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The Continuing Pedagogical Training of University Mathematics Teachers from a Critical Pedagogical Perspective

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Abstract: This paper analyzes the continuous pedagogical training of mathematics professors at a public university in Latin America from a critical perspective, highlighting the importance of evaluating and transforming educational practices. The study, framed within the social sciences through ethnography, adopted a mixed-methods approach, predominantly qualitative, with the integration of quantitative techniques. The complexity paradigm was employed to understand systemic socio-educational realities, recognizing the subject-object interaction from a dialectical perspective. Additionally, it focused on examining the pedagogical practices of the professors and revealed a significant gap between institutional statements and the reality observed in classrooms. This study aims to theoretically underpin pedagogical practices in higher education through a theoretical-methodological framework based on critical pedagogy, critical mathematics, and the systematization of experiences. Critical pedagogy, developed by theorists such as Paulo Freire, advocates education that fosters critical consciousness and social emancipation; in turn, critical mathematics emphasizes the importance of contextualizing teaching mathematics within social and cultural issues, promoting a deeper and more relevant understanding of mathematical concepts. The systematization of experiences, as a methodology, allows for the collection, analysis, and reflection of pedagogical practices, facilitating the generation of knowledge from educational practices in context. The results revealed a lack of integration of social issues into mathematics classes and the persistence of traditional pedagogical practices that did not support the development of critical thinking or the contextualization of mathematical knowledge. This disconnection between theory and practice reflects the urgent need for pedagogical reforms incorporating a critical and contextual perspective into mathematics teaching. The novelty of this study lies in its relevance to the Latin American context, highlighting the need to integrate pedagogy and politics in education. The theoretical contribution of this study consists of incorporating critical perspectives to support the continuous pedagogical training of university mathematics professors. This integration has significant practical implications because it aims to transform academic culture and pedagogical practices, promoting a more inclusive, critical education that aligns with students' social and cultural realities.

Keywords: university teacher training, critical pedagogy, critical mathematics, education, systematization of experiences.

批判教學視角下的大學數學教師繼續教育培訓

摘要：本文從批判的角度分析了拉丁美洲一所公立大學數學教授的持續教學培訓，強調了評估和轉變教育實踐的重要性。這項研究透過人類學以社會科學為框架，採用了混合方法，主要是定性研究，並結合了定量技術。複雜性典範被用來理解系統的社會教育現實，從辯證的角度來認識主體與客體的互動。此外，它還重點檢查教授的教學實踐，並揭示了機構陳述

與課堂上觀察到的現實之間的巨大差距。本研究旨在透過基於批判性教育學、批判性數學和經驗系統化的理論方法框架，從理論上支持高等教育的教學實踐。由保羅·弗里爾等理論家發展的批判教育學提倡培養批判意識和社會解放的教育；反過來，批判數學強調將數學教學置於社會和文化問題的背景下的重要性，促進對數學概念更深入、更相關的理解。經驗的系統化作為方法論，可以收集、分析和反思教學實踐，促進從教育實踐中產生知識。結果表明，數學課堂中缺乏社會問題的整合，並且傳統教學實踐的持續存在，不支持批判性思維的發展或數學知識的情境化。理論與實踐之間的脫節反映了教學改革的迫切需要，將批判性和情境觀點納入數學教學。這項研究的新穎性在於它與拉丁美洲背景的相關性，強調了將教育和政治納入教育的必要性。本研究的理論貢獻包括納入批判性觀點來支持大學數學教授的持續教學訓練。這種整合具有重大的實際意義，因為它旨在改變學術文化和教學實踐，促進更具包容性、批判性的教育，符合學生的社會和文化現實。

关键词：大學教師培訓、批判性教育學、批判性數學、教育、經驗系統化。

1. Introduction

This paper examines the pedagogical training of mathematics teachers at a public higher education institution in Latin America from a critical perspective. The need to evaluate and improve current pedagogical practices through qualitative and quantitative methods justifies this research. Despite institutional statements on alternative pedagogical approaches, a significant gap has been identified between these statements and the reality observed in classrooms. This study aims to address these inconsistencies and enhance the quality of mathematics education.

In this context, the following research question arises: how can pedagogical practices in mathematics classrooms be transformed? Consequently, the focus of this study is on the continuous pedagogical training of university mathematics professors, emphasizing social relevance and originality as critical criteria for the research object. This research proposes a theoretical-methodological conception of this training from a critical perspective.

