusions depending on whose priorities were foregrounded, a multiplicity that unsettled

students who were used to mathematics producing one right answer, and opened space for reflecting on how mathematical reasoning works in real-world decision-making.

Across these three mechanisms, a consistent picture emerges: urban contexts do more than motivate students. They change what mathematical inquiry is for, transforming it from a technical exercise to a way of understanding and questioning the social conditions that students actually inhabit.

#### *Existing inquiry-oriented practices*

Observations revealed that teachers already employ instructional practices that could support critical approaches.

These existing practices show teachers' capacity for facilitating rather than engaging in transmission-oriented instruction. One academic noted the following:

> "Teachers already know how to guide student investigations and manage collaborative learning. They just need frameworks for directing inquiry toward social issues and critical consciousness, not only toward content mastery."

Participants also noted growing institutional interest in 21st-century competencies—critical thinking, problem-solving, communication, and responsible citizenship—a discourse that could create space for introducing CME as aligned with contemporary priorities, although careful framing would be needed given cultural sensitivities around social critique.

### Questioning Practices in Mathematics Classrooms

Teachers regularly employed questioning as a central teaching tool, but question types and purposes remained focused on cognitive reasoning rather than critical social analysis.

#### *Observed question patterns*

Teachers frequently use open-ended questions to promote student explanation and reasoning. Common questions included the following:

> "How did you reach this solution?"

> "What method did you use, and why did you choose that approach?"

These questions successfully encouraged student articulation of mathematical thinking and created opportunities for peer learning through shared explanations.

Teachers also posed questions connecting mathematics to context:

> "Where might you encounter this type of problem in real life?"

> "Can you think of situations in our community where this concept applies?"

Such questions attempt to show the relevance and practical utility of mathematics. However, discussions typically remained at the level of application—identifying where mathematical concepts appear—rather than critically examining social dimensions.

#### *Limitations in critical questioning*

Missing from these lessons were questions about social implications, equity, or structural issues. For instance, during observed lessons where students investigated community-based problems, teachers asked students to identify issues and propose mathematical solutions but did not prompt examination of the following:

- Underlying causes of problems (Why does this issue exist?)
- Differential impacts on various groups (Who is most affected? Who benefits?)
- Power relations and decision-making processes (Who determines resource allocation? Whose interests are prioritized?)
- Equity and fairness dimensions (Is this distribution just? What would be more equitable?)

In one illustrative example, students analyzed survey data about the transportation methods students use to reach school. Teachers guided the statistical analysis—which included frequencies, percentages, and graph creation—but did not raise questions about differential access to transportation on the basis of socioeconomic status, the environmental impacts of various choices, or the fairness of school location decisions that affect commute burden.

#### *Synthesis*

Dialogic practices and the questioning skills critical approaches require are already present in mathematics classrooms in Thailand but remain oriented toward cognitive problem-solving rather than critical interrogation of social realities.

### Synthesis of Findings

Across data sources, mathematics educators in Thailand value inquiry-based instruction and possess the facilitation and questioning skills CME requires, yet conceptualize CME in largely cognitive and procedural terms, with its social-justice and critical-consciousness dimensions still unfamiliar—reflecting the early encounter of CME with Thai contexts rather than individual limitations. Implementation is constrained by an interlocking system of centralized curricula, examination pressure, hierarchical

norms, student deference, and gaps in teacher formation, even as teacher openness and existing project-based practice offer real foundations. These Phase 1 findings establish the groundwork for the contextualized model developed in subsequent work.

## DISCUSSION

The findings presented above raise theoretical questions that extend beyond the Thai context. This discussion develops those questions through three steps: theorizing the conceptual gap as depoliticization, examining structural barriers as ideological systems, and identifying facilitating conditions as pathways toward culturally adapted CME.

### Theorizing the Gap: Depoliticization, Suppressed Silence, and Gentle Criticality as Cross-Cultural Contributions to CME

The conceptual gaps documented in Section *Conceptualizations of Critical Mathematics Education: Depoliticization as a Structural Process (RQ1)* could be read as straightforward findings: Thai mathematics educators are unfamiliar with the social justice orientation of CME and require professional development to address this deficit. This study resists that reading. Our data reveal not only an information gap but also a theoretical problem—one that has implications for CME scholarship well beyond the Thai context. Three interconnected theoretical contributions emerge from this analysis.

#### *Depoliticization: Rethinking the barrier*

Teachers' genuine surprise upon learning that mathematics could address social inequality—*"I never thought mathematics could be connected with inequality"*—has been interpreted in Section *Conceptualizations of Critical Mathematics Education: Depoliticization as a Structural Process (RQ1)* as evidence of depoliticization operating at the institutional level. Here, we extend that analysis theoretically.

The view of mathematics as neutral, objective, and value-free is not unique to Thailand. It connects to what D'Ambrosio (1985) and Ernest (1991) identify as a long-standing tendency in Western mathematics education to present the subject as standing apart from culture and politics—as knowledge that simply is, rather than knowledge shaped by particular histories and interests. This view has spread widely through colonial educational systems, international curriculum frameworks, and standardized testing regimes (Roberts et al., 2024). The fact that this view predominated among participants—particularly the teachers, with only two academics articulating a structural understanding of mathematics—is consistent with the argument that such assumptions are passed on through professional training rather than arrived at through personal reflection. This is an interpretation, however. Understanding precisely how particular views of mathematics become norms in Thai educational settings remains a question for future research.

