
Critical Pedagogy in Mathematics Education: A Systematic Review of Practices, Challenges, and Opportunities

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Abstract

Critical pedagogy has gained global recognition for fostering emancipatory and socially connected educational practices, yet its integration within mathematics classrooms, particularly in Nepal, remains underexplored. This systematic review, conducted in accordance with PRISMA 2020 guidelines, synthesises findings from 25 peer-reviewed articles published between 2012 and 2024, including empirical qualitative and quantitative studies. The results demonstrate that applying critical pedagogy in mathematics enhances student engagement, critical thinking, and conceptual understanding, while also promoting social justice by linking mathematical concepts to real-life social issues. However, significant challenges hinder widespread adoption, including resistance stemming from entrenched traditional teaching methods, cultural values, emphasis on rote memorisation, and limited teacher training resources. The review reveals the urgent need for targeted professional development to effectively support educators in implementing these transformative approaches. Addressing these barriers can foster more equitable, student-centered mathematics education and contribute to broader educational reforms.

Keywords: critical pedagogy, mathematics teaching-learning, academic achievement, systematic review

Introduction

Critical pedagogy, first introduced by Paulo Freire in the 1970s, is an educational framework emphasising teaching as a political act aimed at liberation and social justice (Freire, 1970). It challenges traditional education methods, which often see students as passive recipients of knowledge, advocating learners to be engaged critically with content and their environment. This pedagogical approach has significantly influenced mathematics education, where conventional teaching methods have been critiqued for perpetuating social inequalities (Gutstein, 2012; Skovsmose, 2020).

In Asian context, particularly in Nepal, education systems have historically been shaped by rank order and rote learning practices. These characteristics are reflected in mathematics education, which often prioritises procedural knowledge and standardised testing over conceptual understanding and critical engagement (Panthi et al., 2021). However, recent educational reforms and researches underscore the need for pedagogical approaches that not only improve academic outcomes but also empower students to become critical thinkers and active societal participants (Ham, 2022).

Nepal's mathematics education, like that of many other Asian countries, has traditionally been teacher-centered, emphasizing memorization and precise calculation (Luitel & Taylor, 2007). While this approach may help students prepare for exams, it often falls short of providing meaningful learning experiences that connect mathematical concepts to real-world situations (Pokhrel et al., 2024). The implementation of critical pedagogy in mathematics teaching seeks to address these limitations by fostering more inclusive and reflective learning environment. For instance, incorporating local cultural contexts and social issues into the curriculum has been shown to boost student engagement and understanding of mathematical concepts (Acharya et al., 2021).

Recent studies related to teaching and learning activities in mathematics conducted in Nepal and other parts of Asia have demonstrated the potential of critical pedagogy to transform education. Research shows that students who are taught mathematics through a critical pedagogical lens are more likely to engage with the material and apply their learning to real-world problems (Shrestha et al., 2020). Critical pedagogy enables students to better understand mathematical concepts and develop a deeper awareness of how mathematics can be used as a tool for social change (Pokhrel et al., 2024). Gutstein (2012) strengthens the idea that students use mathematics to critically analyse and address social issues.

Despite the promising outcomes associated with critical pedagogy, its implementation in mathematics education in Nepal and other Asian countries faces significant challenges (Chapai, 2022). One of the primary barriers is the deeply entrenched traditional teaching methods that prioritise rote memorisation and standardised testing. As Gutierrez (2017) points out, educators often struggle to adopt a critical pedagogical approach due to a lack of resources, professional development opportunities, and support from educational institutions. These challenges are exacerbated by overcrowded classrooms, limited access to teaching materials, and

societal expectations that prioritise exam results over critical thinking and engagement (Likuru & Mwila, 2022).

Educational reform in Nepal reveals difficulties in shifting from traditional to progressive teaching methods. Resistance from educators and parents, who view critical pedagogy as a deviation from established educational norms, is a significant obstacle (Kunwar, 2020). This resistance often stems from cultural values that emphasise respect for authority and teacher-centered instruction, creating barriers to implementing equitable pedagogy (Lamsal, 2024). Additionally, Nepal's broader educational system, heavily influenced by national examination frameworks, often discourages innovative teaching practices that deviate from the prescribed curriculum (Acharya, 2020).

There is also a lack of empirical research on the long-term effects of critical pedagogy on student achievement in mathematics, especially in Nepal. While evidence indicates that participatory and critical pedagogy can enhance students' conceptual understanding and engagement, more rigorous studies are necessary to evaluate its impact on standardized test scores and academic performance (Dhungana et al., 2022). Research into the implementation of critical pedagogy in rural and under-resourced schools in Nepal is particularly needed (Shrestha et al., 2020).