This research purpose is twofold: to characterize the pedagogical practices employed by professors and propose a theoretical-methodological conception that can support and transform these practices. The proposed conception is based on critical pedagogy, critical mathematics, and the systematization of experiences, providing a solid theoretical foundation for pedagogical reflection and transformation in the context of public higher education in Latin America.

The background of the study reveals a lack of integration of social issues in mathematics classes and the prevalence of traditional pedagogical methods. The need to integrate pedagogy and politics into education is identified, especially in Latin American and Colombian contexts. The study's results indicate

deficiencies in mathematics professors' pedagogical practices, such as a lack of specific training in pedagogy and the limited contextualization of mathematical content in relevant social, economic, and political contexts. Additionally, resistance exists to address political and social issues in mathematics classrooms.

To address these deficiencies, this paper proposes the theoretical-methodological foundations of a continuous training program for university mathematics professors, transforming them into agents of democratic change. This program should provide a solid ethical, political, and axiological foundation based on a critical perspective. It should generate significant transformations in the educational field by promoting educational mathematics that contributes to the transformation and liberation of society. This article is a research product of the doctoral thesis: "Continuous Pedagogical Training of University Mathematics Professors from a Critical Pedagogical Perspective," Universidad de Ciencias Pedagógicas Enrique José Varona, Havana, Cuba.

2. Theoretical/Conceptual Framework: An Approach to the Continuous Pedagogical Training of University Professors

The concept of training, according to various perspectives, goes beyond conventional educational conditions and processes. Plato considered training crucial for the growth of both the spirit and the body, emphasizing its role in preparing warriors. Today, authorial criteria highlight the importance of training for pedagogical science and its orientation toward development, moving away from pragmatic approaches.

This perspective underscores the social influence on training, viewing it as a process that reflects and projects specific socio-historical ideals and objectives.

Teacher training in higher education encompasses various perspectives, highlighting the importance of initial training as a foundation for teachers' professional performance. In addition, continuous learning is considered a fundamental principle for the ongoing pedagogical development of university instructors. On the other hand, [1] equated permanent training with continuous training, emphasizing the need for new intellectual demands and competencies for social transformation. Thus, teacher training is an ongoing process that influences both formative processes and institutionalization. The importance of a multidimensional and integrative perspective is emphasized, recognizing the professional and personal development of both the teacher and the university institution.

For a long time, it was considered that mastery of a subject (Mathematics) was sufficient for a good teacher. However, the importance of pedagogical knowledge in approaching students, facilitating learning, and motivating them to learn is now recognized. Continuous pedagogical training is thus perceived as a continuous, systematic, and planned process that impacts the quality of higher education [1, 2]. In this context, a critical pedagogical perspective prioritizes criteria that emphasize professional development that is committed to social issues [3]. Consequently, continuous pedagogical training is understood as part of professionalization processes that depend on teachers' commitment to self-improvement and institutional demands.

From a sociological perspective, professional practice is recognized as a field of pedagogical knowledge where teaching concepts and methods are legitimized, influenced by socio-historical processes; this leads to re-signifying the training space as a symbolic place, especially relevant for the pedagogical training of mathematics teachers [4].

The above suggests that continuous pedagogical training for university teachers is essential for addressing current and future challenges in global higher education. This requires the implementation of effective policies, adequate resource allocation, and active collaboration among educational institutions, teachers, and governments. Evidence from UNESCO conferences [5, 6] and specific research in different regions of the world underscores the urgency of reviewing and improving university teacher preparation to ensure quality and relevant higher education for the 21st century.

The adaptation of universities to social and economic changes involves not only training competent professionals but also fostering values and skills to contribute to social development and justice. However, significant obstacles exist, such as resistance to

continuous training, job insecurity, and a lack of clear incentives and policies at institutional and governmental levels. Addressing these barriers is essential to ensure quality training for university teachers.

A brief examination of other contexts is urgent. In Europe, the diversity of approaches to teacher training varies widely, from institutional programs to individual initiatives. Although there is a trend toward a student-centered model, especially in the European Higher Education Area, challenges persist in its implementation and the lack of a common framework for continuous training. In North America, experiences are varied, with leading institutions offering teacher training and a range of programs and pedagogical approaches. However, a lack of regulation and dependence on individual initiatives can result in inequities in access to continuous training. In Latin America, countries like Mexico, Argentina, and Brazil have made significant efforts to professionalize university teaching through postgraduate education programs, although challenges persist in integrating pedagogical training with labor market demands.