What makes this theoretically significant is that the construction of neutrality is self-protecting: a discipline presenting itself as beyond politics is, by definition, beyond political critique. Teachers who understand mathematics as neutral cannot easily recognize the social justice orientation of CME as mathematically relevant; it instead appears as an external imposition that confuses a technical discipline with a political agenda. Introducing CME to Thai educators is therefore not simply a matter of providing new information; it requires disrupting a hegemonic assumption so naturalized that it no longer appears as an assumption at all (Apple, 2004). Professional development for CME should therefore begin by questioning the nature of knowledge itself rather than merely offering frameworks and strategies: What is mathematics, and whose interests does it serve to treat it as neutral?

This argument extends beyond Thailand. CME scholarship in Western contexts has largely been able to assume that critical pedagogy's legitimacy as an educational orientation is at least debatable—that teachers have encountered social justice discourse and can engage with CME's premises, even if they resist them. In contexts where mathematics-as-neutral functions as hegemonic common sense rather than a contested assumption, the entry point for CME must be different: not advocacy for a pedagogical approach but interrogation of a foundational disciplinary myth.

#### *Suppressed silence and the limits of dialogic pedagogy*

This construct emerged from a contrast in the data: teachers reported that students were capable of critical thinking, yet classroom observations revealed that students responded minimally and waited for confirmation before speaking (Section *Structural and Cultural Barriers to CME Implementation: From Obstacles to Ideology (RQ2)*). That gap—between the critical capacity teachers described and the restraint actually observed—is suppressed silence.

Freire's (1973) concept of conscientização development through dialogic classrooms involves an implicit assumption that students, once given opportunity and encouragement, will voice their critical perspectives. Our findings complicate this assumption in ways that have theoretical implications for the pedagogical foundations of CME.

Section *Structural and Cultural Barriers to CME Implementation: From Obstacles to Ideology (RQ2)* suggested that student silence in Thai mathematics classrooms may not be uniform. Some silence reflects the willing deference of students who accept hierarchical norms as culturally appropriate expressions of respect, collective harmony, and kreng jai. Another form—suppressed silence—reflects something different: a strategic, institutionally learned response in which students who possess critical awareness choose not to voice it because experience has taught them that doing so carries social and academic costs.

The theoretical significance of suppressed silence extends beyond cultural description: it challenges a core assumption of Freirean dialogic pedagogy—that classroom silence indicates an absence of critical consciousness. Our data suggest that the opposite may often be true. Students who remain silent in Thai mathematics classrooms may not lack critical awareness but have learned through institutional literacy that expressing it is inadvisable. Academic 004 described this dynamic as follows: "*Students*

*become different when the problem is theirs, not something from a textbook. They argue more, they question more, they care about whether the answer is fair—not just correct."* Here, critical awareness was already present, and what changed was the perceived safety of expressing it. This interpretation rests on educators' accounts of student behavior rather than on direct evidence from students, as the present phase did not include student participants. The pattern it points to, in which students who are reticent under conventional conditions become vocal when a mathematical problem touches their own lives, is consistent with critical awareness that is contained rather than absent, although confirming the distinction would require research that engages students directly.

This has direct implications for CME pedagogy. If suppressed silence extends to hierarchical educational contexts beyond the Thai classrooms studied here—a possibility this study can raise but not yet establish—then the pedagogical task is not primarily to develop the critical consciousness that students lack. It is creating institutional conditions safe enough for students to voice the critical awareness that they already possess. These are very different projects: the former calls for curriculum redesign and new instructional approaches; the latter calls for attention to classroom power dynamics, trust-building, and the creation of what Skovsmose (1994) termed risk-free zones for intellectual exploration.

We propose that suppressed silence, understood as a theoretical construct rather than a cultural description, represents a significant but undertheorized phenomenon in CME scholarship. Western CME research has focused extensively on developing students' critical consciousness through mathematical inquiry (Gutstein, 2006; Wickstrom et al., 2024). Less attention has been given to contexts where critical consciousness is already present but institutionally contained—where the work of CME is the liberation of existing awareness rather than the cultivation of new awareness. Whether hierarchical educational systems—which characterize much of Asia and are not absent from Western contexts—produce suppressed silence more widely than CME scholarship has recognized is a question this study raises for future investigation rather than one its data can answer.

### *Gentle criticality: Theorizing culturally adapted critical consciousness*

Gentle criticality captures the forms of critique that actually appeared in the data. Across classroom observations and teacher accounts, critique surfaced not through open confrontation but through indirect questioning, careful phrasing, and community-oriented problem solving (Sections *Facilitating Factors and Emerging Opportunities* and *Questioning Practices in Mathematics Classrooms*).

Gutstein's (2006) framework of reading and writing the world with mathematics was developed in contexts where critical consciousness is expressed through public voice, collective action, and explicit challenges to dominant narratives. Our findings suggest that in collectivist, hierarchical contexts, critical consciousness may develop through different channels—channels that are no less critical in their substance but that manifest in forms shaped by cultural values and institutional constraints.