Mathematical proficiency is essential for problem-solving and global opportunities. The National Council of Teachers of Mathematics (NCTM, 2000) asserts, those who understand and can apply mathematics significantly increase their future opportunities and choices. Mathematics enables individuals to make informed decisions in a data-driven world and provides the foundation for careers in science and technology.

Critical pedagogy engages students in meaningful learning, allowing them to lead their learning and form their own opinions (Uddin, 2019). Rather than providing correct answers, teachers foster an environment where students assess their understanding, focusing on constructive dialogue between teacher and student. This approach promotes self-directed learning, echoing the historical use of a dialogical method by Socrates, who encouraged learners to think critically and discover answers independently. Thus, critical pedagogy enhances critical thinking and self-evaluation in the learning process.

Although Socrates used a student-centered approach, it was historically uncommon. Paulo Freire later criticised teacher-centered models for perpetuating knowledge reproduction and stifling critical thought. In "Pedagogy of the Oppressed",

Freire described this as the “Banking Model of Education” (Freire, 1970), where students are passive learners. He argued that education should empower students to challenge inequalities, advocating for a dialogical and problem-solving based approach (Guilherme, 2017).

Critical pedagogy examines teacher-student power dynamics and how they may privilege teachers and oppress students (Crowley & King, 2018). Teachers may treat students as inferiors, but critical pedagogy raises awareness of inequality and encourages learner empowerment (Oxford & Spaaij, 2020). Yet, many teacher education programs do not prepare candidates to generate knowledge in practice (Kincheloe et al., 2011).

Freire’s notion of conscientisation—becoming aware of societal injustices—has shaped the evolution of critical pedagogy (Shih, 2020). It encourages students to recognise oppression and advocate for social justice (Freire, 2020; Giroux, 1988). This pedagogy equips learners with tools to challenge societal norms and become agents of change. By equipping individuals with the tools to critically analyse and challenge societal norms, Freire's pedagogical approach enables them to actively participate in shaping a more inclusive and democratic society. Through this process of conscientisation, individuals not only become aware of their oppression but also gain the agency to advocate for systemic change and social justice. This transformative pedagogy encourages individuals to question power structures and work towards dismantling them, fostering a culture of resistance and collective action. Ultimately, Freire's pedagogy empowers individuals to become active participants in their liberation and the liberation of others, creating a more equitable and just society for all.

Building on Freire's principles, critical pedagogy has been further shaped by critical theorists like Michel Foucault, who analysed power, knowledge, and discourse, providing a deeper understanding of how educational settings can reinforce power structures (Foucault, 1977). Similarly, Antonio Gramsci's concepts of hegemony and cultural struggle have offered frameworks for analysing roles of education in maintaining societal power imbalances (Gramsci, 2020; Smith & Seal, 2021). These contributions have expanded the theoretical foundation of critical pedagogy, highlighting the complex interplay between education, power, and society (Kincheloe, 2008).

The Frankfurt School theorists Theodor Adorno, Max Horkheimer, and Herbert Marcuse have also enriched critical pedagogy by critiquing the influence of mass

culture and instrumental rationality on educational systems, which perpetuate societal inequalities. Their contributions have shaped the philosophical foundations of critical pedagogy, emphasising its importance in critiquing and transforming societal structures through education.

Critical pedagogy has been adapted and implemented across various disciplines and educational levels in modern contexts. It is particularly evident in inclusive and digital pedagogies, as demonstrated by (Mehta & Aguilera, 2020), who explore the humanisation of digital learning environments. This adaptability shows critical pedagogy's relevance in addressing contemporary educational challenges and integrating technology, promoting inclusion, and critical participation in virtual learning environment.

In mathematics teaching, critical pedagogy fosters inclusive and transformative practices that address broader social and cultural issues. Its application underscores its adaptability and relevance across diverse disciplinary contexts (Stinson et al., 2012). Despite its widespread application, critical pedagogy faces critiques, particularly regarding its ontological, epistemological, and ethical foundations in democratic education. These critiques highlight ongoing debates and the evolving nature of critical pedagogy within educational theory (Sant, 2019).

Critical pedagogy empowers individuals and transforms societies through critical reflection and action. Its varied interpretations, rooted in rich theoretical traditions and adaptable across educational contexts, emphasise its ongoing relevance and transformative potential in addressing current educational challenges (Valls-Carol et al., 2022). Moreover, critical pedagogy enhances educational outcomes, student engagement, and social awareness by promoting academic success and fostering a deeper understanding of social issues.