In Colombia, the lack of clear requirements for university teaching and the undervaluation of pedagogical knowledge in higher education pose significant challenges. Despite the existence of postgraduate education programs, high economic costs and the predominance of private over public universities hinder access to continuous training. The covert privatization of higher education and the gradual reduction of academic careers reflect a phenomenon described as the neoliberal assault on universities, implying that both student and teacher training are influenced by the interests of educational institution owners [7]. Colombian legislation, especially Law 30 of 1992 [8], promoted university autonomy and facilitated the expansion of the private sector in higher education. However, this law has led to an unregulated market and the proliferation of institutions with questionable quality standards.

Studies, such as one conducted at a private university [9], highlighted teachers' pedagogical deficiencies, impacting knowledge construction and students' learning experiences. These deficiencies are not limited to the private sector; the conditions for pedagogical training in public universities are similar [10]. The above evidences a lack of defined policies by the State to guide and ensure the quality of teacher training in Malawi. On the other hand, university autonomy, promoted as a democratic principle, can mask ideological and economic interests. Bourdieu and Passeron [4] assumed that the perception of autonomy can be illusory because educational institutions are intrinsically linked to society's class structures. Consequently, the state's role is limited to regulation without significantly intervening in the direction and development of higher education.

The Colombian Ministry of National Education introduced the document "Teacher Training in Colombia" in 2022 [11], aiming to establish policies to train competent professionals in pedagogy and social skills. However, the effectiveness of these policies in addressing the current challenges in higher education still requires evaluation. Continuous training of university teachers in Colombia faces notable challenges in terms of focus, scope, and institutional resistance. Adopting approaches such as Critical Pedagogy can offer new perspectives and opportunities to improve the quality of teacher training and ultimately contribute to more inclusive and transformative education. Despite the implementation of systems and public policy proposals, such as the National System of Teacher Training and Professional Development and the Agreement for Higher Education 2034 [12], these have not focused on continuous training for university teachers.

In the context of a particular institution, there is an effort to offer professional qualification programs, but it still faces obstacles in adapting to the specific needs of different faculties. In the field of mathematics education, continuous training for university teachers focuses on general pedagogy and lacks specific attention to integrating theory and practice from didactics.

In this regard, critical pedagogy emerges as a promising and committed approach to addressing these challenges, highlighting the importance of continuous pedagogical training oriented toward critical reflection and social sensitivity. This approach transforms the traditional teacher into a reflective agent capable of questioning power structures and dominant educational practices. However, implementation faces resistance from conservative sectors and requires solid commitment from educational institutions and university teachers themselves [13].

3. Research Methodology

The study, which is situated within the social sciences through ethnography, adopted a mixed-methods approach, primarily qualitative but also integrating quantitative techniques. The complexity paradigm was employed to understand systemic socio-educational realities, recognizing the subject-object interaction from a dialectical perspective. A critical perspective was used, forming a metalanguage, to characterize the pedagogical practices of mathematics professors at a public higher education institution in Latin America, taking into consideration the cultural context and the actors involved. Additionally, the research was based on Dialectical Materialism and its systemic, complex implications as a philosophical foundation.

Theoretical methods included documentary triangulation to identify coincidences in the ongoing pedagogical training of university professors and

historical-logical and critical methods to reveal causal relationships. Empirical methods, both qualitative and quantitative, involved surveys of professors and students, focus groups, classroom observations, and documentary analyses of national and institutional regulations related to higher education and critical reflection in the classroom, particularly in mathematics. These methods allowed for the characterization of the current state of mathematics professors' pedagogical practices at a higher education institution in Latin America.

It is important to highlight that within the framework of ethnographic research, the author emphasizes the influence of the researcher on the phenomenon studied, recognizing their own frames of reference and subjectivities. The ethnographic methodology allows for a hermeneutic approach to the reality of pedagogical practices, where the participatory action of professors is highlighted as key, voluntary, and discretionary. Regarding instruments and procedures [14], surveys were conducted with professors (61) and students (425), aiming to capture descriptive and diagnostic information from various perspectives; three focus groups with professors: mathematics (42), physics (11), and statistics (8), centered on specific subjects, sought to characterize the collective thinking of professors around critical social positions in the classroom; and classroom observations of professors: mathematics (42), physics (11), and statistics (8), conducted with disciplinary experts to analyze pedagogical practices from a critical perspective.