We introduce the concept of *gentle criticality* to name this phenomenon. Gentle criticality describes the expression of critical mathematical consciousness through culturally appropriate forms—quiet resistance, respectful advocacy, a community-improvement orientation, and constructive policy recommendation—rather than through public confrontation, direct challenge to authority, activist mobilization, or institutional critique. It is not a diminished or incomplete form of critical consciousness—it is critical consciousness adapted to institutional and cultural environments where direct confrontation has high social costs and where collective values shape how critical insight may be expressed appropriately.

Indications of gentle criticality appeared at several points in the data, most clearly where mathematical inquiry into local problems opened space for critical questions. When students investigating school restroom inadequacy moved from calculating facility-to-student ratios toward asking why the school had not addressed a disparity they experienced daily, they were engaging in critical analysis—but through the relatively safe channel of mathematical evidence rather than direct complaint. When teachers proposed using urban problems as contexts for mathematical inquiry, they were, knowingly or not, creating spaces where critical questions could arise through mathematical reasoning without requiring students to voice political positions directly. When Academic 003 observed that students begin asking *"not just "how much" but "why this way" and "who decided"*, the movement described is from procedural to critical questioning—but it emerges through mathematical investigation rather than political declaration.

Gentle criticality extends Gutstein's framework in a specific direction. Gutstein (2006) distinguishes between reading the world with mathematics—using mathematical tools to analyze social realities—and writing the world with mathematics—using mathematical analysis to propose and enact change. Our findings suggest that in the Thai classrooms studied here, writing the world may not take the forms of public activism or direct institutional challenge that Gutstein's framework, developed in the context of urban schools in Chicago, implicitly assumes. Writing the world, in Thai educational contexts, may manifest as mathematically grounded recommendations to school administrators, community improvement proposals channeled through legitimate institutional structures, or the quiet but cumulative development of students' capacity to see mathematical decisions as political ones—to recognize, as Skovsmose (2023) argues, that mathematical knowledge functions as a form of power in modern societies.

This theoretical extension has practical implications. CME professional development designed for Thai contexts should not ask teachers to facilitate confrontational public debate about inequality—a pedagogical form likely to trigger both cultural resistance and institutional sanction. Instead, it should help teachers create structured spaces for inquiry where mathematical analysis of community problems can naturally generate critical questions, where students can voice mathematical findings without being required to voice political positions, and where the shift from procedural to critical questioning happens through the logic of mathematical investigation rather than through explicit social justice instruction. The goal—developing students' capacity to use mathematics to understand and question power relations—remains constant; what changes is the pedagogical pathway through which that goal is pursued.

### *Implications for CME theory: Cultural translation as a theoretical contribution*

The three constructs developed in this analysis—depoliticization as a structural process, suppressed silence as critical consciousness that has learned to stay quiet, and gentle criticality as a culturally adapted form of critical expression—offer a shared language for thinking about CME in hierarchical, collectivist educational contexts. These constructs emerged not from isolated statements but from patterns evident across the full set of participants (five academics and seven teachers), with depoliticization further corroborated by the seven classroom observations and document review. They are not merely descriptive of Thai conditions; they identify theoretical gaps in the existing frameworks of CME and propose conceptual tools adequate for contexts that Western-derived frameworks have not fully addressed.

Stinson et al. (2024) called for strengthening equity and social justice research by confronting the structural inequities embedded in mathematics education. Roberts et al. (2024) called for theoretical frameworks adequate for diverse cultural conditions. Khan and Rizvi (2024) reported that even in contexts where mathematics has historically been taught through rote learning and procedural drills, students can engage meaningfully with social justice-oriented inquiry when given appropriate scaffolding—a finding that resonates with the Thai context documented here. This study responds to these calls not by rejecting Freire, Gutstein, and Skovsmose but by extending their frameworks to address conditions that their original formulations did not anticipate; these constructs are offered to the international CME conversation as concepts for further testing, with potential relevance to hierarchical educational contexts beyond Thailand that subsequent research would need to examine.

## Structural and Cultural Barriers: Beyond Surface Obstacles

Participants identified centralized curricula, time constraints, and examination pressures as primary barriers. However, our deeper analysis reveals that these structural obstacles interact with cultural norms and assumptions about knowledge to create mutually reinforcing systems that are resistant to critical pedagogical innovation.

### *The political economy of mathematics education*

Thailand's examination-oriented system favors procedural knowledge measurable through standardized testing. Drawing on Apple's (2004) analysis of assessment regimes, this study interprets such systems as potentially serving political and economic functions beyond mere measurement: sorting students for educational advancement and maintaining meritocratic legitimacy through ostensibly objective evaluation.

Examination systems of this kind do more than constrain pedagogy—they actively reproduce the view of mathematics as neutral, technical knowledge, reinforcing the depoliticization that Section *Theorizing the Gap: Depoliticization, Suppressed Silence, and Gentle Criticality as Cross-Cultural Contributions to CME* describes. When every high-stakes examination asks students to calculate correctly rather than question what calculations serve, the implicit message is repeated and reinforced: mathematics is about right answers, not about whose interests particular answers serve. Teachers who might otherwise begin to introduce critical questions find that the examination calendar works against them—not merely as a practical time constraint but as a structural signal about what mathematics is for. In this sense, the examination system is not simply a barrier to CME implementation; it is one of the key institutional mechanisms through which depoliticized mathematics reproduces itself across generations of students and teachers alike.

