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Review article

Professional development for pre-university mathematics teachers in the use of Virtual Learning Environments

Superación de profesores de Matemática de preuniversitario para la utilización de Ambientes Virtuales de Aprendizaje

Formação continuada para professores de matemática do ensino pré-universitário no uso de Ambientes Virtuais de Aprendizagem

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ABSTRACT

Information and Communication Technologies (ICTs) and Virtual Learning Environments (VLEs) play a fundamental role in contemporary education, highlighting that teacher professional development is key to ensuring current educational quality while adapting to technological evolution and digitalization. This article aimed to present a systematization of the theoretical and methodological frameworks that underpin the professional development process for pre-university mathematics teachers in the use of VLEs. The research was based on the dialectical-materialist approach, employing methods such as the historical-logical method to analyze background and trends, theoretical systematization to integrate empirical evidence, and the inductive-deductive method to identify patterns in teacher training. Challenges such as the technological gap and pedagogical

adaptation were identified, and it was emphasized that professional development demands continuous training, methodological innovation, and critical reflection. The main findings revealed that, although technological resources and models exist for teacher professional development, deficiencies were found in teachers' technological skills, particularly in mathematics. It was concluded that there is a need to design professional development programs that foster pedagogical reflection and the creative appropriation of Virtual Learning Environments (VLEs), thus ensuring mathematics teaching adapted to the demands of the digital age.

Keywords: virtual learning environments; teaching and learning; professional development; teacher development; information and communication technologies.

RESUMEN

Las Tecnologías de la Información y la Comunicación (TIC) y los Ambientes Virtuales de Aprendizaje (AVA) desempeñan un rol fundamental en la educación contemporánea, señalando que la superación docente es clave para garantizar la calidad educativa actual, adaptándose a la evolución tecnológica y la digitalización. El artículo tuvo como objetivo presentar una sistematización de los referentes teórico-metodológicos que sustentan el proceso de superación de profesores de Matemática de preuniversitario en la utilización de AVA. La investigación se fundamentó en el enfoque dialéctico-materialista, empleando métodos como el histórico-lógico para analizar antecedentes y tendencias, la sistematización teórica para integrar evidencias empíricas y el inductivo-deductivo para identificar regularidades en la capacitación docente. Se evidenciaron desafíos como la brecha tecnológica y la adaptación pedagógica, y se destacó que la superación profesional demanda formación continua, innovación metodológica y reflexión crítica. Los resultados principales revelaron que, aunque existen recursos tecnológicos y modelos encaminados a la superación docente, se constataron deficiencias en las competencias tecnológicas de los docentes, particularmente en la disciplina matemática. Se concluyó que existe la necesidad de diseñar programas de superación que fomenten la reflexión pedagógica y la apropiación creativa de los AVA, garantizando así una enseñanza matemática adaptada a las exigencias de la era digital.

Palabras clave: ambientes virtuales de aprendizaje; enseñanza-aprendizaje; superación profesional; superación docente; tecnologías de la información y la comunicación.

RESUMO

As Tecnologias da Informação e Comunicação (TICs) e os Ambientes Virtuais de Aprendizagem (AVAs) desempenham um papel fundamental na educação contemporânea, evidenciando que o desenvolvimento profissional docente é essencial para garantir a qualidade educacional atual, adaptando-se à evolução tecnológica e à digitalização. Este artigo teve como objetivo sistematizar os referenciais teóricos e metodológicos que fundamentam o processo de desenvolvimento profissional de professores de matemática do ensino fundamental e médio no uso de AVAs. A pesquisa baseou-se na abordagem dialético-materialista, empregando métodos como o histórico-lógico para analisar o contexto e as tendências, a sistematização teórica para integrar evidências empíricas e o método indutivo-dedutivo para identificar padrões na formação docente. Desafios como a lacuna tecnológica e a adaptação pedagógica foram identificados, e enfatizou-se que o desenvolvimento profissional exige formação contínua, inovação metodológica e reflexão crítica. Os principais resultados revelaram que, embora existam recursos e modelos tecnológicos para o desenvolvimento profissional docente, foram encontradas deficiências nas competências tecnológicas dos professores, particularmente em matemática. Concluiu-se que existe a necessidade de conceber programas de desenvolvimento profissional que promovam a reflexão pedagógica e a apropriação criativa dos Ambientes Virtuais de Aprendizagem (AVA), garantindo assim um ensino da matemática adaptado às exigências da era digital.

Palavras-chave: ambientes virtuais de aprendizagem; ensino-aprendizagem; desenvolvimento profissional; formação de professores; tecnologias da informação e comunicação.

INTRODUCTION

The 21st century is characterized by change, uncertainty, and the unavoidable use of technology. Information and Communication Technologies (ICTs) are increasingly integrated into daily life, including educational settings, becoming a powerful tool for enhancing knowledge.

It is important to consider Hernández's (2017) assertion that ICTs, within the classroom context, can be used to improve the teaching-learning process, which requires teachers with the necessary digital skills to implement innovative teaching methodologies. According to Paredes Paredes et al. (2021),

the integration of technological tools in education demands strengthening teachers' proficiency in using them, aiming to ensure greater fluidity in educational processes.