4. Research Findings

Higher education institutions are public institutions in Latin America with over 50 years of history. Its student population mainly comes from low socioeconomic strata. It offers technological, professional, and distance education programs across four faculties and has more than 12,000 students and over 700 professors.

This Latin American institution, in its institutional documents, declares its social commitment, promoting constructive dialog, equity, social justice, and human development. The strategic development plan emphasizes critical thinking and the use of technologies in teaching and learning processes. Similarly, the Institutional Educational Project [15] underscores critical thinking, democracy, and its contribution to the analysis of social problems. Likewise, the Institutional Pedagogical Model highlights comprehensive education, critical thinking, and research as core components of its institutional philosophy. It also recognizes students as unique individuals, fostering critical thinking and free thought; the training has a humanistic approach and develops cognitive, socio-emotional, and communicative competencies.

Additionally, higher education institutions in Latin America promote formative research to cultivate critical thinking in their students. The Office of Faculty Development and the Educational Program for Faculty Development [16] aim to strengthen the relationship between academic and institutional culture by promoting self-reflection and creating self-critical and democratic academic communities. The qualification program, from its functions, defines faculty competence, emphasizing the importance of critical reflection in teaching; consequently, the metaphor of the self-reflective spiral guides continuous planning, action, and reflection. Accordingly, the institution recognizes the need to transcend the theory of its institutional documents to take action in academic settings, particularly in the area of continuous teacher training, to foster critical thinking in the classroom.

Based on the previous context, the author referenced a system of categorical relationships for research, focusing on the scenarios of teacher performance and their pedagogical practices, highlighting three dimensions: 1) space-time, 2) disciplinary knowledge, and 3) an epistemology that guides it. The first considers pedagogical practice as a social praxis affected by subjective and sociocultural aspects; the second relates to disciplinary knowledge and didactics of the discipline; and the third seeks to base practice on a critical epistemology to generate transformations in the educational field. It emphasizes that pedagogical practices are not neutral because of dominant power, and ethics and policy influence them.

Subsequently, the authors defined their own model of a categorical relationship system (Fig. 1).

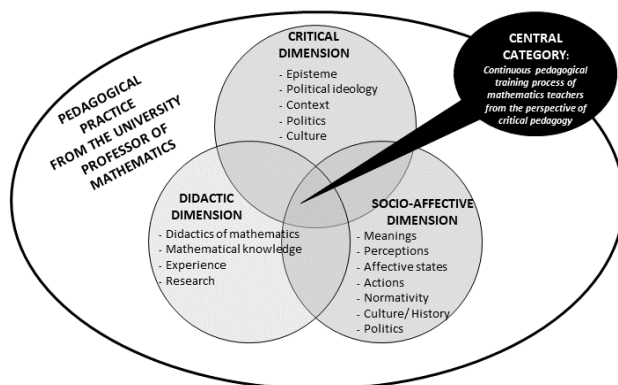


Fig. 1 System model of the categorical relationships of the research (The authors)

As a qualitative variable of the phenomenon: critical reflection of mathematics teachers in the basic sciences department of higher education institutions in Latin America; this is articulated to the institutional regulatory framework, one central category (the field understood as the central category): the process of continuous pedagogical training of mathematics teachers in higher education institutions, from a critical pedagogical perspective, which coincides with the same field of research in this study.

Additionally, three categorical pedagogical

dimensions are identified: socio-emotional, didactic, and critical, which interact in networks of relationships, sourced from critical pedagogy, the institutional pedagogical model, the concept of faculty competence in the faculty qualification program, and the cultural phenomenon of the pedagogical practices of mathematics teachers in higher education institutions in Latin America.

This study revealed a detailed view of the characteristics of mathematics teachers in the basic sciences department of a higher education institution, highlighting sociodemographic aspects, training, didactic strategies, and critical attitudes in the classroom. The results raise important questions about the alignment between the institution's declared intentions and effective practices in teaching mathematics in this university context. The analysis of the findings reveals significant information in three categorical dimensions: socio-emotional, didactic, and critical for teachers in the basic sciences department of a higher education institution in Latin America.

In the socio-emotional dimension, the predominance of male teachers was noted, with the majority of teachers ranging in age from 40 to 59 years. Most students come from public universities, and their academic training is mostly at the master's level. Although some teachers expressed leftist political positions in focus groups, classroom observations do not necessarily reflect these positions. Additionally, most teachers are adjuncts or contractors, which could affect their attachment and commitment to the institution.