Within this system, mathematics functions as a sorting mechanism rather than a tool for social understanding. Teachers face real conflicts: extended critical investigations of inequality might create disadvantages for students on examinations that determine their life opportunities. As one teacher noted, "If I focus on social justice, am I really helping students succeed?"

This tension shows how structural barriers reflect deeper ideological commitments. The examination system is a central feature of education's social functions, not an incidental obstacle, and advocating for CME thus implicitly challenges existing power structures that determine how educational opportunity is allocated—which helps explain why structural barriers persist despite widespread recognition of their pedagogical limitations.

### *Cultural norms as institutional reproduction*

Hierarchical classroom relationships and student deference patterns are often framed as cultural traditions distinct from educational structures. However, these cultural norms actively reproduce and are reproduced by institutional arrangements that serve specific social functions.

This is where the construct of *suppressed silence*, which was introduced in Section *Theorizing the Gap: Depoliticization, Suppressed Silence, and Gentle Criticality as Cross-Cultural Contributions to CME*, becomes analytically important. Student silence in mathematics classrooms in Thailand is not simply the expression of cultural values around respect and collective harmony—it is, in many cases, a learned institutional response. Students who have developed critical awareness choose not to voice it because experience has taught them that doing so has real costs: social friction, teacher disapproval, or the subtle penalties of appearing difficult. Their silence does not indicate the absence of critical thought. It indicates a sophisticated awareness of when critical thought is—and is not—safe to express. Cultural norms around deference and *kreng jai* provide the vocabulary through which this institutional learning is expressed, but the silence itself is shaped as much by institutional structure as by cultural value.

Conversely, hierarchical structures persist partly because they align with broader cultural values—respect for authority, collective harmony, and deference to elders that extend through Thai social institutions—so educational hierarchy reflects and reinforces wider arrangements.

This complex interaction means that transforming classroom cultures requires addressing not only immediate pedagogical practices but also broader institutional structures and cultural values simultaneously. Neither structural reforms alone nor

cultural change alone will suffice; both must occur together through gradual, negotiated transformation that respects legitimate cultural values while expanding possibilities for critical engagement.

### *Teacher preparation as conceptual formation*

Teachers' uncertainty about connecting mathematics with social issues—*"I don't know how to link quadratic equations with inequality"*—reflects gaps in professional preparation that go beyond content knowledge or pedagogical strategies. The issue runs deeper and is about how teachers understand mathematical knowledge itself.

Teacher education programs that emphasize procedural knowledge and instructional techniques without addressing the social dimensions of mathematics produce teachers who are conceptually unprepared for critical approaches. They possess useful pedagogical skills—questioning, facilitation, and assessment—but lack frameworks that position mathematics as a socially embedded knowledge system and teaching as a potentially transformative practice.

Thus, supporting CME goes beyond adding modules to existing programs; it calls for rethinking what mathematics teacher education is for—engaging prospective teachers with the philosophical, historical, and political dimensions of mathematics and building the foundational understanding that makes critical pedagogical practice conceivable.

## Facilitating Factors: Pathways for Culturally Adapted CME

Despite these barriers, our findings point to promising foundations for developing culturally appropriate critical mathematics pedagogies in the context of Thailand.

### *Urban contexts as critical lenses*

Participants identified urban contexts—waste management, traffic congestion, and public space allocation—as promising entry points for critical mathematics education. However, this study argues that urban contexts should be understood as more than convenient sources of locally relevant problems. They function, at their most powerful, as critical lenses: structured ways of seeing social arrangements that mathematics can make visible, question, and potentially transform.

This distinction matters theoretically. When urban problems are used merely as application settings—as backdrops against which mathematical procedures are practiced—the critical potential of the context is not realized. Students calculate areas of parking spaces without asking who decided how space was allocated or measure waste volumes without examining which neighborhoods bore the greatest environmental burden. Mathematics remains, in Skovsmose's (1994) terms, an exercise rather than an investigation. What transforms the urban context from the backdrop to the lens is the deliberate pedagogical move of asking not just what the numbers show but also what the numbers reveal about power, fairness, and whose interests current arrangements serve.

This reframing has a specific connection to the construct of gentle criticality developed in Section *Theorizing the Gap: Depoliticization, Suppressed Silence, and Gentle Criticality as Cross-Cultural Contributions to CME*. Urban contexts provide something that more abstract social justice topics often cannot: a domain where critical questions arise naturally through mathematical investigation rather than through explicit political instruction. A student who asks why one district's roads are maintained while another's roads deteriorate is engaging in critical social analysis—but the question emerges from mathematics, not from a teacher asking students to voice political opinions. This matters enormously in institutional environments where expressing dissent has social costs: urban contexts are not just pedagogically interesting but structurally enabling, creating conditions under which gentle criticality can operate—students can move from procedural inquiry toward critical questioning through mathematical investigation itself, without stepping outside what the institution considers acceptable.

Urban contexts in Thai provincial cities present an authentic complexity suitable for this type of inquiry: visible inequalities in resource distribution, contested public spaces, environmental degradation affecting different communities differently, and economic disparities that manifest in spatial patterns students encounter daily. These are not imported social justice topics—they are part of the environment in which the students themselves live, which is precisely what gives them critical pedagogical power.