Beyond the classroom, critical pedagogy has a transformative impact on broader educational practices and policies (Flores & Alfaro, 2022). When institutions and educators embrace critical pedagogical techniques, it can lead to systemic changes in how education is delivered and conceptualised, making educational systems more responsive to the needs of diverse student populations. As educators and institutions increasingly recognise the benefits of critical pedagogy, its impact on educational outcomes, student engagement, and social consciousness is expected to grow, with the main challenge being the effective integration of its principles into mainstream education.

Rooted in Paulo Freire's work and expanded by theorists like Michel Foucault and Bell Hooks, critical pedagogy advocates for an educational framework that is both informative and transformative. This approach empowers students to question the status quo and actively create their knowledge and values, demonstrating its universal relevance across various disciplines and cultural contexts (Shih, 2018; Shih, 2020; Smith & Seal, 2021).

Despite its broad application, academic literature shows inconsistent impacts of critical pedagogy on educational outcomes. While some studies report positive effects on student engagement and social awareness, varied methodologies complicate comparative analysis (Pinedo et al., 2021). This review aims to consolidate these findings, examining both quantitative and qualitative effects. Moreover, the literature primarily focuses on higher education and adult learning contexts, with less attention to secondary-level mathematics teaching settings. This review explores this distribution and identifies significant research gaps, particularly in less-studied educational settings such as mathematics teaching.

There is a notable gap in fully understanding the impact of critical pedagogy on specific learning outcomes like critical thinking, academic performance, and student empowerment. Although various studies have examined these aspects (Jeyaraj & Gandolfi, 2022), a unified synthesis of these findings is necessary to guide future educational practices and policymaking. Additionally, the dynamic nature of critical pedagogy, shaped by modern social, political, and technological shifts, requires ongoing reassessment of its core principles and approaches. As digital technologies become more ingrained in education, understanding how critical pedagogy adapts and thrives in these new digital environments is vital for improving mathematics education. This review examines how emerging trends in mathematics education and pedagogical approaches, including critical pedagogy frameworks, enhance or transform students' learning experiences in mathematics.

Significance of Critical Pedagogy

Critical pedagogy offers a transformative approach to teaching and learning, particularly in social sciences. It addresses the reciprocal relationship between pedagogical practices and social justice by challenging traditional methods and advocating for a more inclusive and democratic classroom environment.

Traditional teaching methods, such as teacher-centered techniques and lecturing, have long dominated education, often reinforcing power dynamics and social

hierarchies. These methods can limit students' opportunities to engage fully in the learning process.

In contrast, critical pedagogy seeks to empower students by promoting gender equality, social justice, and democratic participation in the classroom. This approach is deeply influenced by political and social changes, which are often challenging to integrate into existing education systems. Implementing critical pedagogy in mathematics education requires a shift from traditional teacher-dominated practices to more student-centered approaches, where the classroom becomes a space for dialogue, interaction, and shared learning.

However, applying critical pedagogy in mathematics teaching has its own challenges. Ensuring equal participation of all students, particularly those from diverse ethnic backgrounds and varying academic abilities, is difficult. Teachers must navigate the complexities of creating an interactive environment that fosters discussion while maintaining a focus on mathematical content.

Additionally, the entrenched use of traditional methods, where teachers impose their ideologies on students without considering their diverse perspectives, further complicates the adoption of critical pedagogy. Mathematics teaching, like other disciplines, is highly politicised, with various resources, methods, discourses, and languages influencing how knowledge is transmitted.

Critical pedagogy offers an alternative by exploring different approaches for engaging students in meaningful learning experiences. As Freire (1993) stated, education becomes an act of depositing, where students are depositories, and the teacher is the depositor. This traditional view of education fails to recognise the importance of equal socio-cultural, socio-political, and meta-discourse representation of mathematics, which are essential for fostering a more inclusive and just learning environment.

Additionally, Sarroub and Quadros (2014) highlight that critical pedagogy developed out of the recognition that education is crucial not only for gainful employment but also for creating the formative culture of beliefs, practices, and social relations that enable individuals to use power, learn how to govern, and nurture a democratic society. Despite this recognition, many mathematics teachers continue to rely on outdated methods ignoring the potential of critical pedagogy to transform the learning experience.

This systematic literature review aims to explore teachers' perceptions and use of critical pedagogy in the mathematics classroom. It examines the dialogic process of

teaching, which is emancipatory, inclusive, and equality-based. In many mathematics classrooms in Nepal, students learn without questioning or engaging in meaningful interactions with their teachers (Lamsal, 2024). Critical pedagogy seeks to change this by fostering a learning environment where social relations, power dynamics, and equality are integral to the teaching process. This study promotes the level of understanding of critical classroom management and critical pedagogy in secondary mathematics classes, ultimately contributing to a more just and equitable education system.