In the didactic dimension, 44% of the teachers have licensure, and most consider strengthening logical thinking to be the fundamental purpose of a mathematics course. Although they self-identify as constructivists, a significant percentage identify themselves as behaviorists. The most commonly used didactic strategy is problem-solving, but some teachers do not have a clear understanding of this strategy and confuse it with mere algorithmic problem-solving. The sources of problems used in the classroom are mostly reference books, raising questions about the cultural adaptability and relevance of the content.

In the critical dimension, the results indicate an interest in incorporating reflections on the country's social problems into mathematics teaching. However, teachers show some reluctance and fear when openly expressing their political positions in the classroom. The observations revealed that social situations are rarely presented in mathematical problems and exercises in class, and discussions on political issues in mathematics are also limited. Although some teachers expressed a desire to be critical in the classroom, the evidence indicates that this attitude does not fully translate into practice.

Regarding mathematics teachers' pedagogical practices in higher education institutions in Latin

America, highlighting important findings, strengths, deficiencies, and potentialities is significant. The importance of addressing shortcomings in pedagogical training, fostering critical reflection in the classroom, and promoting contextualized teaching that links mathematics with students' social realities is also emphasized.

The strengths identified in the pedagogical practices of teachers in the basic sciences department at the Latin American university include their academic diversity; they are professionals from various disciplines related to mathematics. Additionally, many of them have solid theoretical and practical training and extensive university teaching experience. Their kindness, affection, and dynamic interaction in their classes were noted, demonstrating their sensitivity to students' academic and social difficulties. Responsibility and commitment to the institution, and willingness to participate in academic debates on pedagogy and didactics, are also recognized.

The study identified multiple deficiencies in mathematics teachers' pedagogical practices, many of whom lack specific pedagogy training due to their training in areas unrelated to education. Although problem-solving is a common strategy, there is a lack of theoretical-methodological understanding of this strategy, which is mainly limited to algorithmic problems without fostering critical reflection on the results. Additionally, few teachers contextualize mathematical problems in relevant social, economic, and political contexts, limiting the significance of learning for students.

The lack of reflection in mathematics classrooms and the reluctance to address political and social issues are also emphasized. The teaching of mathematics is often characterized by a dogmatic approach, in which problem-solving is neither discussed nor validated, and feedback is limited. There is a lack of knowledge and application of institutional policies that promote critical reflection in teaching. Consequently, classes tend to adopt behaviorist and lecture-based approaches, perpetuating traditional pedagogy.

Despite these deficiencies, revealing potentialities are recognized. Teachers are willing to participate in pedagogical and didactic training processes, especially if they do not require much time. Many students have a good academic level with postgraduate training, indicating an approach to research processes in education and other disciplines. Their solidarity, especially among those from popular sectors that have improved their quality of life through teaching, is also highlighted. Despite these limitations, some teachers expressed interest in improving their practices and presented theoretical approaches to pedagogy and critical mathematics.

5. Discussion

One of the most significant outcomes of this study

involves developing a theoretical-methodological conception for the continuous pedagogical training of university mathematics teachers at a public higher education institution in Latin America. This approach is grounded in a critical pedagogical perspective and integrated into the previously described research system of categorial relationships.

The notion of theoretical-methodological conception is defined as a system of ideas, representations and interpretations about a particular phenomenon, encompassing philosophical, epistemological and scientific aspects. In scientific research, the notion of "conception" in pedagogical sciences is a subject of debate. According to [17], a theoretical conception in this context implies objectives, essential concepts, principles, and a characterization of the research object, with the purpose of comprehensively modeling the study object. In the case of research on the pedagogical practices of university mathematics teachers, the theoretical conception characterizes the educational phenomenon to meet specific objectives.

Valle [17] emphasized that the concept of conception in pedagogical research is relatively new and equates conception to its foundations. He noted that the term is built upon research that adopts as an epistemic foundation, indicating a lack of uniformity in the methodological criteria.

Correspondingly, a theoretical-methodological pedagogical conception is proposed for research, which characterizes pedagogical practices and provides a theoretical foundation for the continuous training of university mathematics teachers. This conception is articulated to the central categorial system and its dimensions, determining specific subdimensions for this research (Fig. 2).