### *Building on existing pedagogical practices*

Teachers already employ practices that can support CME, such as collaborative learning, open-ended questioning, project-based activities, and connections to real-world contexts. This existing capacity matters not only because it reduces the distance between current and critical practices but also because it suggests a pathway for gradually reducing suppressed silence without requiring institutional confrontation.

The five question types documented in the classroom observations—critical evaluation, contextual connection, methodological inquiry, application, and design—show that sophisticated facilitation skills are already in place. Teachers need to learn how to extend these questioning practices toward social dimensions: "Whose interests does this resource distribution serve? ", "What patterns of inequality do these data show? ", "How might mathematical analysis inform more equitable policies?" These are not categorically different from the questions that teachers already ask—they extend the same intellectual moves into social territory.

This matters for suppressed silence because gradual, mathematics-grounded critical questioning creates lower-risk entry points for students who already possess critical awareness but have learned not to express it. When critical questions arise through the logic of mathematical investigation—emerging from what the data show rather than from what the teacher declares to be politically important—students have more institutional coverage to engage. Mathematics authorizes the question. This is a more realistic path toward unlocking existing critical consciousness than asking teachers to restructure classroom power relations wholesale.

Our analysis therefore supports gradual implementation strategies that build on the strengths teachers possess rather than requiring wholesale pedagogical transformation. Teachers might begin by adding critical dimensions to existing project-based units, experimenting with social justice questions in familiar contexts, and gradually developing confidence for more sustained critical inquiry. Change through accumulated small innovations is more sustainable—and more likely to create the conditions for gentle criticality to take root—than dramatic shifts that trigger institutional resistance before trust has been established.

### *Teacher capacity and professional learning communities*

Participants' emphasis on teacher capacity as the most important factor aligns with international research on the central role teachers have in pedagogical change (Bartell, 2013). However, Thai teachers' specific needs have concrete implications for how professional development should be designed.

Teachers asked for practical lesson examples, step-by-step guidance, and sustained support—not theoretical workshops delivered once and forgotten. This does not reflect anti-intellectualism. This reflects honest recognition that implementing unfamiliar pedagogies under existing institutional pressures requires practical scaffolding. The teachers expressed a genuine willingness to experiment when they were provided with clear models adapted to the Thai curriculum and cultural context.

Effective professional development should employ collaborative inquiry: teachers should collectively develop, implement, and refine CME lessons within institutional constraints, with professional learning communities providing ongoing support and generating contextually appropriate pedagogical resources.

Teachers also need space to examine their own assumptions about mathematics, develop their critical consciousness about social issues, and explore how their personal values align with critical pedagogical commitments. Teacher education for CME involves not only skill development but also a shift in how teachers understand their role—from neutral transmitters of mathematical knowledge to facilitators of inquiry that take the social dimensions of mathematics seriously.

## Contributions to International CME Scholarship

Phase 1 of this study contributes to the predominantly Western CME literature by examining CME in a Southeast Asian context, offering theoretical insights into cultural transferability and practical knowledge about implementation challenges in non-Western settings.

### *Expanding the geographic and cultural scope of CME*

Our study shows that the foundational ideas of CME—the use of mathematics to understand and transform social realities—remain philosophically compelling across cultural contexts. However, pedagogical implementation, appropriate forms of critical consciousness expression, culturally suitable dialog practices, and feasible institutional change pathways vary significantly depending on local conditions.

By documenting these variations, this research expands the geographical scope of CME while highlighting the need for theoretical development to address cultural adaptation, conceptual pluralism, and context-specific implementation strategies. Future CME scholars must pay more attention to how Western theoretical frameworks translate—or fail to translate—across diverse educational contexts.

### *Exposing barriers to critical pedagogy*

Our finding that teachers interpret mathematics as neutral, value-free knowledge points to deeper obstacles than previously emphasized in the CME literature. While scholars acknowledge the social construction of mathematics (D'Ambrosio, 1985; Ernest, 1991), less attention has focused on how dominant assumptions about mathematical knowledge function as barriers to critical pedagogical adoption.

Thai teachers' genuine surprise that mathematics could address inequality is consistent with a broader theoretical concern in critical mathematics education: that Western Enlightenment ideals positioning mathematics as universal, objective, and culturally neutral have traveled widely through colonial educational legacies, international development programs, and standardized curriculum exports (D'Ambrosio, 1985; Ernest, 1991). This study's findings add a small but concrete example to that theoretical picture—one drawn from Thai secondary classrooms. Whether such patterns reflect the reach of these global processes more broadly or are shaped by dynamics specific to the Thai educational context is a question that cross-national comparative research would be better positioned to address.

Supporting CME adoption requires not only pedagogical strategies but also questions about the nature, purpose, and cultural embeddedness of mathematical knowledge; teacher education must address how teachers conceptualize mathematics, not just methods.

### *Demonstrating the necessity of cultural translation*

Our documentation of the tensions between dialogic pedagogy ideals and hierarchical cultural norms reveals that the core concepts of critical pedagogy require cultural translation rather than direct transfer. While some scholars acknowledge cultural considerations (Gutstein, 2012), less empirical research examines specific translation challenges and locally appropriate solutions.