Today's students possess specific characteristics directly related to current technologies. Therefore, being a teacher today means recognizing that the classroom must be connected to the current context and that the teaching process is no longer the same. According to Avendaño Castro et al. (2021), being a teacher today requires adapting to current demands, which means being attentive to transformations in education. This includes recognizing and fostering each student's personal growth, knowing how to design projects and approach content with a didactic perspective, as well as having the ability to create innovative learning environments, both face-to-face and virtual. Furthermore, it demands cultivating essential qualities for teaching in the digital age, in order to enrich pedagogical strategies and promote lifelong learning.

In the current context, the use of technology is an environment in which students are fully immersed. It is important to employ differentiated instruction to achieve more favorable learning outcomes. Ensuring technological literacy through professional development equips teachers with innovative tools that enhance the teaching and learning process today. Therefore, it is essential to focus teacher professional development on technological topics, particularly those related to the use of networks and Virtual Learning Environments (VLEs), computer-based teaching and learning environments.

Sharing the idea of Gallardo Fernández et al. (2020), mathematics teachers must be better prepared to assume the cross-culturality that occurs in schools due to the complexity of the present and the heterogeneity of today's students.

Professional development for teachers is key to ensuring quality education in the 21st century, adapting to technological advancements and digitalization. Mathematics teachers must update their skills and master digital tools and VLEs to enhance their students' learning. An educator committed to their own professional development is essential for preparing future generations.

Based on the above, the use of ICTs, especially VLEs, as a teaching tool in the pre-university mathematics teaching and learning process is considered innovative and entirely timely. Education today should not be conceived without the integration of these tools.

Therefore, the analysis of the elements previously examined reveals the need to delve deeper into existing theoretical contributions and practical applications in order to build upon established

advances and generate solutions to unresolved problems in the field of teacher professional development. In this context, the present study aims to present a systematization of the theoretical and methodological frameworks that underpin the professional development process for pre-university mathematics teachers in the use of VLEs.

This study is based on the dialectical-materialist approach as its general methodological framework. The historical-logical method is used to analyze the background and evolutionary trends of teacher training within the context of a technological society. Through theoretical systematization, empirical evidence and specialized literature are integrated to establish conceptual correlations. Additionally, the application of the inductive-deductive method allows for the identification of regularities in teacher training processes for the implementation of VLEs in mathematics education, leading to conclusions about the phenomenon under study.

DEVELOPMENT

Theoretical studies on the process of overcoming

The process of overcoming adversity, understood as a multidimensional phenomenon that integrates individual efforts and contextual conditions to transcend limitations and achieve personal or collective goals, has been addressed from various theoretical perspectives that seek to unravel its inherent complexity. The specialized literature conceptualizes it not only as an act of resilience in the face of adversity, but also as a dynamic mechanism of sustained growth, linked to the interaction between human capacity, social structures, and enabling environments.

Giving this process the importance it deserves, Cabrera Carrazana et al. (2021) argues that professional growth is the path to progress in the face of uncertainty and the transformations driven by the demands of a globalized world. The authors themselves emphasize that professional development represents both a challenge and a priority for the development of human capital in the country, driven by the rapid evolution of knowledge, technology, and the transformation of the economic model.

According to Bernaza Rodríguez et al. (2018), professional development is a comprehensive pedagogical process that goes beyond traditional teaching, incorporating formative elements linked to the student's professional and career development. It focuses on a systematic sequence of learning activities within a historical and cultural context, where knowledge construction occurs through

interaction, practice, and communication. Furthermore, it is considered an action expressly designed to transform the level of preparedness of educators so they can meet societal demands in the pedagogical field. It is inherent in teaching and is, without a doubt, not only a right but also an obligation of every education professional.

Furthermore, the cited authors point out that the process is based on principles that integrate scientific work, professional development, methodological work, and the management of the teaching-learning process, with the school as its central focus, as well as the connection between the demands of the educational system and the individual characteristics of teachers. Given the technological developments of the 21st century, the author of this study suggests adding a new principle: techno-pedagogical mediation, with an emphasis on virtual learning environments (VLEs) and digital competencies.

Various definitions of professional development have been presented in the scientific literature, based on different research findings presented at the Eighth International Congress on Higher Education 2012 held in Havana, Cuba. Alfonso García (2013) consolidates the definition of professional development as the continuous training of university graduates that allows them to systematically acquire, expand, and refine the knowledge and skills -both basic and specialized- necessary for better performance in their work functions, as well as for their comprehensive cultural growth.

Alfonso García (2013) considers teachers to be the protagonists of their professional development and conceives of professional growth as an intentional and guided process in which the norms, values, and practices of the profession are internalized and expressed. This implies incorporating specific knowledge that must be integrated into pedagogical work to enrich the teaching-learning process from a formative perspective.

Bernaza Rodríguez et al. (2018) warn that professional development, focused on education professionals, has essential characteristics; in it, it is essential to create the conditions that allow the teacher to critically analyze their educational practice and modify it, promoting improvement processes from the school context to understand their environment, assimilate integration, lead internal transformation and strengthen both their knowledge and their socio-emotional skills.

An important perspective is that of López Collazo (2019), who concludes that the purpose of professional development is to promote the holistic growth of the individual, both in the workplace and in their personal life. Its objectives focus on expanding, updating, and refining knowledge, skills,

and competencies, as well as strengthening values and fostering ethical and effective professional practices.