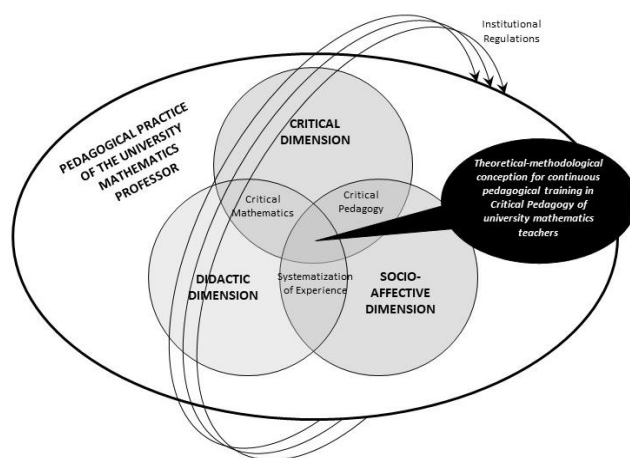


Fig. 2 Model of the dimensions of systemic interrelationships and subdimension (The authors)

Fig. 2 displays a categorial system model with three main dimensions: critical, didactics, and socio-affective, and their systemic interactions. These interactions cause subdimensions such as critical mathematics, critical pedagogy, and systematization of experience.

Institutional regulations influence the system. In this context, a model of theoretical-methodological conception for continuous pedagogical training in Critical Pedagogy for university mathematics teachers at higher education institutions in Latin America is presented, following the logogrammatic principle of systems. Thus, the categorial system establishes theoretical-methodological bases, whereas the sub-dimension system is hermeneutic, explanatory, and deontological. The intersection between category systems generates subdimensions and establishes connections between them. Thus, the theoretical-methodological conception addresses the critical, didactics, and socio-affective dimensions, highlighting their interrelationship in the conception itself. The three subdimensions are described below.

5.1. Critical Pedagogy: The Transformative Discourse of Mathematics Teachers

Critical pedagogy is a dynamic and committed educational approach that seeks to challenge power structures and promote social emancipation through critical reflection and transformative action both inside and outside the classroom. Its relevance lies in its ability to question established norms and promote significant changes in education and society in general [18].

It represents a dialectical and transformative discourse that challenges the entrenched pedagogical traditions of universities. It emerges as a struggle between opposing forces in the field of education, classrooms, and interactions between students and teachers. This perspective seeks to redefine, reinterpret, and rethink the very understanding of the educational process, highlighting the structural and relational dimensions of knowledge and the complex interactions between power and knowledge [19, 20]. It contrasts with traditional, unconscious, and reproductive pedagogy, advocating a more rational, necessary, and real approach.

The foundation of critical pedagogy in Latin America can be found in the seminal work [21], which proposed a participatory educational approach that questioned power and domination relations in the educational field. Adopting a dialectical approach implies acknowledging that the outcomes of human thought and action are transient and contextualized and subject to change and evolution based on new historical and social conditions.

In contemporary capitalist societies, traditional pedagogy is insufficient to address educational challenges because it tends to perpetuate the structures of social reproduction imposed by dominant elites. The school, and particularly the university, reflects the contradictions of social contexts, where Critical Pedagogy can help unravel the underlying logics and hidden interests underlying traditional educational practices.

The conscious pedagogical discourse of the teacher has a significant impact on students, mobilizing both their minds and actions within social contexts. This discourse must generate reflection and tensions in students, which, in turn, motivates teachers to address tensions and conflicts in classrooms through critical pedagogical approaches. The critical function of knowledge lies in its ability to address and resolve social conflicts and promote transformative alternatives. Dogmatic knowledge disconnected from reality lacks relevance in the context of Critical Pedagogy, which recognizes the collective and historical-social nature of knowledge construction.

In this regard, educational curricula should be conceived as political and cultural spaces that reflect and perpetuate existing power relations. Critical pedagogy advocates a dialectical and contradictory curriculum that recognizes and voices students' experiences and realities, promoting political awareness and transformative action. Similarly, teachers play a crucial role as transformative intellectuals [13] who are responsible for reflecting on their practices and promoting critical and liberating education. The university is thus conceived as a space of symbolic struggle linked to power and control, where teachers have the duty to politicize the pedagogical and vice versa, for a freer and more democratic society [22].

5.2. Critical Mathematics: Formative Power of Mathematics

The philosophy of critical mathematics education involves a deep reflection on the role of mathematics and its teaching, recognizing both its formative potential and social and political implications. This approach seeks to promote dialog, deliberation, and transformation in the classroom to provide new perspectives for interpreting and understanding mathematics and its influence on social and political realities. Its main objective is to cultivate critical citizenship through reflective analysis of mathematics and its impact on society.