Review Methodology

In the age of evidence-based education, the systematic literature review is increasingly used as an investigation method, combining different studies to produce evidence for policy-making, teacher professional development planning, effective teaching-learning activities planning, and other research (Cohen et al., 2018). This systematic literature review used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedure (Page et al., 2021) (see Fig. 1) to investigate critical pedagogy-related studies in the mathematics teaching-learning domain published during the last 12 years. The PRISMA approach was selected for its rigorous and transparent methodology, ensuring a comprehensive and reproducible synthesis of the existing literature, which is crucial for the reliability and validity of current review findings. The PRISMA process is a systematic review methodology applied to identify, screen, and evaluate relevant research for inclusion in a review, which is then used to inform evidence-based decision-making. Subsequently, the researchers articulate the research method through three dimensions: search strategy, selecting articles, and data analysis.

The systematic review's "Critical Pedagogy and Mathematics Teaching-Learning" literature search was precisely crafted to synthesise existing research and develop a comprehensive understanding of critical pedagogy's impact on mathematics teaching-learning and students' learning outcomes. This section outlines the structured approach adopted from PRISMA 2020 guidelines and authors' views (Xiao & Watson, 2019), detailing each phase from inclusion criteria to the final selection of pertinent studies.

Review Questions

The following questions guide the present review:

- What research experience already exists in the field of critical pedagogy used in mathematics teaching?
- How does the application of critical pedagogy affect students' achievement in mathematics?
- What are the strengths and limitations of implementing the critical pedagogy approach in mathematics teaching and learning?
- What recommendations can be derived from existing research for the effective implementation of the critical pedagogy approach in mathematics teaching and learning?

Search Strategy

The primary studies of the critical pedagogy and mathematics teaching-learning activities were initially located using a manual search using keywords. Google Scholar, ERIC, JSTOR, and the scientific database Scopus were used. These provided comprehensive coverage of journal and conference articles, ensuring a more thorough analysis of the subject (Kitchenham & Charters, 2007). The search used a comprehensive set of keywords to minimise the risk of overlooking any crucial documents. Boolean operators were employed in the search queries to extract the most pertinent documents. A comprehensive search was conducted through the Scopus database to retrieve literature meeting the specified criteria. The search string applied on August 1, 2024, was: TITLE-ABS-KEY (("Critical Pedagogy") AND ("Mathematics Teaching and Learning") OR ("Learning Outcome") OR ("Critical Thinking") OR ("Academic Achievement") OR ("Learning Achievement")). The preliminary search yielded 47 articles. Similarly, a comprehensive search was conducted through Google Scholar, ERIC, and JSTOR to retrieve literature meeting the specified criteria. The search string applied on August 1, 2024, was: TITLE-ABS-KEY (("Critical Pedagogy") AND ("Mathematics Teaching and Learning" OR "Learning Outcome" OR "Critical Thinking" OR "Academic Achievement" OR "Learning Achievement")). The preliminary search yielded 1190 documents. Kitchenham (2004) suggests conducting a manual screening of the primary study resources. Thus, a manual search through all of the initial research references was conducted in the second stage.