Our findings indicate that respecting cultural values while advancing critical goals requires creative adaptation. The development of critical consciousness does not require confrontational public debate if alternative culturally appropriate forms achieve similar purposes. Hierarchical teacher–student relationships need not completely dissolve if expanded dialog within existing structures enables critical inquiry.

These insights contribute to broader discussions about educational transfer, cultural appropriateness, and possibilities for maintaining critical commitments while respecting legitimate cultural differences—showing that "critical" mathematics education may manifest quite differently across contexts while maintaining core social justice orientations.

#### *Providing an empirical foundation for Asian CME research*

Finally, this study contributes to emerging but limited research on CME in Asian contexts (Atweh et al., 2011). By documenting current understandings, barriers, opportunities, and existing practices in Thai secondary mathematics education, we provide an empirical foundation for future scholarship examining CME possibilities in Southeast Asian settings.

Our findings establish a baseline understanding from which future research can develop contextually appropriate instructional models, investigate implementation processes, examine impacts on student learning and consciousness development, and theorize culturally adapted critical pedagogies—building sustained research programs on critical mathematics education in non-Western contexts.

## CONCLUSIONS

### Summary of Key Findings

Through interviews with five academics and seven teachers and observations of project-based instruction, Phase 1 of this study examined how secondary mathematics educators in Thailand understand and enact CME. Analysis revealed three conceptual constructs: depoliticization, the tendency for the political dimensions of critical frameworks to become muted or absent; suppressed silence, the learned response in which students who hold critical awareness choose not to voice it; and gentle criticality, the culturally adapted, indirect, community-oriented form of critique that surfaced. Urban settings further functioned as critical lenses, opening mathematical investigations to critical questioning rather than serving merely as problem sources.

### Theoretical Contributions

As developed in Section *Discussion*, depoliticization, suppressed silence, and gentle criticality together offer a working vocabulary for theorizing CME in hierarchical, collectivist educational settings—constructs for further empirical testing rather than established theory. The study suggests that CME's commitments to mathematics as a tool for social understanding remain relevant in Thai contexts, but the frameworks of Freire, Gutstein, and Skovsmose require cultural translation rather than direct transfer. The view of mathematics as neutral may need to be examined before critical pedagogical practices become conceivable; hierarchical classroom structures need not be fully dismantled for critical inquiry to take root, and confrontational dialog is not the only form of critical engagement—gradual transformation building on existing practices may prove more sustainable.

### Practical Implications

With respect to teacher education, professional development should address how teachers understand mathematical knowledge alongside pedagogical skills, engage their own critical consciousness, and provide concrete, locally adapted lesson examples within sustained collaborative learning communities. With respect to curriculum design, urban contexts should serve as critical lenses rather than as content sources alone, project-based approaches should extend toward social-justice dimensions, and assessments should be broadened to value critical thinking and social analysis. With respect to policy, examination systems centered on procedural knowledge constrain critical innovation and reproduce the depoliticized view of mathematics; reforms valuing a deeper understanding alongside social applications, together with professional learning structures that enable experimentation, form necessary conditions for systemic change.

### Limitations

Several limitations support how the findings should be interpreted. First, the sample of twelve participants drawn from secondary schools in Thai provincial cities is small and purposively selected; analytical claims are conceptual extensions of existing CME scholarship for further testing, not generalizations. Second, participants had limited prior exposure to the CME frameworks, which may have shaped their responses. Third, as the first phase of a larger project, this exploratory study prioritizes breadth over depth in terms of implementation processes. Fourth, the limitations of the publication design prevent the discussion of specific urban context details that might illuminate the findings further. Fifth, the observations captured single lessons rather than sustained implementation. In addition, because teachers selected the lessons to be observed, the observations may have captured relatively comfortable or polished examples of practice rather than the full range of classroom interaction. Finally, claims about student-level phenomena, including suppressed silence, rest on educators' accounts and warrant direct investigation with students.

### Recommendations for Future Research

Future research should develop and pilot contextually adapted CME instructional models in diverse Thai settings, examining implementation processes, the challenges teachers face, and the adaptations they make under real conditions. Longitudinal studies of how teachers' understanding of CME evolves with sustained support would clarify developmental pathways. Equally needed are studies of students' responses to critical mathematics instruction—how they engage social-justice content, develop critical consciousness, and navigate norms around questioning authority, including the conditions under which suppressed silence gives way to expressed inquiry—and comparative work across Southeast Asia to refine the constructs proposed here.

Further directions include reframing the curriculum through critical lenses, developing culturally appropriate CME assessments, and analyzing the policy conditions that enable or constrain critical innovation.

### Final Reflections

CME in secondary school Thai contexts, while constrained by conceptual, structural, and cultural obstacles, is neither impossible nor merely aspirational. The analysis points to a path of cultural translation—building on existing pedagogical strengths while gradually expanding practice toward critical purposes—rather than the wholesale import of Western models. The data also suggest that students may possess more critical awareness than their silence implies, with that silence functioning as a learned institutional response rather than the absence of thought. By documenting how Thai educators understand CME, the conditions shaping that understanding, and the culturally specific forms of critical engagement already taken, this study lays the groundwork for the next stage: developing, implementing, and evaluating an urban context-based critical mathematics model. This study has framed the question of whether such a model can help students use mathematics to read and act on the social conditions of their own communities, and the next phase is designed to answer this question.