Skovsmose and Valero [23] have formulated the interrelationships between philosophy, critical pedagogy, and educational practice in the classroom, especially in the context of mathematics teaching. These authors proposed a philosophy of critical mathematics education to develop critical citizenship in a democratic society, where this relatively new perspective was influenced by various theoretical and methodological frameworks, such as the cognitive, constructivism, systemic, anthropological, semiotic, and critical approaches [24].

The ethno-mathematical dimension, for example, establishes a relationship between mathematics and the culture of various ethnic groups and recognizes the diversity and social, cultural, historical, and political implications in the teaching of mathematics [24]. This

perspective addresses the conceptual, historical, cognitive, social, epistemological, political, and educational dimensions of mathematics [25].

Mathematics has formative power that can transform reality and either colonize or decolonize it, highlighting the need for critical mathematics education that allows citizens to understand and question the social and political impact of mathematics. Therefore, civic competencies are linked to citizens' ability to exercise control over their rulers, underscoring the importance of mathematics education in strengthening democracy [23].

For this reason, the same authors emphasize that critical pedagogy and critical mathematics education complement each other in seeking new possibilities for interpreting and understanding mathematics education and promoting reflection and transformation in the classroom.

Critical mathematics education questions the neutrality of mathematics and its role in society, promoting a critical reflection on its power and social implications. Mathematics, as a formal and abstract discipline, has formative power by offering new interpretations of reality and transforming perceptions, implying ethical and social responsibility in its teaching.

Moreover, during the development of the teaching-learning process of mathematics from a critical perspective, the teacher becomes an agent of change, which involves collective deliberation, reflective reflection, and transformation as integral and permanent communicative processes in the classroom. The teacher's role in teaching is crucial in creating meaningful didactic situations through problem-solving and open dialog between students and teachers.

Critical mathematics not only provides guidelines for mathematics teaching but also seeks to create new possibilities for interpreting and understanding mathematics education, recognizing the importance of a committed teacher who explores new conceptions and shares their pedagogical practice to transform mathematics teaching [26].

In the field of applied mathematics, there is a particular case of Financial Mathematics, which calls for a critical approach in its teaching. Its origin begins with social situations that have created needs for humanity, such as the creation of the decimal numbering system, which allows solving commercial situations, particularly those related to the growth or decline of money, due to its ability to handle calculations with smaller subunits of a unit. Over time, this motivates reflection on the growth of money from two perspectives: one concerning the method of making calculations (modeling) [27] and the other on its social impact and ethical component, which arises from values and anti-values, as mentioned by Rojas [28]. Understanding the scope of application and solving the problem situation leads to a numerical

response, which the person is responsible for providing according to the need. Only through an objective analysis can critical thinking and a critical stance on the event be strengthened.

The modeling process, to consolidate it, requires a real situation (social context) in which relationships between parts of the situation are identified and compared with mathematical structures until the functionality of the representation is achieved through a formula, which must respond to the parameters of the context that motivated its creation. So, the modeling process is: real problem situation – problem formulation – model (coherence-validation) [28].

5.3. Systematization of Experience: Systematizing Action as a Critical Investigative Practice

The systematization of experiences is an alternative research approach that recognizes the importance of situated knowledge and the diversity of epistemological approaches. This process, which combines critical reflection with theorization, allows transformation of reality through the dialog of knowledge and the collective construction of knowledge.

The UNESCO Venice Declaration in 1987 marked a turning point by recognizing the need to integrate various forms of knowledge and research methods to obtain a broader and more complete vision of the world [29]. This approach, supported by the 1986 symposium on "Science and the Frontiers of Knowledge" [30], advocated for transdisciplinarity and the complementarity of different epistemological approaches. In line with these ideas, a movement of "epistemic rebellion" has emerged in Latin America, represented by the Systematization of Experiences, which seeks to value and theorize practices that generate knowledge. This social research methodology recognizes the importance of situated knowledge and the richness of practical experiences, especially in the educational field; it is a systemic and dialogic process that seeks to transform reality through the reflection and theorization of lived experiences [30].

Regarding its methodology, Systematization does not follow a linear and unique path; rather, it adapts to the particularities of each experience. This process is based on reconstructing and organizing the objective and subjective elements involved in the practice to extract lessons and share them. The theorization resulting from the systematization of experiences is fundamental to making explicit the networks of relationships generated in practice, thereby facilitating their global understanding [31]. This process involves the participation of various actors and the collective construction of knowledge.