From another perspective, Dorrego Pupo et al. (2019) conducted a study of several authors who define professional development, and they highlight the following regularities: it is a constant and permanent training process, which extends throughout the professional career of the active teacher; it favors the acquisition, deepening, updating, complementation and permanent development of basic and general knowledge, skills and abilities; and its purpose is to achieve optimal professional performance, which translates into a significant improvement in the quality and effectiveness of the work.

In addition to the above, Troitiño Díaz (2021) defines it as a process through which university graduates develop actions aimed at enhancing their training and achieving goals at different levels. Furthermore, Hernández Álvarez et al. (2024) conclude that it is a path of constant learning that integrates new knowledge, practical skills, and personal values. In doing so, it raises the quality of work and shapes professional identity within its social and cultural context.

Perdomo Pérez et al. (2024) concur with and expand upon the above, stating that the inseparable link between theory, practice, and civic education highlights the value of "learning by doing", an approach that promotes the constant updating of knowledge in both professional practice and personal development. Previously, López Collazo (2019) had recognized that teachers and their teaching activity are products of their own professional development, and that professional pedagogical work has materialized in the forms of teaching performance, which are developed through professional development processes and expressed in the concrete practice of the profession.

The definitions of the process of overcoming adversity discussed in this article share common elements, but also reflect distinct nuances and emphases. An evaluative analysis of these definitions follows:

1. Common elements and strengths:
    - Continuous and permanent process: Professional development is not limited to a specific stage but encompasses the entire work career.
    - Comprehensive approach: Combines theoretical knowledge, practical skills, ethical values, and personal development.

- Linking theory and practice: The importance of "learning by doing" and the application of knowledge in real-world contexts is emphasized.
- Improved work performance: The main objective is to optimize the quality of work through constant updating.
- Individual and institutional responsibility: It is considered both a right and an obligation of the professional, especially in the educational field.

2. Different nuances and emphases:
    - Pedagogical approach: Several conceptualizations present it as a formative process linked to teaching, with emphasis on self-criticism and the transformation of educational practice.
    - Cultural and historical dimension: It is mentioned that the construction of knowledge occurs in a sociocultural context, which implies adapting to social demands.
    - Personal growth versus professional growth: Some definitions prioritize career development, while others explicitly integrate personal and civic growth.
    - Teacher's role: It is emphasized that the educator must be an active agent of his own improvement, assimilating norms and values of his profession.
3. Possible contradictions or tensions:
    - Obligation versus right: While some definitions emphasize that professional development is a duty of the professional, others present it as a right that must be guaranteed by institutions. This can generate tensions in environments where there are not enough opportunities for continuing education.
    - Individual versus collective: Some texts highlight the active role of the professional in their improvement, while others emphasize the need for institutional conditions and public policies that facilitate it.
    - Technical versus human approach: Some definitions prioritize the acquisition of technical knowledge and skills, while others give more weight to values, ethics, and socio-emotional development.

In the author's opinion, a more complete conceptualization of overcoming should consider elements such as:

- Professional development is a continuous, systematic, and intentional process that combines theoretical training, reflective practice, and ethical development, with the aim of improving job performance and personal growth.

- It must be contextualized, considering the social, technological, and cultural demands of the environment.
- It requires co-responsibility, both from the professional (as an active agent) and from the institutions (which must provide conditions for its development).
- It must integrate not only technical skills, but also soft skills, critical thinking, and the ability to adapt to change.

VLEs as a tool for educational innovation: Concepts and characteristics

In the digital age, Virtual Learning Environments (VLEs) have become fundamental tools that transform teaching and learning processes. According to Cedeño Romero and Murillo Moreira (2019), VLEs aim to promote a diversity of educational methods at different levels, integrating digital technologies that facilitate interaction, access to resources, and personalized learning, while also fostering collaboration among participants.

The school, traditionally conceived as a space for civic education, has expanded its reach to include urban and digital settings. Ortiz Yanez et al. (2019) classify learning environments into three categories: classroom settings (traditional classrooms), real-world environments (laboratories, companies, libraries, natural spaces), and virtual spaces (mediated by ICT), highlighting the multiplicity of settings in which education takes place today.

López Rayón Parra et al. (2002) conceptualize VLEs as integrated systems of interaction, real-time or asynchronous, structured through educational management platforms that support an intentional pedagogical design. Complementarily, Cedeño Romero and Murillo Moreira (2019) highlight the dynamic interaction and collaborative work that these environments allow, while Arjona Gordillo and Blando Chávez (2007) emphasize their formative function, with high interactivity both within and outside the institution, supported by digital technologies.

In summary, VLEs are characterized by three essential elements: a focus on teaching and learning processes, support for learning with digital technologies, and the promotion of interaction among participants. According to Ortiz Aguilar et al. (2020), these environments require more flexible and adaptable educational models, operating not based on physical presence or simultaneous interaction, but rather through digital connections that allow for geographically distributed interaction.

Authors such as Cedeño Romero and Murillo Moreira (2019) and Mestre Gómez et al. (2007) define VLEs as techno-pedagogical systems that integrate five components: space, learner, teacher guide, knowledge objects, and technological support. Salinas (2011) adds that they are web platforms that eliminate space-time barriers, allowing multidirectional communication and collaborative knowledge construction.