Inclusion-Exclusion Criteria

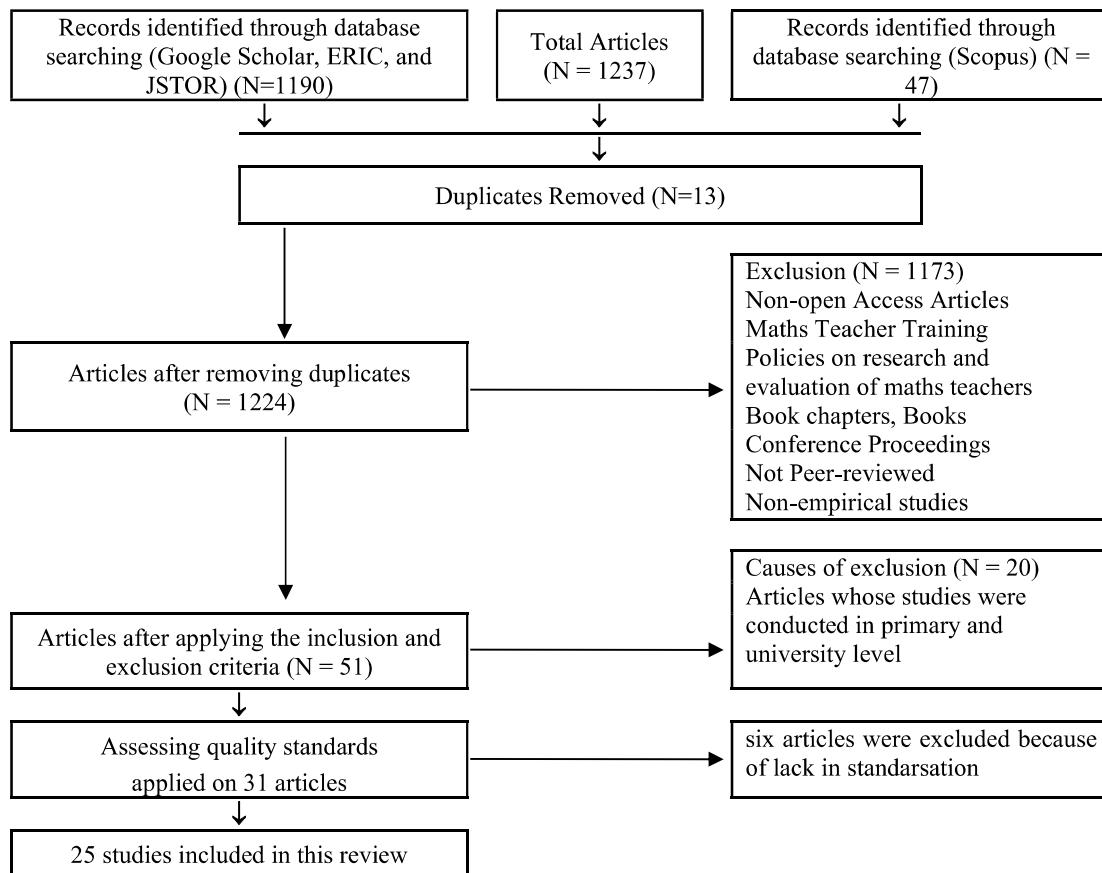
The studies included in this review were selected based on specific criteria. Inclusion criteria encompassed peer-reviewed journal articles and review papers published in English that focused on critical pedagogy and its application in mathematics teaching and learning. The temporal range was set from 2012 to 2024 to

capture recent developments in the field. Exclusion criteria eliminated non-peer-reviewed articles, book chapters, conference proceedings, and studies that did not directly address the impact of critical pedagogy on student learning outcomes in mathematics. This rigorous selection process ensured that the review focused on high-quality empirical research that directly contributes to understanding the role of critical pedagogy in mathematics education.

The next step was the screening for inclusion. The researchers then reviewed the titles, abstracts, and keywords of these 1224 documents for relevance to the research topic. This crucial step involved meticulously evaluating each study's unity with the principal theme of critical pedagogy and mathematics teaching-learning, and its influence on various learning outcomes of students. Finally, 31 journal articles were retained from the screening process. See figure 1

Figure 1

Flow chart –Source data (2012-2024)



Assessing Quality and Eligibility

The evaluation of study quality and eligibility is crucial for assessing research calibers, as outlined by Kitchenham & Charters (2007). This study established four criteria for evaluating articles: relevance to critical pedagogy and mathematics teaching at the secondary level, use of empirical methods, mention of critical pedagogy's impact in mathematics classrooms, and demonstration of its implementation. A full-text screening led to the exclusion of six studies that did not closely align with these criteria, resulting in 25 studies selected for the systematic review. These studies underwent thematic analysis to identify common themes and methodologies, ensuring a comprehensive understanding of critical pedagogy's role in mathematics education. The rigorous selection process provided a solid foundation for examining the impact of critical pedagogy on teaching and learning outcomes in mathematics.

Overview of Selected Studies

The systematic literature review included 25 studies that adhered to these rigorous inclusion criteria, covering a broad range of educational contexts. These studies outline critical pedagogy's multifaceted nature and ramifications across different educational strata.

Guided by the framework of Kitchenham and Charters (2007), this study employed four rigorous criteria to evaluate article quality: alignment with critical pedagogy and secondary mathematics education, application of empirical research methods, explicit discussion of critical pedagogy's impact within mathematics classrooms, and evidence of its practical implementation. A comprehensive full-text screening process resulted in the exclusion of six studies that did not satisfy these criteria, yielding a final corpus of 25 studies for systematic review. These studies underwent thematic analysis to discern recurrent themes and methodological patterns, thereby establishing a robust evidentiary foundation for examining the influence of critical pedagogy on mathematics teaching and learning outcomes.

Critical pedagogy, a transformative educational approach, seeks to empower students and challenge traditional educational norms that may perpetuate inequality. It draws attention to critical thinking, social justice, and student agency. The reviewed literature points up its potential benefits, particularly in mathematics education, while also revealing gaps and limitations in its application.