**Author contributions: NP:** conceptualization, methodology, investigation, data collection, data analysis, writing — original draft; **PN:** supervision, conceptual framework development, writing — review & editing; **OJ:** supervision, methodology consultation, writing — review & editing; **JS:** supervision, formal analysis, writing — review & editing. All authors agreed with the results and conclusions.

**Funding:** The authors gratefully acknowledge Nareerat School, Phrae Province, for providing the research setting, and the administrators, teachers, and students for their valuable cooperation. Special thanks are extended to the mathematics education experts who provided constructive guidance throughout this research.

**Ethical statement:** The authors stated that the study was approved by the Human Research Ethics Committee of Chiang Mai University (Certificate of Approval No. COA 108/66; CMUREC No. 66/204, approved 12 September 2023, renewed 7 August 2024, valid until 11 September 2025) and conducted in accordance with the Declaration of Helsinki and relevant ethical research standards. All participants provided written informed consent prior to participation. Identifying information was removed; pseudonyms were used throughout all records and reporting; and audio recordings, transcripts, and field notes were stored securely with access limited to the research team.

**AI statement:** The authors stated that they used AI-based language tools (e.g., Claude) for English-language editing and grammatical refinement only. All analytical content, theoretical arguments, interpretations, and references were developed and verified by the authors. The manuscript additionally underwent professional language editing by qualified human editors at American Journal Experts (AJE); the AJE Editing Certificate (verification code DB21-3F76-C900-12CC-5E06, issued 3 June 2026) is attached as a supplementary file. The authors take full responsibility for the integrity of the manuscript.

**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** The data that support the findings of this study (de-identified interview transcripts, observation field notes, and document excerpts) are available from the corresponding author on reasonable request, subject to participant confidentiality agreements approved by the Human Research Ethics Committee of Chiang Mai University.

## REFERENCES

Apple, M. W. (2004). *Ideology and curriculum* (3rd ed.). Routledge. https://doi.org/10.4324/9780203487563

Atweh, B., Graven, M., Secada, W., & Valero, P. (Eds.). (2011). *Mapping equity and quality in mathematics education*. Springer. https://doi.org/10.1007/978-90-481-9803-0

Bartell, T. G. (2013). Learning to teach mathematics for social justice: Negotiating social justice and mathematical goals. *Journal for Research in Mathematics Education, 44*(1), 129-163. https://doi.org/10.5951/jresematheduc.44.1.0129

Berger, R. (2015). Now I see it, now I don't: Researcher's position and reflexivity in qualitative research. *Qualitative Research, 15*(2), 219-234. https://doi.org/10.1177/1468794112468475

Brantlinger, A. (2013). Between politics and equations: Teaching critical mathematics in a remedial secondary classroom. *American Educational Research Journal, 50*(5), 1050-1080. https://doi.org/10.3102/0002831213487195

Corbin, J., & Strauss, A. (2015). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). SAGE Publications.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 44-48.

Ernest, P. (1991). *The philosophy of mathematics education*. Falmer Press.

Frankenstein, M. (1983). Critical mathematics education: An application of Paulo Freire's epistemology. *Journal of Education, 165*(4), 315-339. https://doi.org/10.1177/002205748316500403

Freire, P. (1970). *Pedagogy of the oppressed*. Continuum.

Freire, P. (1973). *Education for critical consciousness*. Seabury Press.

Geiger, V., & Schmid, M. (2024). A critical turn in numeracy education and practice. *Frontiers in Education*, *9*, Article 1363566. https://doi.org/10.3389/feduc.2024.1363566

Geiger, V., Gal, I., & Graven, M. (2023). The connections between citizenship education and mathematics education. *ZDM – Mathematics Education*, *55*(5), 923-940. https://doi.org/10.1007/s11858-023-01521-3

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods, 18*(1), 59-82. https://doi.org/10.1177/1525822X05279903

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. Routledge.

Gutstein, E. (2012). Mathematics as a weapon in the struggle. In O. Skovsmose & B. Greer (Eds.), *Opening the cage: Critique and politics of mathematics education* (pp. 23-48). Sense Publishers. https://doi.org/10.1007/978-94-6091-808-7_2

Hirsch, W. Z. (1973). *Urban economic analysis*. McGraw-Hill.

Karakose, T., Tülübaş, T., & Papadakis, S. (2023). The scientific evolution of social justice leadership in education: Structural and longitudinal analysis of the existing knowledge base, 2003–2022. *Frontiers in Education*, *8*, Article 1139648. https://doi.org/10.3389/feduc.2023.1139648

Khan, S. S., & Rizvi, N. F. (2024). Mathematics for social justice: An action research study with working-class children in a Pakistani classroom. *Asian Journal for Mathematics Education*, *3*(4), 493-514. https://doi.org/10.1177/27527263241293196

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE.