Based on this analysis, a VLE can be considered a digital space designed to facilitate learning, either as a primary or complementary environment, where any learning-oriented software, mediated by teacher guidance and with student-teacher interaction, can be considered part of a VLE.

Teacher training in the use of VLEs

VLEs are key tools in today's digital education, but their implementation faces challenges such as the digital divide and pedagogical adaptation. Their effectiveness requires not only technical expertise but also innovative teaching strategies that leverage their interactive and inclusive potential. Professional development in this field demands ongoing training, methodological innovation, and critical reflection to transform obstacles into opportunities for dynamic and personalized learning, in line with the needs of the 21st century.

Regarding the use of technologies in education, Pando Fernández and Páez Paredes (2021) express that the integration of ICT in education has become an unavoidable requirement, with the aim of preparing new generations to function in an increasingly digital environment.

In the teaching-learning process, the use of VLEs as a technological tool is a fundamental facilitator. Therefore, the teacher and their professional development constitute a crucial link, as corroborated by León Cáceres et al. (2016), who state that it is essential to have teaching professionals with specialized training in pedagogical methodologies and digital skills applicable to virtual learning environments.

The effective integration of digital resources in virtual learning environments requires teachers to be trained in their theoretical, pedagogical, and didactic dimensions. However, studies reveal shortcomings in teacher professional development, which limits both the use of these tools for student development and the formation of a technological culture (León Cáceres et al., 2016). This problem is exacerbated by the lack of theoretical systematization on continuing teacher training in virtual environments, particularly regarding professional development processes with a systemic and

sequential approach linked to educational platforms (León Cáceres et al., 2016). Recent findings corroborate this gap, highlighting limitations in teacher preparation to assume guidance roles in virtual classrooms (Abreu Vázquez & Pérez Mallea, 2024).

The study by Rojas Hernández and González Méndez (2021) provides evidence supporting this problem, identifying insufficient planning in professional development programs for teachers focused on virtual learning environments (VLEs) and the pedagogical integration of digital technologies. This finding is reinforced by the results of Balarezo Velasco et al. (2024), who particularly highlight the deficiencies in digital competence among teachers with more professional experience, demonstrating a marked need for specialized training for the effective implementation of technological resources in educational contexts.

Regarding the educational technology landscape, while a wide range of digital tools with didactic potential exist, Quintero Chávez (2024) demonstrates through quantitative research that a significant gap persists between technological availability and teachers' skills, noting that teachers show insufficient development of digital competencies for the pedagogical implementation of technologies in virtual learning environments. These findings align with the observations made in the present study, confirming the existence of this problem in the current educational field.

The research conducted by Ruiz Quizhpe et al. (2024) consistently indicates that teacher training in managing resources available in Virtual Learning Environments (VLEs) requires continuous updating. This necessitates the implementation of regular training programs with broad institutional coverage, synchronized with technological innovations in the educational platform. Such ongoing training fosters teacher professional development, as teaching is a lifelong learning process.

These findings suggest that such problems constitute manifestations of an unmet training need among teachers. This perspective is supported by the study of Pinto Sudario and Plaza Andrade (2021), who, through qualitative analysis, determined that:

There is a significant lack of motivation among teachers towards techno-pedagogical training, requiring differentiated interventions for those teachers who present:

- Intrinsic factors: lack of motivation, apathetic attitudes towards the educational value of ICT.
- Extrinsic factors: lack of basic technological infrastructure (equipment / connectivity)
- Psychosocial factors: lack of technological appropriation and professional empowerment.

Additionally, Palma Troncoso et al. (2024) points out that teachers perceive virtual environments as a new educational paradigm, one they faced for the first time and described as challenging. Among the difficulties reported, they highlighted uncertainty regarding their mastery of digital tools and the pedagogical skills necessary for effective implementation.

In line with the above, Quintero Chávez (2024) emphasizes the need for future teachers to develop the skills to manage diversity in contemporary classrooms, characterized by heterogeneity in abilities, learning styles, and specific educational needs. This approach underscores the requirement to adapt to dynamic contexts, supported by Suárez Urquijo et al. (2019), who maintain that contemporary teachers have the imperative to research, assimilate, and implement innovative pedagogical methodologies, which implies the development of a fundamental competency: digital competence. However, this transition is hampered by deficiencies in training and institutional support, particularly in contexts with limited technological infrastructure.

In this sense and aimed at ensuring that teachers acquire true training in the use of ICT, Pinto Sudario and Plaza Andrade (2021) suggest actively engaging them in the use of these, stating that a teacher forgets if you only mention a concept, remembers it if you teach it to them, but really learns it when they put it into practice.

There are many potential benefits that technology offers for the professional development of teachers. Based on the above criteria, Guzmán Gómez et al. (2023) They explain that in the digital age, teachers' professional development is facilitated by the benefits of ICT. These benefits include faster access to data and knowledge, fluid communication and easy collaboration with other professionals, involvement in research initiatives and projects, and access to training programs, specializations, master's degrees, and doctorates offered by professors from world-renowned universities, without geographical limitations.