Several studies explore how critical pedagogy can transform mathematics classrooms into spaces for student empowerment and critical thinking. Vimbelo and Bayaga (2024) demonstrate that a humanising pedagogy fosters deeper student engagement and connects mathematical concepts to real-life applications, improving learning outcomes in classrooms. Similarly, Matiti (2024) illustrates how combining critical pedagogy with participatory action research (PAR) during the transition to secondary school mathematics boosts student confidence and collaboration.

Studies like Gargroetzi et al. (2021) and Stinson et al. (2012) promote using mathematics as a tool to interrogate social issues, fostering a sense of agency among students. In the South African context, Lénárt et al. (2018) advocate integrating indigenous knowledge and centering marginalised voices, underscoring the potential of critical pedagogy to dismantle systemic inequalities in mathematics education. These examples underscore its potential for promoting equity and encouraging students to view mathematics as a transformative tool for societal change.

Broader Applications and Contributions.

Critical pedagogy's influence extends beyond mathematics. Pollard (2019) demonstrates how it promotes critical thinking and social engagement across disciplines, while Ahmad et al. (2021) and Uddin (2019) emphasise its role in fostering social justice. However, successful implementation often hinges on teachers' ability to create inclusive and student-centered learning environment.

Kareepadath (2018) and Sarroub and Quadros (2014) examine the systemic barriers teachers face when adopting critical pedagogy, such as rigid institutional frameworks, cultural constraints, and limited teacher agency. These studies reveal the importance of addressing external challenges to enable educators to adopt innovative pedagogical approaches effectively.

Gaps in the Existing Literature

The problematic areas in existing studies on critical pedagogy in mathematics teaching and learning are highlighted through a correlative and holistic review. The practices of critical pedagogy have received significant theoretical attention, along with individuals exploring its benefits in mathematics education. However, research demonstrating the effectiveness of critical pedagogy as a classroom approach across diverse educational settings remains very limited. Current studies often lack sufficient detail on how critical pedagogy was implemented in alignment with standard curricula

and standardized testing, making it difficult to translate these practices into practical applications (Rubel & McCloskey, 2021; Xenofontos et al., 2021).

Along with this, the role of the teachers of mathematics who implement constructivism in the curriculum is also scantily investigated. It is fundamental to identify and address these gaps through more in-depth research which would then lead to a greater recognition of the complexities and usefulness of such critical pedagogical methods in mathematics teaching-learning. Filling these blank spaces will make the purpose of critical pedagogy in diverse mathematical learning environment clearer and more pronounced too (Sebsibe et al., 2023).

In addition, most of the current literature relates to the higher education context, where authors mainly discuss the applicability and effects of critical pedagogy in the scope of secondary-level mathematics classrooms. The said gap is an important one for the reason that the dynamics in school-level education may be quite different from those in higher education. Besides this identified gap, even without much substantial examination on how technology enhances the critical pedagogy in mathematics lectures.

With the development of digital devices, the indistinguishable integration of these devices into the classroom has brought about several expectations that technology has the potential to enrich or hinder the instruction of the principles of critical pedagogy in mathematics (Aliyu et al., 2021).

Critical pedagogy literature fails to look into the cultural factors, giving it needed attention since its effectiveness can be improved by adding rigorous and culturally context-dependent dimensions of critical pedagogy in diverse educational settings. The underlying factor to student performance in mathematics, as well as the educational process, is the culture.

Educators are obliged to apply these to individual learning styles and perceptions of students from different cultures. Engaging and participating in these spaces will not only improve comprehension of critical pedagogy in mathematics teaching-learning but, also, will fuel educators, policymakers, and researchers in implementing contextual pedagogy aiming to solve education problems from different cultures (Costa et al., 2020). Future attempts need to be made up by trying to overcome these shortcomings for a greater understanding of the role of critical pedagogy in mathematics teaching.

Review Findings

The systematic literature review revealed that the critical pedagogy approach plays a significant role in mathematics teaching-learning and student achievement. The common theme among the studies is that critical pedagogy empowers students by fostering critical thinking, social awareness, and active engagement, promoting educational practices that challenge traditional power structures and emphasise inclusivity and democratic values.

This is particularly evident in studies like those of Pollard (2019), Vimbelo and Bayaga (2024), and Stinson et al. (2012), which highlight its transformative potential in creating student-centered and socially conscious learning environments. However, some studies, such as Jeyaraj (2020) and Shareef and Sadiq (2023), note resistance and challenges in implementing critical pedagogy, especially in socio-politically sensitive contexts, while Smith and Seal (2021) point out the difficulties of adapting it within higher education settings.