Makramalla, M., Coles, A., le Roux, K., & Wagner, D. (2025). Mathematics education for sustainable futures: A strengths-based survey of the field to invite further research action. *Educational Studies in Mathematics*, *119*(3), 535-556. https://doi.org/10.1007/s10649-025-10389-x

Nokkaew, A., & Chuechote, S. (2022). Guideline for conducting classroom activities integrated with local wisdom and critical mathematics pedagogy to develop six core competencies. *Journal of Education Khon Kaen University, 45*(2), 69-81. https://so02.tci-thaijo.org/index.php/EDKKUJ/article/view/255312

O'Brien, B. C., Harris, I. B., Beckman, T. J., Reed, D. A., & Cook, D. A. (2014). Standards for reporting qualitative research: A synthesis of recommendations. *Academic Medicine, 89*(9), 1245-1251. https://doi.org/10.1097/ACM.0000000000000388

OECD. (2023). *PISA 2022 results (Volume I and II): Country notes – Thailand*. OECD Publishing. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/thailand_6138f4af-en.html

Panthi, R. K., Khanal, B., Kshetree, M. P., Acharya, B. R., & Belbase, S. (2021). Challenges of social justice in mathematics classrooms. *SN Social Sciences, 1*(9), 227. https://doi.org/10.1007/s43545-021-00233-3

Papadakis, S., Kanadlı, S., Kardas, A., Tülübaş, T., Karakose, T., & Polat, H. (2024). Investigating the relationship between leadership for learning and student achievement through the mediation of teacher performance: A meta-analytic structural equation modeling (MASEM) approach. *Education Sciences, 14*(12), 1320. https://doi.org/10.3390/educsci14121320

Patton, M. Q. (2015). *Qualitative research & evaluation methods* (4th ed.). SAGE.

Payadnya, I. P. A. A., Wulandari, I. G. A. P. A., Puspadewi, K. R., & Saelee, S. (2024). The significance of ethnomathematics learning: A cross-cultural perspective between Indonesian and Thailand educators. *Journal for Multicultural Education, 18*(4), 508-522. https://doi.org/10.1108/JME-05-2024-0049

Penteado, M. G., & Skovsmose, O. (Eds.). (2022). *Landscapes of investigation: Contributions to critical mathematics education*. Open Book Publishers. https://doi.org/10.11647/OBP.0316

Roberts, D. L., Banerjee, R., & Vistro-Yu, C. P. (2024). Mathematics education in Asia: Curriculum and its origins. In M. A. Clements, B. Kaur, T. Lowrie, V. Mesa, & J. Prytz (Eds.), *Fourth international handbook of mathematics education* (pp. 29-72). Springer. https://doi.org/10.1007/978-3-031-51474-6_3

Royal Institute. (2013). Phcnānukrm chbạb rāchbaṇṭhitysīthān ph.Ṣ. [Royal Institute dictionary B.E. 2554]. Royal Institute of Thailand.

Skovsmose, O. (1994). *Towards a philosophy of critical mathematics education*. Kluwer Academic Publishers. https://doi.org/10.1007/978-94-017-3556-8

Skovsmose, O. (2023). *Critical mathematics education*. Springer. https://doi.org/10.1007/978-3-031-26242-5

Stinson, D. W., Subramanian, J., & Yeh, C. (2024). Strengthening equity and social justice research in mathematics education through critical interrogations of white supremacy and settler colonialism. In M. A. Clements, B. Kaur, T. Lowrie, V. Mesa, & J. Prytz (Eds.), *Fourth international handbook of mathematics education* (pp. 531-562). Springer. https://doi.org/10.1007/978-3-031-51474-6_21

Suh, J. M., Aguirre, J., Turner, E., Carlson, M. A., Fulton, E., Tate, H., & McVicar, E. (2024). Exploring racial justice with culturally responsive mathematical modeling in the primary grades: Cultivating criticality in the problem-based learning space. *Interdisciplinary Journal of Problem-Based Learning, 18*(1). https://doi.org/10.14434/ijpbl.v18i1.36976

Takona, J. P. (2025). Transformative education: Paulo Freire's pedagogy of the oppressed and its contemporary resonance. *Journal of Global Education and Research, 9*(1), 87-107. https://doi.org/10.5038/2577-509X.9.1.1351

Taranet, C. (2017). *The development of mathematics achievement in probability using group process-based instruction for Mathayomsuksa V students, Sa School, Nan* [Master's thesis, Burapha University]. Burapha University Research Information. https://buuir.buu.ac.th/xmlui/handle/1234567890/6131

Uğraş, H., Uğraş, M., Papadakis, S., & Kalogiannakis, M. (2024). Innovative early childhood STEM education with ChatGPT: Teacher perspectives. *Technology, Knowledge and Learning*, *30*, 809-831. https://doi.org/10.1007/s10758-024-09804-8

Wickstrom, M. H., Lopez-Mercado, C., & Jung, H. (2024). Cultivating K-8 teachers' critical consciousness through social justice mathematical modeling: The teacher pay task. *Mathematics Teacher Educator*, *13*(1), 6-30. https://doi.org/10.5951/MTE.2023-0039

Wright, P. (2017). Critical relationships between teachers and learners of school mathematics. *Pedagogy, Culture & Society, 25*(4), 515-530. https://doi.org/10.1080/14681366.2017.1285345

Wright, P. (2020). Transforming mathematics classroom practice through participatory action research. *Journal of Mathematics Teacher Education, 24*(2), 155-177. https://doi.org/10.1007/s10857-019-09452-1