From a practical-educational perspective, the author identifies that, while a significant number of teachers possess technological skills, difficulties persist in effectively integrating them into the teaching process. This problem aligns with the observations of Quintero Chávez (2024), who notes that technology use is often fragmented, lacking connection to pedagogical objectives and subject content, thus limiting the transfer of these skills to the classroom.

Given the importance of professional development for teachers, especially in the use of VLEs, León Cáceres et al. (2016) define the systematization of professional development for teachers using

virtual environments as a structured system of interrelated elements, based on face-to-face, virtual, and constructivist approaches. This system fosters an understanding of the virtual teaching-learning environment, both in its conceptual dimension (as educational content) and in its practical function (as a tool for pedagogical development). This allows teachers to embrace the pedagogical and didactic culture of virtual learning, thus optimizing the quality of their professional development.

The authors mentioned above conceptualize this professional development process as a structured and planned system which, through reflective, interactive, and collaborative participation, facilitates the identification of training needs and the progressive mitigation of teaching weaknesses, thus constituting an optimal model for continuous professional development. Based on the definition given by León Cáceres et al. (2016) regarding the systematization of teacher professional development for the use of virtual environments, the author proposes a pedagogical model grounded in the dialectical interaction of interconnected subsystems through relationships of coordination, complementarity, and subordination. Post-implementation analysis revealed significant improvements in teacher digital competence, pedagogical integration of VLEs, and the effectiveness of training processes, validating the effectiveness of the proposed systemic model.

On the other hand, Zhunio Ordoñez et al. (2025) developed a structured program to mitigate technology phobia in Ecuadorian university professors, using the ADDIE instructional model (Analysis, Design, Development, Implementation, Evaluation). The study identified the main barriers as: resistance to change (78%), a deficit in digital skills (65%), and work overload (57%). The model proved effective in the acquisition of digital teaching competencies, particularly in contexts with initial resistance to virtual education, achieving: a 42% increase in digital competencies, a 65% reduction in technology anxiety, and 89% satisfaction with the methodology (Zhunio Ordoñez et al., 2025).

In the study conducted by Palma Troncoso et al. (2024), negative perceptions regarding the use of VLEs were identified. Student teachers stated that these environments do not foster student-teacher interaction, which hinders knowledge construction, makes it difficult to adapt pedagogical processes, and even negatively impacts students' emotional well-being. Similarly, mentor teachers indicated that the lack of face-to-face contact limits their understanding of student diversity.

In the analysis of the socio-affective dimension in digital environments, Balarezo Velasco et al. (2024) identified a process of educational dehumanization, demonstrating that technological advances have not been able to compensate for the absence of face-to-face interactions and interpersonal contact,

essential elements of traditional education. This problem correlates with the findings of Quintero Chávez (2024), who, through a study, demonstrated that limited teacher-student interaction in virtual environments significantly reduces levels of academic engagement, negatively affecting both intrinsic motivation and long-term cognitive retention. The author attributes this phenomenon to the deficient implementation of interactive digital resources, which generates predominantly passive student participation.

In general, the incorporation of VLEs into the contemporary educational context represents a crucial step forward in adapting to the demands of the digital age. However, their effective implementation faces multidimensional challenges, ranging from technological gaps and teacher resistance to the need to replace pedagogical strategies that leverage their interactive and inclusive potential.

Authors such as León Cáceres et al. (2016), Pando Fernández and Páez Paredes (2021), and Abreu Vázquez and Pérez Mallea (2024) consider teacher professional development to be an essential element for transforming these obstacles into opportunities. This implies not only technical mastery of digital tools, but also systematic and critical continuous training that integrates didactic, technological, and affective aspects, as proposed by the pedagogical model of subsystems (orientative, visual, and constructive) by León Cáceres et al. (2016) and the program structured under the ADDIE approach by Zhunio Ordoñez et al. (2025).

Although concerns about dehumanization in virtual environments persist, studies such as those by Quintero Chávez (2024) and Balarezo Velasco et al. (2024) highlight that teacher training focused on active methodologies -such as gamification, online collaboration, and personalized feedback- can mitigate these limitations by fostering meaningful interactions and motivating students. Ultimately, educational transformation through VLEs requires institutional policies that promote comprehensive teacher training, combining technological innovation with pedagogical reflection to shape learning demands.

Professional development for pre-university mathematics teachers focused on the use of VLEs

In today's educational landscape, marked by digital acceleration and the redefinition of pedagogical strategies, VLEs emerging as a key tool for revitalizing mathematics teaching at the pre-university level. However, the effective integration of these environments faces challenges, linked not only to

the technological gap but also to the specialized teacher training required to adapt traditional methodologies to interactive digital contexts.

Characterizing the professional development of mathematics teachers in this area is urgent, given the need to balance disciplinary mastery with technological and pedagogical skills that allow them to leverage the potential of VLEs for problem-solving, visualizing abstract concepts, and personalizing learning. It is important to consider that the processes of professional development, continuing education, and pedagogical reflection for mathematics teachers can become cornerstones, not only for adopting these tools but also for integrating them in innovative and critical ways, overcoming resistance and building practices aligned with the demands of an inclusive, collaborative, and 21st-century mathematics education.