The relationship between practice and knowledge is not automatic [32] but requires reflective and dialogic process. Therefore, the systematization of experiences offers a methodological framework for this process, which involves reconstructing the project, identifying

hypotheses, and orienting toward new points of reflection [33].

To promote and legitimize a continuous pedagogical training process for university mathematics teachers, based on critical pedagogy, critical mathematics, and systematization of experiences, it is necessary to question the foundations of this change and innovation, define implementation goals, and reveal its transformative intention in a university environment rooted in conservative structures. This conception must transcend the limits of theory to action.

The proposed training process is based on teaching practice, and the systematization of experiences plays a central role in the research and formative processes. Critical reflection acts as a guiding thread that unites pedagogy, didactics, and systematization; these three foundations structure the training program, providing a solid theoretical-methodological base for its implementation.

The adoption of critical pedagogy, critical mathematics and the Systematization of Experience in the training of mathematics teachers' questions transforms traditional pedagogical practices that may limit effective learning in this discipline. Critical Pedagogy provides tools to analyze power structures and inequalities within educational contexts and fosters inclusive and equitable teaching approaches. Integrating critical mathematics aims to situate mathematics in contexts relevant to students and link it to their everyday experiences to increase motivation and prepare them for real-world challenges through reflective and critical use of mathematics. Systematizing experience involves systematic reflection on educational practices to identify the most effective strategies, which allows teachers to continuously adjust their teaching to the specific needs of students and the current context.

This continuous training strengthens teachers' pedagogical and didactic skills and empowers them to challenge established norms and explore new educational methodologies. In a dynamic educational environment, this is essential for improving students' quality of education and learning experience.

6. Conclusion

Continuous pedagogical training for university faculty in higher education is considered a contemporary educational phenomenon. Although traditional professors prioritize mastery of disciplinary content over pedagogical competencies, there is growing recognition that these competencies are essential for academic success. Therefore, continuous training is perceived as an ongoing, systematic, and planned process by institutions to improve the quality of university education [34].

In different contexts, such as Europe, North America, Latin America, and Colombia, university teachers face various challenges. These challenges

include teachers' resistance to continuous training, lack of clear institutional policies, job insecurity, and a trend toward the covert privatization of higher education.

Critical pedagogy is a structured body of knowledge that examines educational practices concerning the social and political dynamics imposed by dominant sectors. Thus, it emerges as a potential perspective to address these challenges and promote critical reflection and social sensitivity in teacher training.

In the specific case of the Higher Education Institution in Latin America, its commitment to equity, social justice, and human development stands out, as reflected in its institutional documents and pedagogical model. Additionally, there is a clear effort to promote holistic education and critical thinking among its students, recognizing their diversity and fostering cognitive, socio-emotional, and communicative competencies in teaching practice [34].

In the teaching and learning processes of mathematics professors at this higher education institution in Latin America, strengths such as disciplinary mastery and teaching experience were identified. However, there are also deficiencies, such as the lack of specific pedagogical training and reluctance to adopt political and social stances. Nevertheless, potentialities were also identified, such as willingness to participate in training processes and interest in improving pedagogical practices.

The study stands out for its academic contribution because its approach is innovative in continuously training university mathematics faculty, especially in the Latin American context. Its integration of critical pedagogy, critical mathematics, and the systematization of experiences as foundations for the professional development of teachers distinguishes this. This combination offers a new perspective to address the deficiencies identified in specific pedagogical training and students' reluctance to adopt critical approaches in the classroom. Additionally, it proposes a systematic and reflective model that not only enhances pedagogical skills but also strengthens educators' ethical and political convictions, preparing them as transformative agents in higher education.

A continuous pedagogical training program for mathematics professors at higher education institutions in Latin America should use critical pedagogy, critical mathematics, and the systematization of experiences to form university professionals as transformative agents. These professionals should possess solid ethical, political, and axiological convictions, a strong disciplinary foundation in mathematics, and a broad cultural background that will enable them to contribute to the emancipation and transformation of society.

Finally, we recommend a research project or structured continuous training program based on critical pedagogy, critical mathematics, and the systematization of experiences. This program will address the identified needs of professors at higher

education institutions in Latin America and respond to the common challenges faced by diverse educational contexts. The aim is to improve the quality of mathematics teaching through this strategy while fostering a reflective approach committed to social justice and educational equity. This approach can significantly transform teaching practices and contribute to the integral development of students in the region.

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