Additionally, the review revealed that critical pedagogy promotes active engagement, self-regulated learning, and critical thinking leading to improved outcomes. Prioritising inclusive and student-centered strategies are essential for addressing diverse backgrounds and fostering effective learning. Research supports collaborative, evidence-based approaches, integrating problem-posing and critical thinking models to tackle social justice issues in mathematics education. These strategies ensure active participation and a better understanding of mathematical concepts, ultimately boosting student achievement in diverse educational contexts.

Current Practices and Strategies of Critical Pedagogy in Classroom Teaching

Critical pedagogy has emerged as a transformative approach in mathematics education, challenging traditional teacher-centered methods and supporting student-centered learning. The review indicates that this pedagogical approach encourages active student engagement, where learners are not just passive recipients of knowledge but active participants in constructing their understanding (Gargroetzi et al., 2021; Vimbelo & Bayaga, 2024).

Teachers who adopt critical pedagogy in mathematics often focus on creating inclusive and participatory classroom environments that promote dialogue and critical thinking (Stinson et al., 2012). For example, Vimbelo and Bayaga (2024) demonstrated how integrating humanising pedagogy in Technical and Vocational Education and

Training (TVET) settings helped transform mathematics classrooms by shifting from teacher-centered instruction to student-centered discussions. Despite these promising strategies, many studies do not provide concrete examples of how critical pedagogy can be practically implemented within the mathematics curriculum.

Stinson et al. (2012) note that while there is significant interest in applying critical pedagogy to promote social justice through mathematics, the lack of practical guidelines makes it difficult for educators to align these methods with standardised curricula and testing requirements. This gap is further highlighted by Rubel and McCloskey (2021) and Xenofontos et al. (2021), who stress the need for more research focused on practical applications in diverse educational settings.

Moreover, critical pedagogy requires a fundamental shift in the teacher's role—from being the sole authority to acting as a facilitator of learning. This role change is essential for fostering a classroom environment conducive to critical inquiry and student autonomy (Matiti, 2024; Kareepadath, 2018). However, educators often struggle with this transition due to insufficient training and support (Luitel et al., 2022).

One of the key review questions sought to establish the strengths and limitations of implementing critical pedagogy approach in mathematics teaching and learning. The literature reviewed shows that social justice can be included in the classroom environment. The limitations emerging were that lack adequate training of programmes for pre-service and in-service teachers. The literature underscores the importance of professional development programs that equip teachers with the skills and confidence to implement critical pedagogy effectively in their mathematics classrooms (Panthi, 2023). The fourth review question sought to elicit recommendations from existing research for effective implementation of critical pedagogy in mathematics teaching and learning. The emerging recommendations include the conduction of comprehensive experimental research in mathematics classrooms, wherein critical pedagogy is incorporated in teacher training, curriculum materials development and assessment.

Effect of Critical Pedagogy on Student Achievement in Mathematics

The impact of critical pedagogy on student achievement in mathematics is promising but under-documented. This approach underscores the relevance of mathematics to students' lives, leading to deeper understanding and increased engagement (Stinson et al., 2012). Research by Gargroetzi et al. (2021) and Vimbelo and Bayaga (2024) indicates that teaching through a critical pedagogy lens helps

students connect mathematical concepts to real-world issues, enhancing their motivation and conceptual understanding.

However, there is a notable gap in empirical studies measuring the impact of critical pedagogy on traditional academic outcomes, such as standardised test scores and grades. Rubel and McCloskey (2021) and Xenofontos et al. (2021) assert that this lack of data complicates the assessment of critical pedagogy's effectiveness in improving student achievement, especially in systems focused on standardized testing. Generally, very limited studies have related the use of technology to the enhancement of critical thinking in mathematics teaching and learning (Boadu & Boateng, 2024).

Despite these gaps, some studies suggest that critical pedagogy can enhance critical thinking skills and empower students to use mathematics for social change (Gargroetzi et al., 2021; Matiti, 2024). Stinson et al. (2012) argue that this approach not only improves academic performance but also fosters social awareness and responsibility among students.

In a nutshell, while critical pedagogy has potential for enhancing student achievement in mathematics, particularly regarding engagement and understanding, more rigorous studies are needed to evaluate its impact on traditional academic outcomes. Future research should focus on how critical pedagogy affects standardised test scores and other conventional metrics to provide a comprehensive understanding of its effectiveness in mathematics education.

Attitudes of Students and Educators Towards Critical Pedagogy in Mathematics Education

The attitudes of students and educators towards critical pedagogy in mathematics education are largely positive. Students appreciate the active engagement and real-world connections facilitated by this approach, which empowers them and fosters motivation often absent in traditional classrooms (Gargroetzi et al., 2021; Kareepadath, 2018; Stinson et al., 2012; Vimbelo & Bayaga, 2024). Educators also favor critical pedagogy for its potential to enhance student engagement and understanding, recognizing the importance of a classroom environment that promotes dialogue and critical thinking (Matiti, 2024; Luitel et al., 2022).