Recent studies highlight challenges in teacher training for the integration of VLEs in mathematics education. Manjarrez Yépez and Cordero (2023), in a study focused on mathematics teachers at a general education institution in Ecuador, identified three key limitations: inefficiencies in collaborative skills among the teaching staff, restrictive use of VLEs in the classroom, and limited knowledge about the diversity of VLE tools available for teaching mathematics. These findings are consistent with the research of Paredes Díaz et al. (2024), who emphasize that mastery of basic digital skills is a fundamental requirement for mathematics teachers to optimize the pedagogical potential of virtual environments.

Mendoza et al. (2019) investigated the pedagogical practices of mathematics teachers in online education within a Colombian institution. Their findings showed that, although the teachers possess a high level of subject matter expertise, the adoption of digital tools and teaching strategies presents significant limitations. A limited use of technological resources was observed, with a predominance of adaptations of traditional methodologies in virtual environments, as well as the persistence of conventional teaching approaches, even in digital modalities.

However, the study revealed differences based on teaching experience, highlighting that 48% of teachers with more than 11 years of experience have implemented innovative strategies in online mathematics teaching through the frequent use of technology. Furthermore, their methodologies and assessment systems partially align with the role of the tutor in virtual environments, prioritizing collaborative and independent work as key tools for evaluating student learning.

These results suggest that experience in VLEs and ongoing training are key factors for an effective transition to digital pedagogical models. These conclusions align with the perspective of the present study, which maintains that exposure time and training in virtual environments significantly improve outcomes in mathematics teaching in non-face-to-face settings. Furthermore, Padilla Escorcia and Conde Carmona (2020) They identified a double training gap in teachers: on the one hand, deficiencies in technological-pedagogical knowledge that limit the meaningful integration of ICT with mathematical content, and on the other hand, an insufficient mastery of didactic strategies to convert technological knowledge into effective and assessable educational practices.

These studies agree that mere familiarity with digital tools (software, web platforms) is insufficient. An integrated mastery of three dimensions is required: mathematical content, pedagogy, and technology. These dimensions should enable the development of genuine technological-pedagogical knowledge of the content within the specific context of mathematics education.

The model proposed by Olivier Rodríguez et al. (2016) constitutes a theoretical and practical framework for teaching mathematics through ICT, centered on Computerized Mathematical Tasks (CMTs). It combines an integrative didactic structure (organizing objectives, content, and assessment around CMTs), a contextualized approach (linking mathematics to real-world situations), a formative dimension (holistic student development), and adaptive flexibility (adjustments according to needs). It operates through three phases: planning (design), systematization (implementation), and evaluation (formative assessment). It is based on project-based learning and considers the synergistic influence of educational stakeholders (teachers, families, and the community) in a process characterized by its interactive and developmental nature.

In Cuba, Bendoiro Pérez and Díaz Tejera (2024) analyze the fundamental challenges faced by mathematics teachers in a context enhanced by technology. They state that the technological gap between so-called digital natives and digital immigrants represents the main challenge teachers have faced in incorporating ICT into their teaching. This disparity can be examined both in terms of teachers' access to these technologies and their application in the classroom. In the Cuban context, while institutional policies have favored greater teacher access to technology, its effective integration in the classroom depends primarily on the teachers' pedagogical and digital preparation.

Recent studies highlight deficiencies in teachers' technological skills, particularly in mathematics, where both subject-matter expertise and the ability to incorporate digital tools into instructional

design are essential. Undoubtedly, the effectiveness of this process is contingent upon teachers' attitudes toward techno-pedagogical innovation (Bendoiro Pérez & Díaz Tejera, 2024).

In addition to the above, it should be noted that although Cuban teachers have access to the CUBAEDUCA educational platform -which offers digital resources such as educational software, teleclasses, virtual libraries and online courses- according to the experiences of the author of this study, there is a systematic underutilization of these resources in mathematics classes, limiting their didactic potential.

For further study, and based on the theoretical and methodological systematization carried out, it is considered appropriate to operationally define the professional development process for pre-university mathematics teachers regarding the use of Virtual Learning Environments (VLEs) as a systemic, continuous, and comprehensive process that: *updates digital skills*, *refines teaching methodologies*, promotes interdisciplinary and collaborative *practices, and facilitates the renewal of pedagogical models*. This approach seeks to transform mathematics education practice through the critical appropriation of technologies, positioning them as a strategic axis for educational innovation in the 21st century.

CONCLUSIONS

The systematization carried out reveals that the professional development process, particularly for pre-university mathematics teachers, must be approached as a comprehensive system that combines ongoing training, pedagogical innovation, and adaptation to digital environments. VLEs emerge as key tools for revitalizing teaching, but their effectiveness depends on teacher development that transcends technical mastery and addresses pedagogical, didactic, and affective dimensions. Persistent challenges are identified, such as resistance to change, the technological-pedagogical gap, and the underutilization of digital resources, all of which require systemic and contextualized training strategies.

Teaching experience and specialized training demonstrate that the successful integration of ICT in mathematics education requires shared responsibility between institutions and teachers, as well as a critical perspective that balances technological innovation with meaningful educational practices. Consequently, the need to design professional development programs that foster pedagogical

reflection, and the creative appropriation of VLEs is reaffirmed, thus ensuring mathematics teaching adapted to the demands of the digital age.

REFERENCES

Abreu Vázquez, Y., & Pérez Mallea, I. (2024). Estrategia de superación para la mejora del desempeño del docente en el aula virtual de la facultad de Ciencias Médicas "Julio Trigo López". *Serie Científica De La Universidad De Las Ciencias Informáticas, 17*(11), 76-85. https://publicaciones.uci.cu/index.php/serie/article/view/1714

Avendaño Castro, W. R., Gamboa Suárez, A. A., & Hernández Suárez, C. A. (2022). Cualidades de un buen docente en el imaginario de los estudiantes a partir de las habilidades del siglo XXI y las TIC. *Revista Boletín Redipe*, *10*(13), 530-548. https://doi.org/10.36260/rbr.v10i13.1768

Balarezo Velasco, M. M., Barbosa Calderón, S. A., Calderón Togra, M. d. C., & Bejarano Gavilanes, X. P. (2024). Entornos virtuales de aprendizaje: Innovación y desafíos en la educación contemporánea. *Revista Imaginario Social, 7*(4), 61-78. https://doi.org/10.59155/is.v7i4.236

Bendoiro Pérez, I., & Díaz Tejera, K. I. (2024). Retos de la Didáctica de la Matemática con el empleo de las tecnologías. *Revista Varela*, *24*(67), 10-17. https://doi.org/10.5281/zenodo.10429078

Bernaza Rodríguez, G. J., Troitiño Díaz, D. M., & López Collazo, Z. S. (2018). *La superación del profesional: Mover ideas y avanzar más*. Editorial Universitaria del Ministerio de Educación Superior. https://www.academia.edu/69360019/La_superacion_del_profesional?auto=download

Cabrera Carrazana, Y., Martínez Álvarez, F. F., Martín Agüero, O. J., Serrano Tamayo, M. A., & Mestre León, A. V. (2021). La superación profesional desde una perspectiva transdisciplinar. *Revista Cognosis, 3*(julio-septiembre), 87-96. https://www.academia.edu/84521517/Superaci%C3%B3n_Profesional_Desde_Una_Perspectiva_Transdisciplinaria

Cedeño Romero, E. L., & Murillo Moreira, J. A. (2019). Entornos virtuales de aprendizaje y su rol innovador en el proceso de enseñanza. *Rehuso, 4*(1), 138-148. https://doi.org/10.33936/rehuso.v4i1.2156

Dorrego Pupo, M., López Aballe, M., & Avila Guerra, E. R. (2019). La superación psicopedagógica del docente de la enseñanza media: una necesidad para el trabajo educativo. *Opuntia Brava*, *11*(2), 145-161. https://doi.org/10.35195/ob.v11i2.750

Figueroa Nazuno, J., Vargas Medina, E. & Cruz Cortés, N. (2007). *Metodología para la Educación a Distancia*. https://www.academia.edu/download/48160136/Metodologia_2007.pdf

Gallardo Fernández, I. M., De Castro Calvo, A., & Saiz Fernández, H. (2020). Interacción y uso de tecnologías en los procesos de enseñanza y aprendizaje. *Educatio Siglo XXI, 38*(1), 119-138. https://doi.org/10.6018/educatio.413441

Hernández Álvarez, A., Álvarez López, L. E., & García Beracierto, J. (2024). Lo distintivo de la capacitación y superación profesional en la dinámica educativa. *Educación y sociedad*, *22*(3), 130-147. https://doi.org/10.5281/zenodo.13854461

Hernández, R. M. (2017). Impacto de las TIC en la educación: Retos y Perspectivas. *Propósitos y Representaciones, 5*(1), 325. https://doi.org/10.20511/pyr2017.v5n1.149

León Cáceres, F. M., Moracén Cuevas, J. R., & Caballero Rodríguez, A. N. (2016). Los entornos virtuales de enseñanza-aprendizaje. Un contenido a sistematizar en el proceso de superación profesional del docente. *Santiago, 140*(mayo-agosto), 292-307. https://dspace.itb.edu.ec/bitstream/123456789/1099/1/Los%20entornos%20virtuales%20de%20enseñanza-aprendizaje.%20Un.pdf

López Collazo, Z. S. (2019). Enfoques teóricos acerca de la superación profesional, una mirada en las áreas técnicas. *Varona. Revista Científico Metodológica, 68,* (enero-junio), 1-6. http://scielo.sld.cu/pdf/vrcm/n68/1992-8238-vrcm-68-e04.pdf

López, A. E., Escalera, S., & Ledesma, R. (2002). *Ambientes virtuales de aprendizaje.* Presimposio Virtual SOMECE 2002. México: SOMECE.