However, significant challenges hinder its implementation. A primary barrier is the lack of professional development focused on critical pedagogy in mathematics (Panthi, 2023). Without adequate training, teachers struggle to transition from traditional methods to a more student-centered approach. Additionally, institutional and

societal resistance, particularly in regions like Nepal where standardized testing and rote memorization dominate, complicates the adoption of progressive teaching practices (Likuru & Mwila, 2022)

In summary, while there is a generally positive outlook on critical pedagogy among students and educators, addressing the challenges of training and cultural resistance is essential for its effective implementation in mathematics education.

Discussion

This review highlighted the significant potential of critical pedagogy in enhancing mathematics education by promoting active student engagement and a deeper understanding of mathematical concepts. Studies by Gargroetzi et al. (2021) and Vimbelo and Bayaga (2024) demonstrate that when students participate in problem-posing and dialogic learning, they are not only more motivated but also better equipped to connect mathematical ideas to real-world issues.

This approach, as supported by Stinson et al. (2012), empowers students to see mathematics as a tool for social change, fostering both academic success and social awareness. However, while these benefits are well-documented, the practical application of critical pedagogy in mathematics education remains limited, particularly in contexts where traditional teaching methods prevail.

The implementation of critical pedagogy faces several challenges, primarily due to the stronghold of conventional teaching practices that strengthen rote memorisation and standardised testing (Likuru & Mwila, 2022; Gutiérrez, 2017). Educators often struggle with the transition to student-centered approaches because they lack adequate resources, training, and support (Panthi, 2023; Luitel et al., 2022).

Teacher practices could be aligned with a dialogic space, a democratic environment, pairing and sharing activities, hands-on projects, and learning by doing space in classrooms. Additionally, structural issues such as overcrowded classrooms and limited access to teaching materials further hinder the adoption of innovative teaching practices (Matiti, 2024; Kareepadath, 2018).

Moreover, the institutional focus on exam results, particularly in regions like Nepal, discourages educators from deviating from the prescribed curriculum, making it difficult to integrate critical pedagogy effectively (Kunwar, 2020; Lamsal, 2024). Cultural norms that favor respect for authority and traditional methods also pose significant barriers, as they conflict with the critical inquiry and dialogue that are central to critical pedagogy (Gutiérrez, 2017; Gargroetzi et al., 2021).

Despite the challenges, there are clear gaps in the literature that need to be addressed to advance the application of critical pedagogy in mathematics teaching. There is a notable lack of empirical studies that document how critical pedagogy can be practically implemented in secondary-level mathematics classrooms, especially within the constraints of standard curricula and assessment frameworks (Rubel & McCloskey, 2021; Xenofontos et al., 2021).

The role of technology in supporting critical pedagogy is another underexplored area, with the potential for digital tools to facilitate more interactive and collaborative learning experiences (Aliyu et al., 2021). Additionally, cultural factors that influence the effectiveness of critical pedagogy need further investigation to develop culturally responsive teaching practices (Costa et al., 2020). Addressing these gaps through targeted research will be crucial for creating a more equitable and effective mathematics education that fully realises the potential of critical pedagogy.

Conclusion, Limitations, and Future Directions

In conclusion, this systematic review underscores the significant promise of critical pedagogy in enhancing mathematics education. By actively engaging students and fostering a deeper understanding of mathematical concepts, critical pedagogy empowers learners to connect mathematics with real-world issues, thereby promoting both academic success and social awareness. However, the practical application of critical pedagogy in mathematics classrooms remains limited, primarily due to the entrenched nature of traditional teaching methods that prioritise rote memorisation and standardised testing.

The review identifies several limitations, including a scarcity of empirical studies that measure the impact of critical pedagogy on conventional academic outcomes, such as standardised test scores and grades. This lack of data hinders a comprehensive assessment of critical pedagogy's effectiveness in improving student achievement in mathematics, particularly in educational systems where standardised testing is the primary measure of success. Additionally, the existing literature often overlooks the role of technology in enhancing critical pedagogy and the influence of cultural factors on its implementation.

Future research should focus on the impact of critical pedagogy on traditional academic metrics. Investigating how critical pedagogy can be effectively integrated into secondary-level mathematics classrooms is crucial for understanding its potential benefits. Furthermore, future research exploring the role of technology in facilitating

critical pedagogy and developing culturally responsive teaching practices will be essential for creating a more equitable and effective mathematics education. By prioritising these areas, educators and researchers can work towards the realisation of the transformative potential of critical pedagogy in mathematics teaching and learning.

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