Manjarrez Yépez, M., & Cordero, Y N. (2023). Competencias digitales de los docentes para la enseñanza de las matemáticas a través de Entornos Virtuales de Aprendizaje (EVA). *Revista Científica Ciencia Y Tecnología, 23*(37), 94-113. https://doi.org/10.47189/rcct.v23i37.560

Mendoza, H. H., Burbano, V. M., & Valdivieso, M. A. (2019). El Rol del Docente de Matemáticas en Educación Virtual Universitaria. Un Estudio en la Universidad Pedagógica y Tecnológica de Colombia. *Formación universitaria, 12*(5), 51-60. https://dx.doi.org/10.4067/S0718-50062019000500051

Mestre Gómez, U., Fonseca Pérez, J. J., & Valdés Tamayo, P. R. (2007). *Entornos virtuales de enseñanza aprendizaje.*https://libros.metabiblioteca.org/server/api/core/bitstreams/5a92bf48-ddbe-4c9f-beba-1c758cccc50a/content

Olivier Rodríguez, O. Z., Díaz López, J. R., & Alonso Betancourt, L. A. (2016). Modelo didáctico de la dinámica del proceso de enseñanza-aprendizaje de la matemática con el uso de las TIC. *Didasc@lia: Didáctica y Educación, 7*(3), 23-35. https://dialnet.unirioja.es/servlet/articulo?codigo=6645302

Ortiz Aguilar, W., Santos Díaz, L. B., & Rodríguez Revelo, E. (2020). Estrategias didácticas en entornos virtuales de enseñanza-aprendizaje universitarios. *Opuntia Brava*, *12*(4), 68-83. https://opuntiabrava.ult.edu.cu/index.php/opuntiabrava/article/view/1105

Ortiz Yanez, G. A., Ruiz Alarcón, M. E., & Guzmán Guamán, E. E. (2019). Ambientes de enseñanza: un acercamiento conceptual en el siglo XXI. *Dominio De Las Ciencias*, *5*(1), 212-234. https://doi.org/10.23857/dc.v5i1.1040

Padilla Escorcia, I. A., & Conde Carmona, R. J. (2020). Uso y formación en TIC de profesores de matemáticas: un análisis cualitativo. *Revista Virtual Universidad Católica del Norte, 60*, 116-136. https://www.redalyc.org/journal/1942/194263234007/html

Palma Troncoso, M., Vallejos Gómez, R. M., & Urra Barra, G. (2024). Ser profesor en entornos virtuales: desafíos y demandas post pandemia a la formación inicial docente. Una aproximación desde la evaluación de futuros profesores y mentores. *Revista de estudios y experiencias en educación*, *23*(51), 197-212. https://dx.doi.org/10.21703/rexe.v23i51.2156

Pando Fernández, A. y Páez Paredes, M. (2021). Retos de la superación para el docente de informática. *Horizonte Pedagógico*, *10*(3), 3-11. https://horizontepedagogico.cu/index.php/hop/article/view/201

Paredes Díaz, D. F., Cadena Valero, J. L., Jácome López, G., & Reigosa Lara, A. (2024). La Tecnología del aprendizaje y del conocimiento (TAC) en ambientes virtuales de aprendizaje de matemáticas en el bachillerato técnico. *Journal Scientific MQR Investigar, 8*(3), 4306-4328. https://doi.org/10.56048/MQR20225.8.3.2024.4306-4328

Paredes Paredes, C. E., Campoverde Agurto, M. P., & Játiva Macas, D. F. (2021). Herramientas tecno-educativas del siglo XXI: Fortaleciendo competencias digitales docentes para la enseñanza y aprendizaje. *Sociedad & Tecnología*, *4*(S2), 335-349. https://doi.org/10.51247/st.v4iS2.155

Pinto Sudario, G. C., & Plaza Andrade, J. N. (2021). Determinar la necesidad de capacitación en el uso de las tecnologías de la información y las comunicaciones para la formación docente. *593 Digital Publisher CEIT, 6*(1), 169-181. https://dialnet.unirioja.es/servlet/articulo?codigo=7897553

Quintero Chávez, C. T. (2024). Integración de tecnologías de la información y la comunicación en el proceso de enseñanza-aprendizaje de entornos virtuales de aprendizaje. *Didasc@lia: Didáctica y Educación*, *15*(1), 418-448. https://dialnet.unirioja.es/servlet/articulo?codigo=9385151

Rojas Hernández, Y., & González Méndez, A. (2021). Estado de preparación de los docentes en ambientes virtuales de aprendizaje en tiempos de COVID-19. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, (28), 379-387. https://doi.org/10.24215/18509959.28.e47

Ruiz Quizhp, R., Sarango Solano, F., & Chumbay Guncay, J. (2024). Empoderamiento docente en Educación Virtual: avances y desafíos del aprendizaje durante toda la vida. *Revista Varela, 24*(67), 18-24. https://www.redalyc.org/journal/7322/732278421003/732278421003.pdf

Salinas, M. I. (2011). Entornos virtuales de aprendizaje en la escuela: tipos, modelo didáctico y rol del docente. *Universidad Católica de Argentina*, *12*, 1-12.

https://cdn.goconqr.com/uploads/media/pdf_media/19450985/a6069975-0a82-4fe9-ae15-3f76cfef8f71.pdf

Troitiño Díaz, D. M. (2021). La superación profesional de los directivos y reservas en las escuelas ramales. *Referencia Pedagógica*, 9(2), 247-258. http://scielo.sld.cu/pdf/rp/v9n2/2308-3042-rp-9-02-247.pdf

Zhunio Ordoñez, J. L., Vinueza Rodríguez, L. T., López Fernández, R., & Caicedo Quiroz, R. (2025). Programa de capacitación docente utilizando la analítica del aprendizaje para mitigar la tecnofobia en el uso de entornos virtuales de aprendizaje. *Revista Metropolitana de Ciencias Aplicadas*, *8*(2), 159-172. https://doi.org/10.62452/keag1v59

Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.